# SEMESTER I

| 22MAT101 | LINEAR ALGEBRA AND CALCULUS | CATEGORY | L | T | P | CREDIT | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | BSC | 3 | 1 | 0 | 4 | 2019 |

**Preamble:** This course introduces students to some basic mathematical ideas and tools which are at the core of any engineering course. A brief course in Linear Algebra familiarises students with some basic techniques in matrix theory which are essential for analysing linear systems. The calculus of functions of one or more variables taught in this course are useful in modelling and analysing physical phenomena involving continuous change of variables or parameters and have applications across all branches of engineering.

**Prerequisite:** A basic course in one-variable calculus and matrix theory**.**

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | solve systems of linear equations, diagonalize matrices and characterise quadratic forms |
| **CO 2** | compute the partial and total derivatives and maxima and minima of multivariable functions |
| **CO 3** | compute multiple integrals and apply them to find areas and volumes of geometrical shapes, mass and centre of gravity of plane laminas |
| **CO 4** | perform various tests to determine whether a given series is convergent, absolutely convergent or conditionally convergent |
| **CO 5** | determine the Taylor and Fourier series expansion of functions and learn their applications. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 3 | 3 | 3 | 2 | 1 | | | 1 | 2 | | 2 |
| CO 2 | 3 | 3 | 3 | 3 | 2 | 1 | | | 1 | 2 | | 2 |
| CO 3 | 3 | 3 | 3 | 3 | 2 | 1 | | | 1 | 2 | | 2 |
| CO 4 | 3 | 2 | 3 | 2 | 1 | 1 | | | 1 | 2 | | 2 |
| CO 5 | 3 | 3 | 3 | 3 | 2 | 1 | | | 1 | 2 | | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination (Marks)** |
|---|---|---|---|
| | **Test 1 (Marks)** | **Test 2 (Marks)** | |
| Remember | 10 | 10 | 20 |
| Understand | 20 | 20 | 40 |
| Apply | 20 | 20 | 40 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks
**Assignments:** Assignment should include specific problems highlighting the applications of the methods introduced in this course in science and engineering.

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):** Solve systems of linear equations, diagonalize matrices and characterise quadratic forms

1. A is a real matrix of order $3 \times 3$ and $X = \begin{bmatrix} x \\ y \\ z \end{bmatrix}$. What can you say about the solution of $AX = 0$ if rank of A is 1? 2 ?3?

2. Given $A = \begin{bmatrix} 3 & 0 & 2 \\ 0 & 2 & 0 \\ -2 & 0 & 0 \end{bmatrix}$, find an orthogonal matrix $P$ that diagonalizes A.

3. Find out what type of conic section the following quadratic form represents

$$17x^2 - 30x_1x_2 + 17x_2^2 = 128$$

4. The matrix $A = \begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$ has an eigen value 5 with corresponding Eigen vector $X = \begin{bmatrix} 1 \\ 2 \\ -1 \end{bmatrix}$. Find $A^5X$

**Course Outcome 2 (CO2):** compute the partial and total derivatives and maxima and minima of multivariable functions

1. Find the slope of the surface $z = x^2y + 5y^3$ in the x-direction at the point (1,-2)

2. Given the function $w = xy + z$, use chain rule to find the instantaneous rate of change of $w$at each point along the curve $x = cost, y = sint, z = t$

3. Determine the dimension of rectangular box open at the top , having a volume 32 cubic ft and requiring the least amount of material for it's construction.

**Course Outcome 3(CO3)**: compute multiple integrals and apply them to find areas and volumes of geometrical shapes, mass and centre of gravity of plane laminas.

1. Evaluate $\iint_D (x + 2y)\, DA$where D is the region bounded by the parabolas $y = 2x^2$and $y = 1 + x^2$

2. Explain how you would find the volume under the surface $z = f(x, y)$and over a specificregion $D$in the $xy$plane using (i) double integral (ii) triple integral?

3. Find the mass and centre of gravity of a triangular lamina with vertices (0,0), (2,1), (0,3) if the density function is $f(x, y) = x + y$

4. Use spherical coordinates to evaluate $\iiint_B (x^2 + y^2 + z^2)^3\, dV$where B is the unit ball defined by $B = \{(x, y, z): x^2 + y^2 + z^2 \leq 1\}$

**Course Outcome 4 (CO4):** perform various tests to determine whether a given series is convergent, absolutely convergent or conditionally convergent.

1. What is the difference between a sequence and a series and when do you say that they are convergent? Divergent?

2. Determine whether the series $\sum_{n=1}^{n=\infty} \frac{5}{2n^2+4n+3}$converges or diverges.

3. Is the series $\sum_{n=1}^{n=\infty} \frac{(-1)^{n-1}}{n}$convergent? Absolutely convergent? Conditionally convergent?

**Course Outcome 5 (CO5):** determine the Taylor and Fourier series expansion of functions and learntheir applications.

1. Assuming the possibility of expansion find the Maclaurin series expansion of

   $f(x) = (1 + x)^k$for$|x| < 1$where $k$is any real number. What happens if $k$is a positiveinteger?

2. Use Maclaurin series of $ln(1 + x), -1 < x \leq 1$to find an approximate value of$ln2$.

3. Find the Fourier series of the function$f(x) = x^2, -2 \leq x < 2, f(x + 4) = f(x)$. Hence using Parseval's identity prove that $1 + \frac{1}{2^4} + \frac{1}{3^4} + \ldots = \frac{\pi^4}{90}$

4. Expand the function $f(x) = x\ (0 < x < 1/2)$ into a (i) Fourier sine series (ii) Fourier cosine series.

**Model Question paper**

**QP CODE:** PAGES:3

Reg No:_______________

Name :_______________

**TKM COLLEGE OF ENGINEERING**

**FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

***Course Code:*** **22MAT101**

**Max. Marks: 100** **Duration: 3 Hours**

**LINEAR ALGEBRA AND CALCULUs**

**(2019-Scheme)**

**(Common to all branches)**

## PART A

(Answer **all** questions, **each** question carries 3 marks)

1. Determine the rank of the matrix $A = \begin{bmatrix} 1 & 2 & -1 \\ -2 & -4 & 2 \\ 3 & 6 & -3 \end{bmatrix}$.
2. Write down the eigen values of $= \begin{bmatrix} 2 & 0 \\ 0 & -1 \end{bmatrix}$. What are the eigen values of $P^{-1}AP$ where $P = \begin{bmatrix} -4 & 2 \\ 3 & -1 \end{bmatrix}$?
3. Find $f_x(1,3)$ and $f_y(1,3)$ for the function $f(x, y) = 2x^3y^2 + 2y + 4x$.
4. Show that the function $u(x, t) = \sin(x - ct)$ is a solution of the equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$.
5. Use double integral to find the area of the region enclosed between the parabolas $y = \frac{1}{2}x^2$ and the line $y = 2x$.
6. Use polar coordinates to evaluate the area of the region bounded by $x^2 + y^2 = 4$, the line $y = x$ and the y axis in the first quadrant
7. Test the convergence of the series $\sum_{k=1}^{\infty} \frac{k}{k+1}$.
8. Test the convergence of the alternating series $\sum_{k=1}^{\infty} (-1)^{k+1} \frac{1}{k}$ using Leibnitz test.
9. Find the Taylor series expansion of $\sin \pi x$ about $x = \frac{1}{2}$
10. Find the values to which the Fourier series of

    $f(x) = x$ for $-\pi < x < \pi$, with $f(x + 2\pi) = f(x)$ converges (10x3=30)

**PART B**

(Answer **one full** question from each module, each question carries **14** marks)

**Module -I**

11. (a) Solve the following system of equations

$$y + z - 2w = 0$$
$$2x - 3y - 3z + 6w = 2$$
$$4x + y + z - 2w = 4$$

(b) Find the eigen values and eigen vectors of the matrix $\begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$

12. (a) Diagonalize the matrix $\begin{bmatrix} -1 & 2 & -2 \\ 2 & 4 & 1 \\ 2 & 1 & 4 \end{bmatrix}$

(b) What kind of conic section the quadratic form $3x_1^2 + 22x_1x_2 + 3x_2^2 = 0$ represents?

Transform it to principal axes.

**Module - II**

13. (a) Find the local linear approximation to $f(x, y) = \sqrt{x^2 + y^2}$ at the point (3, 4).Use it to approximate $f(3.04,3.98)$

(b) Let $w = \sqrt{x^2 + y^2 + z^2}$, $x = cos\theta, y = sin\theta, z = tan\theta$. Use chain rule to find $\frac{dw}{d\theta}$ when $\theta = \frac{\pi}{4}$

14. (a) Let $z = f(x, y)$ where $x = rcos\theta$, $y = rsin\theta$, prove that

$$\left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2 = \left(\frac{\partial z}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial z}{\partial \theta}\right)^2.$$

(b) Locate all relative maxima, relative minima and saddle points

$f(x, y) = xy + \frac{a^3}{x} + \frac{b^3}{y} (a \neq 0, b \neq 0)$.

**Module - III**

15. (a) Evaluate $\iint_D (2x^2y + 9y^3)\, dxdy$ where D is the region bounded by $y = \frac{2}{3}x$ and $y = 2\sqrt{x}$ −

(b) Evaluate $\int_0^4 \int_{\sqrt{y}}^2 e^{x^3}\, dxdy$ changing the order of integration.

16. (a) Find the volume of the solid bounded by the cylinder $x^2 + y^2 = 4$ and the planes $y + z = 4$ and $z = 0$..

(b) Evaluate $\iiint \sqrt{1 - x^2 - y^2 - z^2}\, dxdydz$, taken throughout the volume of the sphere $x^2 + y^2 + z^2 = 1$, by transforming to spherical polar coordinates

**Module - IV**

17. (a) Test the convergence of the series

(i) $\sum_{k=1}^{\infty} \frac{k^k}{k!}$ (ii) $\sum_{k=2}^{\infty} \left(\frac{4k-5}{2k+1}\right)^k$

(b) Determine the convergence or divergence of the series $\sum_{k=1}^{\infty} (-1)^k \frac{(2k-1)!}{3^k}$

18. (a) Check whether the series $\sum_{k=1}^{\infty} (-1)^{k+1} \frac{(2k)!}{(3k-2)!}$ is absolutely convergent, conditionally convergent or divergent.

(b) Test the convergence of the series $1 + \frac{1.2}{1.3} + \frac{1.2.3}{1.3.5} + \frac{1.2.3.4}{1.3.5.7} + \cdots$

**Module - V**

19. (a) Obtain the Fourier series of for $f(x) = e^{-x}$, in the interval $0 < x < 2\pi$.with $f(x + 2\pi) = f(x)$. Hence deduce the value of $\sum_{n=2}^{\infty} \frac{(-1)^n}{1+n^2}$.

(b) Find the half range sine series of $f(x) = \begin{cases} \frac{2kL}{x} & if\ 0 < x < \frac{L}{2} \\ \frac{2k(L-x)}{L} & if\ \frac{L}{2} < x < L \end{cases}$

20. (a)Expand $(1 + x)^{-2}$.as a Taylor series about $x = 0$and state the region of convergence ofthe series.

(b) Find the Fourier series for $f(x) = x^2$ in the interval $-\pi < x < \pi$

with $f(x + 2\pi) = f(x)$.Hence show that $\frac{1}{} + \frac{1}{} + \frac{1}{} + \cdots = \frac{\pi^4}{}$.

(14X5=70)

## Syllabus

**Module 1 (Linear algebra)**

**(Text 2: Relevant topics from sections 7.3, 7.4, 7.5, 8.1,8.3,8.4)**

Systems of linear equations, Solution by Gauss elimination, row echelon form and rank of a matrix, fundamental theorem for linear systems (homogeneous and non-homogeneous, without proof), Eigen values and eigen vectors. Diagonaliztion of matrices, orthogonal transformation, quadratic forms and their canonical forms.

**Module 2 (multivariable calculus-Differentiation)**

**(Text 1: Relevant topics from sections 13.3, 13.4, 13.5, 13.8)**

Concept of limit and continuity of functions of two variables, partial derivatives, Differentials, Local Linear approximations, chain rule, total derivative, Relative maxima and minima, Absolute maxima and minima on closed and bounded set.

**Module 3(multivariable calculus-Integration)**

**(Text 1: Relevant topics from sections 14.1, 14.2, 14.3, 14.5, 14.6, 14.8)**

Double integrals (Cartesian), reversing the order of integration, Change of coordinates (Cartesian to polar), finding areas and volume using double integrals, mass and centre of gravity of inhomogeneous laminas using double integral. Triple integrals, volume calculated as triple integral, triple integral in cylindrical and spherical coordinates (computations involving spheres, cylinders).

**Module 4 (sequences and series)**

**(Text 1: Relevant topics from sections 9.1, 9.3, 9.4, 9.5, 9.6)**

Convergence of sequences and series, convergence of geometric series and p-series(without proof), test of convergence (comparison, ratio and root tests without proof); Alternating series and Leibnitz test, absolute and conditional convergence.

**Module 5 (Series representation of functions)**

**(Text 1: Relevant topics from sections 9.8, 9.9. Text 2: Relevant topics from sections 11.1, 11.2, 11.6 )**

Taylor series (without proof, assuming the possibility of power series expansion in appropriate domains), Binomial series and series representation of exponential, trigonometric, logarithmic functions (without proofs of convergence); Fourier series, Euler formulas, Convergence of Fourier series (without proof), half range sine and cosine series, Parseval's theorem (without proof).

**Text Books**

1. H. Anton, I. Biven,S.Davis, "Calculus", Wiley, 10th edition, 2015.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdition, John Wiley & Sons, 2016.

**Reference Books**

1. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9 th Edition, Pearson,

Reprint, 2002.

3. Peter V. O'Neil, Advanced Engineering Mathematics , Cengage, 7th Edition, 2012
4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36 Edition, 2010.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Linear Algebra (10 hours)** | |
| 1.1 | Systems of linear equations, Solution by Gauss elimination | 1 |
| 1.2 | Row echelon form, finding rank from row echelon form, fundamental theorem for linear systems | 3 |
| 1.3 | Eigen values and eigen vectors | 2 |
| 1.4 | Diagonaliztion of matrices, orthogonal transformation, quadratic forms | 4 |
| | and their canonical forms. | |
| 2 | Multivariable calculus-Differentiation (8 hours) | |
| 2.1 | Concept of limit and continuity of functions of two variables, partial derivatives | 2 |
| 2.2 | Differentials, Local Linear approximations | 2 |
| 2.3 | Chain rule, total derivative | 2 |
| 2.4 | Maxima and minima | 2 |
| 3 | Multivariable calculus-Integration (10 hours) | |
| 3.1 | Double integrals (Cartesian)-evaluation | 2 |
| 3.2 | Change of order of integration in double integrals, change of coordinates (Cartesian to polar), | 2 |
| 3.3 | Finding areas and volumes, mass and centre of gravity of plane laminas | 3 |
| 3.4 | Triple integrals | 3 |
| 4 | Sequences and series (8 hours) | |
| 4.1 | Convergence of sequences and series, geometric and p-series | 2 |
| 4.2 | Test of convergence( comparison, ratio and root ) | 4 |
| 4.3 | Alternating series and Leibnitz test, absolute and conditional convergence | 2 |
| 5 | Series representation of functions (9 hours) | |
| 5.1 | Taylor series, Binomial series and series representation of exponential, trigonometric, logarithmic functions; | 3 |

| | | |
|---|---|---|
| 5.2 | Fourier series, Euler formulas, Convergence of Fourier series(Dirichlet's conditions) | 3 |
| 5.3 | Half range sine and cosine series, Parseval's theorem. | 3 |

| 22CYT103 | ENGINEERING CHEMISTRY | CATEGORY | L | T | P | CREDIT | YEAR OF INTRODUCTION |
|---|---|---|---|---|---|---|---|
| | | BSC | 3 | 1 | 0 | 4 | 2019 |

**Preamble:** To enable the students to acquire knowledge in the concepts of chemistry for engineering applications and to familiarize the students with different application oriented topics like spectroscopy, electrochemistry, instrumental methods etc. Also familiarize the students with topics like mechanism of corrosion, corrosion prevention methods, SEM, stereochemistry, polymers, desalination etc., which enable them to develop abilities and skills that are relevant to the study and practice of chemistry.

**Prerequisite:** Concepts of chemistry introduced at the plus two levels in schools

**Course outcomes:** After the completion of the course the students will be able to

| | |
|---|---|
| **CO 1** | Apply the basic concepts of electrochemistry and corrosion to explore its possible applications in various engineering fields. |
| **CO 2** | Understand various spectroscopic techniques like UV-Visible, IR, NMR and its applications. |
| **CO 3** | Apply the knowledge of analytical method for characterizing a chemical mixture or a compound. Understand the basic concept of SEM for surface characterisation of nanomaterials. |
| **CO 4** | Learn about the basics of stereochemistry and its application. Apply the knowledge of conducting polymers and advanced polymers in engineering. |
| **CO 5** | Study various types of water treatment methods to develop skills for treating wastewater. |

**Mapping of course outcomes with program outcomes**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** | **PO 11** | **PO 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 1 | 2 | 1 | | | | | | | | | |
| **CO 2** | 1 | 1 | | 1 | 2 | | | | | | | |
| **CO 3** | 1 | 1 | | 1 | 2 | | | | | | | |
| **CO 4** | 2 | 1 | | | | | | | | | | |
| **CO 5** | 1 | | | 1 | | | 3 | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 15 | 15 | 30 |
| Understand | 25 | 25 | 50 |
| Apply | 10 | 10 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern:** There will be two parts- **Part A** and **Part B. Part A** contains **10** questions (**2** questions from each module), having **3** marks for each question. Students should answer **all** questions. **Part B** contains **2** questions from each module, of which student should answer any one. Each question can have maximum **2** subdivisions and carries **14** marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO 1):**

1. What is calomel electrode? Give the reduction reaction (3 Marks)

2. List three important advantages of potentiometric titration (3 Marks)

3. (a) Explain how electroless plating copper and nickel are carried out (10 Marks)

(b) Calculate the emf of the following cell at 30ºC, Z n / $Zn^{2+}$ (0.1M) // $Ag^+$ (0.01M) // Ag.

Given $E^0$ $Zn^{2+}$/Zn = -0.76 V, $E^0$ $Ag^+$/Ag = 0.8 V. (4 Marks)

**Course Outcome 2 (CO 2)**

1. State Beer Lambert's law (3 Marks)

2. List the important applications of IR spectroscopy (3 Marks)

3. (a) What is Chemical shift? What are factors affecting Chemical shift? How $^1$H NMR spectrum of $CH_3COCH_2Cl$ interpreted using the concept of chemical shift. (10 Marks)

(b) Calculate the force constant of HF molecule, if it shows IR absorption at 4138 $cm^{-1}$. Given that atomic masses of hydrogen and fluorine are 1u and 19u respectively. (4 Marks)

**Course Outcome 3 (CO 3):**

1. Distinguish between TGA and DTA (3 Marks)

2. Give two differences between GSC and GLC (3 Marks)

3. (a) Explain the principle, instrumentation and procedure of HPLC (10 Marks)

(b) Interpret TGA of $CaC_2O_4 . H_2O$ (4 Marks)

**Course Outcome 4 (CO 4):**

1. Explain the geometrical isomerism in double bonds (3 Marks)

2. What are the rules of assigning R-S notation? (3 Marks)

3. (a) What are conducting polymers? How it is classified? Give the preparation of polyaniline (10 Marks)

(b) Draw the stereoisomers possible for $CH_3$-$(CHOH)_2$-COOH (4 Marks)

**Course Outcome 5 (CO 5):**

1. What is degree of hardness? (3 Marks)

2. Define BOD and COD (3 Marks)

3. (a) Explain the EDTA estimation of hardness (10 Marks)

(b) Standard hard water contains 20 g of CaCO3 per liter,50 mL of this required 30mL of EDTA solution, 50mL of sample water required 20mL of EDTA solution. 50mL sample water after boiling required 14 mL EDTA solution. Calculate the temporary hardness of the given sample of water, in terms of ppm. (4 Marks)

**MODEL QUESTION PAPER**

**Total Pages:**

Reg No.:________________

Name:___________________________

**TKM COLLEGE OF ENGINEERING**

FIRST SEMESTER B.TECH DEGREE EXAMINATION

**Course Code:**
**22CYT103,**

**Course Name: ENGINEERING CHEMISTRY**

Max. Marks: 100 Duration: 3 Hours

**PART A**

***Answer all questions, each carries 3 marks*** Marks

1 What is potentiometric titration? How the end point is determined graphically? (3)

2 What is Galvanic series? How is it different from electrochemical series? (3)

3 Which of the following molecules can give IR absorption? Give reason? (3)

(a) $O_2$ (b) $H_2O$ (c) $N_2$ (d) HCl

4 Which of the following molecules show UV-Visible absorption? Give reason. (3)

(a) Ethane (b) Butadiene (c) Benzene

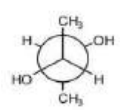
(10)

(4)

1 What are the visualization techniques used in TLC? (3)

2 Write the three important applications of nanomaterials. (3)

3 Draw the Fischer projection formula and find R-S notation of (3)




4 Write the structure of a) Polypyrroleb) Kevlar. (3

5 What is break point chlorination? (3)

6 What is reverse osmosis? (3)

**PART B**

***Answer any one full question from each module, each question carries 14 marks***

**Module 1**

7 a) Give the construction of Li-ion cell. Give the reactions that take place at the electrodes during charging and discharging. What happens to anodic material when the cell is 100% charged. (10)

b) Calculate the standard electrode potential of Cu, if its electrode potential at 25 °C (4)

is 0.296 V and the concentration of $Cu^{2+}$ is 0.015 M.

**O**
**R**

b

)

8 a) Explain the mechanism of electrochemical corrosion of iron in oxygen rich and oxygen deficient acidic and basic environments.

Given below are reduction potentials of some species $MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$; $E^0 = +1.51$ V $Cl_2 + 2e \rightarrow 2Cl^-$ ; $E^0 = +1.36$ V (10)

(4)

$S_2O_8^{2-} + 2e \rightarrow 2SO_4^{2-}$ ; $E^0 = +1.98$ V

Use the above data to examine whether the acids, dil. HCl and dil. $H_2SO_4$ , can be used to provide acid medium in redox titrations involving $KMnO_4$.

**Module 2**

9 a) What is spin-spin splitting? Draw the NMR spectrum of (i) $CH_3 CH_2CH_2$ Br (ii )$CH_3CH(Br)CH_3$ Explain how NMR spectrum can be used to identify the two isomers. (10)

b) A dye solution of concentration 0.08M shows absorbance of 0.012 at 600 nm; while a test solution of same dye shows absorbance of 0.084 under same conditions. Find the concentration of the test solution. (4)

**OR**

10 a) Explain the basic principle of UV-Visible spectroscopy. What are the possible electronic transitions? Explain with examples. (10)

b) Sketch the vibrational modes of $CO_2$ and $H_2O$. Which of them are IR active? (4)

**Module 3**

11 a) Explain the principle, instrumentation and procedure involved in gas chromatography. (10)

b) Explain the DTA of $CaC_2O_4.H_2O$ with a neat sketch. (4)

**OR**

12 a) Explain the various chemical methods used for the synthesis of nanomaterial (10)

b) How TGA is used to analyse the thermal stability of polymers? (4)

**Module 4**

13 a) What are conformers? Draw the *cis* and *trans* isomers of 1, 3-dimethylcylohexane. Which conformer (chair form) is more stable in each case? (10)

b) What is ABS? Give properties and applications. (4)

**OR**

14 a) Explain the various structural isomers with suitable example. (10)

b) What is OLED? Draw a labelled diagram. (4)

**Module 5**

15 a) What are ion exchange resins? Explain ion exchange process for removal of hardness of water? How exhausted resins are regenerated? (10)

b) 50 mL sewage water is diluted to 2000 mL with dilution water; the initial dissolved oxygen was 7.7 ppm. The dissolved oxygen level after 5 days of incubation was 2.4 ppm. Find the BOD of the sewage. (4)

**OR**

16 a) What are the different steps in sewage treatment? Give the flow diagram. Explain the working of trickling filter.

b) Calculate the temporary and permanent hardness of a water sample which contains $[Ca^{2+}]$ = 160 mg/L, $[Mg^{2+}]$ = 192 mg/L and $[HCO_3^-]$ = 122 mg/L.

## Syllabus

### Module 1

### Electrochemistry and Corrosion

Introduction - Differences between electrolytic and electrochemical cells - Daniel cell - redox reactions - cell representation. Different types of electrodes (brief) - Reference electrodes - SHE - Calomel electrode - Glass Electrode - Construction and Working. Single electrode potential - definition - Helmholtz electrical double layer -Determination of $E^0$ using calomel electrode.Determination of pH using glass electrode.Electrochemical series and its applications. Free energy and EMF - Nernst Equation - Derivation - single electrode and cell (Numericals) -Application - Variation of emf with temperature. Potentiometric titration - Introduction -Redox titration only.Lithiumion cell - construction and working.Conductivity- Measurement of conductivity of a solution (Numericals).

Corrosion-Electrochemicalcorrosion – mechanism. Galvanic series- cathodic protection - electroless plating –Copper and Nickel plating.

### Module 2

### Spectroscopic Techniques and Applications

Introduction- Types of spectrum - electromagnetic spectrum - molecular energy levels - Beer Lambert's law (Numericals). UV-Visible Spectroscopy – Principle - Types of electronic transitions - Energy level diagram of ethane, butadiene, benzene and hexatriene. Instrumentation of UV-Visible spectrometer and applications.IR-Spectroscopy – Principle - Number of vibrational modes - Vibrational energy states of a diatomic molecule and -Determination of force constant of diatomic molecule (Numericals) –Applications. $^1$H NMR spectroscopy – Principle - Relation between field strength and frequency - chemical shift - spin-spin splitting (spectral problems ) - coupling constant (definition) - applications of NMR- including MRI (brief).

### Module 3

### Instrumental Methods and Nanomaterials

Thermal analysis –TGA- Principle, instrumentation (block diagram) and applications – TGA of $CaC_2O_4.H_2O$ and polymers. DTA-Principle, instrumentation (block diagram) and applications - DTA of $CaC_2O_4.H_2O$. Chromatographic methods - Basic principles and applications of column and TLC-Retention factor. GC and HPLC-Principle, instrumentation (block diagram) - retention time and applications.

Nanomaterials - Definition - Classification - Chemical methods of preparation - Hydrolysis and Reduction - Applications of nanomaterials - Surface characterisation -SEM – Principle and instrumentation (block diagram).

### Module 4

### Stereochemistry and Polymer Chemistry

Isomerism-Structural, chain, position, functional, tautomerism and matamerism - Definition with examples - Representation of 3D structures-Newman, Sawhorse, Wedge and Fischer projection of substituted methane and ethane. Stereoisomerism - Geometrical isomerism in double bonds and cycloalkanes (cis-trans and E-Z notations). R-S Notation – Rules and examples - Optical isomerism, Chirality, Enantiomers and Diastereoisomers-Definition with examples.Conformational analysis of ethane, butane, cyclohexane, mono and di methyl substituted cyclohexane.

Copolymers - Definition - Types - Random, Alternating, Block and Graft copolymers - ABS - preparation, properties and applications.Kevlar-preparation, properties and applications.Conducting polymers - Doping -Polyaniline and Polypyrrole - preparation properties and applications. OLED - Principle, construction and advantages.

**Module 5**

**Water Chemistry and Sewage Water Treatment**

Water characteristics - Hardness - Types of hardness- Temporary and Permanent - Disadvantages of hard water -Units of hardness- ppm and mg/L -Degree of hardness (Numericals) - Estimation of

hardness-EDTA method (Numericals). Water softening methods-Ion exchange process-Principle, procedure and advantages. Reverse osmosis – principle, process and advantages. Municipal water treatment (brief) - Disinfection methods - chlorination, ozone andUV irradiation.

Dissolved oxygen (DO) -Estimation (only brief procedure-Winkler's method), BOD and COD-definition, estimation (only brief procedure) and significance (Numericals). Sewage water treatment - Primary, Secondary and Tertiary - Flow diagram -Trickling filter and UASB process.

**Text Books**


**1.** B. L. Tembe, Kamaluddin, M. S. Krishnan, "Engineering Chemistry (NPTEL Web-book)",2018.

**2.** P. W. Atkins, "Physical Chemistry", Oxford University Press, 10th edn., 2014.


**Reference Books**


1. C. N. Banwell, "Fundamentals of Molecular Spectroscopy", McGraw-Hill, 4thedn., 1995.
2. Donald L. Pavia, "Introduction to Spectroscopy", Cengage Learning India Pvt. Ltd., 2015.
3. B. R. Puri, L. R. Sharma, M. S. Pathania, "Principles of Physical Chemistry", Vishal PublishingCo., 47th Edition, 2017.
4. H. H. Willard, L. L. Merritt, "Instrumental Methods of Analysis", CBS Publishers, 7th Edition,2005.
5. Ernest L. Eliel, Samuel H. Wilen, "Stereo-chemistry of Organic Compounds", WILEY, 2008.
6. Raymond B. Seymour, Charles E. Carraher, "Polymer Chemistry: An Introduction", MarcelDekker Inc; 4th Revised Edition, 1996.
7. MuhammedArif, Annette Fernandez, Kavitha P. Nair "Engineering Chemistry", Owl Books,2019.
8. Ahad J., "Engineering Chemistry", Jai Publication, 2019.
9. Roy K. Varghese, "Engineering Chemistry", Crownplus Publishers, 2019.
10. Soney C. George,RinoLaly Jose, "Text Book of Engineering Chemistry", S. Chand & CompanyPvt Ltd, 2019.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures (hrs) |
|---|---|---|
| **1** | Electrochemistry and Corrosion | **9** |
| **1.1** | Introduction - Differences between electrolytic and electrochemical cells- Daniel cell - redox reactions - cell representation. Different types of electrodes (brief) - Reference electrodes- SHE - Calomel electrode - Glass Electrode - Construction and Working. | **2** |
| **1.2** | Single electrode potential – definition - Helmholtz electrical double layer - Determination of E0 using calomel electrode. Determination of pH using glass electrode. Electrochemical series and its applications. Free energy and EMF - Nernst Equation – Derivation - single electrode and cell (Numericals) - Application<br>-Variation of emf with temperature. | **3** |
| **1.3** | Potentiometric titration - Introduction -Redox titration only. Lithiumion cell - construction and working. Conductivity- Measurement of conductivity of a solution (Numericals). | **2** |
| **1.4** | Corrosion-Electrochemicalcorrosion – mechanism. Galvanic series- cathodic protection - electroless plating –Copper and Nickel plating. | **2** |
| **2** | Spectroscopic Techniques and Applications | **9** |
| **2.1** | Introduction- Types of spectrum - electromagnetic spectrum - molecular energy levels - Beer Lambert's law (Numericals). | **2** |
| **2.2** | UV-Visible Spectroscopy – Principle - Types of electronic transitions - Energy level diagram of ethane, butadiene, benzene and hexatriene. Instrumentation of UV-Visible spectrometer and applications. | **2** |
| **2.3** | IR-Spectroscopy – Principle - Number of vibrational modes -Vibrational energy states of a diatomic molecule and -Determination of force constant of diatomic molecule (Numericals) –Applications. | **2** |
| **2.4** | 1H NMR spectroscopy – Principle - Relation between field strength and frequency<br>- chemical shift - spin-spin splitting (spectral problems ) - coupling constant (definition) - applications of NMR- including MRI (brief). | **3** |
| **3** | Instrumental Methods and Nanomaterials | **9** |
| **3.1** | Thermal analysis –TGA- Principle, instrumentation (block diagram) and applications – TGA of CaC2O4.H2O and polymers. DTA-Principle, instrumentation (block diagram) and applications - DTA of CaC2O4.H2O. | **2** |
| **3.2** | Chromatographic methods - Basic principles and applications of column and TLC-Retention factor. | **2** |
| **3.3** | GC and HPLC-Principle, instrumentation (block diagram) - retention time and applications. | **2** |

| | | |
|---|---|---|
| **3.4** | Nanomaterials - Definition - Classification - Chemical methods of preparation - Hydrolysis and Reduction - Applications of nanomaterials - Surface characterisation -SEM – Principle and instrumentation (block diagram). | **3** |
| **4** | **Stereochemistry and Polymer Chemistry** | **9** |
| **4.1** | Isomerism-Structural, chain, position, functional, tautomerism and matamerism - Definition with examples - Representation of 3D structures-Newman, Sawhorse, Wedge and Fischer projection of substituted methane and ethane. Stereoisomerism - Geometrical isomerism in double bonds and cycloalkanes (cis-trans and E-Z notations). | **2** |
| **4.2** | R-S Notation – Rules and examples - Optical isomerism, Chirality, Enantiomersand Diastereoisomers-Definition with examples. | **1** |
| **4.3** | Conformational analysis of ethane, butane, cyclohexane, mono and di methyl substituted cyclohexane. | **2** |
| **4.4** | Copolymers - Definition - Types - Random, Alternating, Block and Graft copolymers - ABS - preparation, properties and applications. Kevlar-preparation, properties and applications. Conducting polymers - Doping -Polyaniline and Polypyrrole - preparation properties and applications. OLED - Principle, construction and advantages. | **4** |
| **5** | **Water Chemistry and Sewage Water Treatment** | **9** |
| **5.1** | Water characteristics - Hardness - Types of hardness- Temporary and Permanent - Disadvantages of hard water -Units of hardness- ppm and mg/L -Degree of hardness (Numericals) - Estimation of hardness-EDTA method (Numericals). Water softening methods-Ion exchange process-Principle, procedure and advantages. Reverse osmosis – principle, process and advantages. | **3** |
| **5.2** | Municipal water treatment (brief) - Disinfection methods - chlorination, ozone andUV irradiation. | **2** |
| **5.3** | Dissolved oxygen (DO) -Estimation (only brief procedure-Winkler’s method), BOD and COD-definition, estimation (only brief procedure) and significance (Numericals). | **2** |
| **5.4** | Sewage water treatment - Primary, Secondary and Tertiary - Flow diagram - Trickling filter and UASB process. | **2** |

| 22EST105 | ENGINEERING GRAPHICS | CATEGORY | L | T | P | CREDIT | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | ESC | 2 | 0 | 2 | 3 | 2019 |

**Preamble:** To enable the student to effectively perform technical communication through graphical representation as per global standards.

**Prerequisite:** NIL

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Draw the projection of points and lines located in different quadrants |
| **CO 2** | Prepare multiview orthographic projections of objects by visualizing them in different positions |
| **CO 3** | Draw sectional views and develop surfaces of a given object |
| **CO 4** | Prepare pictorial drawings using the principles of isometric and perspective projections to visualize objects in three dimensions. |
| **CO 5** | Convert 3D views to orthographic views |
| **CO 6** | Obtain multiview projections and solid models of objects using CAD tools |

**Mapping of course outcomes with program outcomes**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** | **PO 11** | **PO 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | | | | | | | | | | |
| **CO 2** | 3 | | | | | | | | | | | |
| **CO 3** | 3 | 1 | | | | | | | | | | |
| **CO 4** | 3 | | | | | | | | | 1 | | |
| **CO 5** | 3 | | | | | | | | | 2 | | |
| **CO 6** | 3 | | | | 3 | | | | | 3 | | |

**<u>Assessment Pattern</u>**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination (100 Marks)** |
|---|---|---|---|
| | **Test 1 ( 15 Marks)** | **Test 2 (15 Marks)** | |
| Remember | | | |
| Understand | 5 | | 20 |
| Apply | 10 | 10 | 80 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE (Marks) | ESE (Marks) | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

CIA for section A carries 25 marks (15 marks for 1 test and Class work 10 marks)CIA for section B carries 15 marks (10 marks for 1 test and Class work 5 marks)

**End Semester Examination Pattern:**

ESE will be of 3 hour duration on A4 size answer booklet and will be for 100 marks. The question paper shall contain two questions from each module of Section A only. Student has to answer any one question from each module. Each question carries 20 marks.

**Course Level Assessment Questions**

(Questions may be framed based on the outline given under each course outcome)

**Course Outcome 1 (CO1):**

1. Locate points in different quadrants as per given conditions.
2. Problems on lines inclined to both planes .
3. Find True length, Inclinations and Traces of lines.

**Course Outcome 2 (CO2)**

1. Draw orthographic views of solids and combination solids
2. Draw views of solids inclined to any one reference plane.
3. Draw views of solids inclined to both reference planes.

**Course Outcome 3 (CO3):**

1. Draw views of solids sectioned by a cutting plane
2. Find location and inclination of cutting plane given true shape of the section
3. Draw development of lateral surface of solids and also its sectioned views

**Course Outcome 4 (CO4):**

1. Draw Isometric views/projections of soilds
2. Draw Isometric views/projections of combination of soilds
3. Draw Perspective views of Soilds

**Course Outcome 5 (CO5):**

1. Draw Orthographic views of solids from given three dimensional view

**Course Outcome 6 (CO6):**

1. Draw the given figure including dimensions using 2D software
2. Create 3D model using modelling software from the given orthographic views or 3D figure or from real 3D objects

**Model Question paper**

**QP CODE:** PAGES:3

Reg No:_______________

Name :_______________

**TKM COLLEGE OF ENGINEERING**

**FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

***Course Code: EST 110***

**ENGINEERING GRAPHICS**

**Max.Marks:100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3**

**MarksInstructions: Retain necessary Construction lines**
**Show necessary dimensions**
**Answer any ONE question from each moduleEach question carries 20 marks**

**MODULE I**

1. The end point A of a line is 20mm above HP and 10mm in front of VP. The other end of the line is 50mm above HP and 15mm behind VP. The distance between the end projectors is 70mm. Draw the projections of the line. Find the true length and true inclinations of the line with the principalplanes. Also locate the traces of the line.
2. One end of a line is 20mm from both the principal planes of projection. The other end of the line is 50mm above HP and 40mm in front of VP. The true length of the line is 70mm. Draw the projections of the line. Find its apparent inclinations, elevation length and plan length. Also locate its traces.

**MODULE II**

3. A pentagonal pyramid of base side 25mm and height 40mm, is resting on the ground on one of its triangular faces. The base edge of that face is inclined 30$^{o}$ to VP. Draw the projections of the solid.

4. A hexagonal prism has side 25mm and height 50mm has a corner of its base on the ground and the long edge containing that corner inclined at 30º to HP and 45º to VP. Draw the projections of the solid.

**MODULE III**

5. A triangular prism of base side 40mm and height 70mm is resting with its base on the ground and having an edge of the base perpendicular to VP. Section the solid such that the true shape of the section is a trapezium of parallel sides 30mm and 10mm. Draw the projections showing the true shape. Find the inclination of the cutting plane with the ground plane.

6. Draw the development of a pentagonal pyramid of base side 30mm and height 50mm. A string is wound from a corner of the base round the pyramid and back to the same point through the shortest distance. Show the position of the string in the elevation and plan.

**MODULE IV**

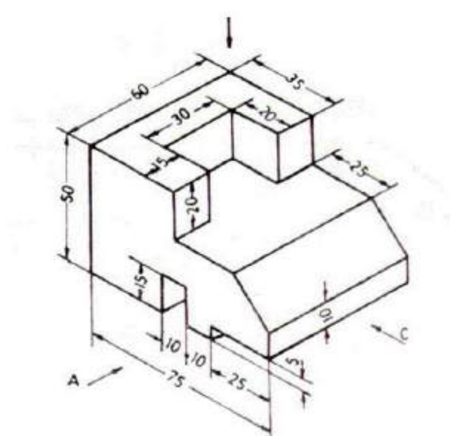
7. The frustum of a cone has base diameter 50mm and top diameter 40mm has a height of 60mm.It is paced centrally on top of a rectangular slab of size 80x60mm and of thickness 20mm. Draw the isometric view of the combination.

8. A hexagonal prism has base side 35mm and height 60mm. A sphere of diameter 40mm is placed centrally on top of it. Draw the isometric projection of the combination.

**MODULE V**

9. Draw the perspective view of a pentagonal prism, 20mm side and 45mm long lying on one of its rectangular faces on the ground and having its axis perpendicular to picture plane. One of its pentagonal faces touches the picture plane and the station point is 50mm in front of PP, 25mm above the ground plane and lies in a central plane, which is 70mm to the left of the center of the prism.

10. Draw three orthographic views with dimensions of the object shown in figure below.



(20X5=100)

**Time : 3 hours** **EST110 ENGINEERING GRAPHICS** **Max. Marks: 100**

## SCHEME OF VALUATION

1. Locating the points and drawing the projections of the line – 4 marks
   Finding true length by any one method – 6 marks
   Finding true inclination with VP – 2
   marksFinding true inclination with HP – 2
   marksLocating horizontal trace – 2
   marks Locating vertical trace – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

2. Locating the points and drawing true length of the line – 4 marks
   Finding projections by any method – 6 marks
   Finding length of elevation and plan – 2 marks
   Finding apparent inclinations – 2 marks
   Locating horizontal trace – 2 marks
   Locating vertical trace – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

3. Drawing initial position plan and elevation – 4 marks
   First inclination views – 4 marks
   Second inclination views -8 marks
   Marking invisible edges – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

   *(Any one method or combination of methods for solving can be used.*
   *If initial position is wrong then maximum 50% marks may be allotted for the answer)*

4. Drawing initial position plan and elevation – 4 marks
   First inclination views – 4 marks
   Second inclination views -8 marks
   Marking invisible edges – 2 marks
   Dimensioning and neatness – 2 marks

   Total = 20 marks

   *(Any one method or combination of methods for solving can be used*
   *If initial position is wrong then maximum 50% marks may be allotted for the answer)*

5. Drawing initial position plan and elevation – 4 marks
   Locating section plane as per given condition – 5 marks
   Drawing true shape -5 marks
   Finding inclination of cutting plane – 2
   marksDimensioning and neatness – 2 marks

   Total = 20 marks

6. Drawing initial position plan and elevation – 4 marks
   Development of the pyramid – 6 marks

Locating string in development -2 marks
Locating string in elevation – 3 marks
Locating string in plan – 3 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

7. Drawing initial positions – 4 marks
Isometric View of Slab -6 marks
Isometric View of Frustum – 10 marksDimensioning and neatness – 2 marks

Total = 20 marks

*(Initial position is optional, hence redistribute if needed.Reduce 4 marks if Isometric scale is taken)*

8. Drawing initial positions – 4 marksIsometric scale – 4 marks
Isometric projection of prism -5 marks
Isometric projection of sphere – 5 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

*(Initial position is optional, hence redistribute if needed.*

9. Drawing the planes and locating the station point – 4 marks
Locating elevation points – 2 marks
Locating plan points – 2 marks
Drawing the perspective view – 10 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

10. Drawing the elevation – 8marks
Drawing the plan – 4 marks
Drawing the side view – 4 marks
Marking invisible edges – 2 marks
Dimensioning and neatness – 2 marks

Total = 20 marks

## SYLLABUS

General Instructions:

- First angle projection to be followed
- Section A practice problems to be performed on A4 size sheets
- Section B classes to be conducted on CAD lab

## SECTION A

**Module 1**

Introduction : Relevance of technical drawing in engineering field. Types of lines, Dimensioning, BIScode of practice for technical drawing.

Orthographic projection of Points and Lines: Projection of points in different quadrants, Projection of straight lines inclined to one plane and inclined to both planes. Trace of line. Inclination of lines with reference planes True length of line inclined to both the reference planes.

**Module 2**

Orthographic projection of Solids: Projection of Simple solids such as Triangular, Rectangle, Square, Pentagonal and Hexagonal Prisms, Pyramids, Cone and Cylinder. Projection of solids in simple position including profile view. Projection of solids with axis inclined to one of the reference planesand with axis inclined to both reference planes.

**Module 3**

Sections of Solids: Sections of Prisms, Pyramids, Cone, Cylinder with axis in vertical position and cutby different section planes. True shape of the sections. Also locating the section plane when the true shape of the section is given.

Development of Surfaces: Development of surfaces of the above solids and solids cut by different section planes. Also finding the shortest distance between two points on the surface.

**Module 4**

Isometric Projection: Isometric View and Projections of Prisms, Pyramids, Cone , Cylinder, Frustum ofPyramid, Frustum of Cone, Sphere, Hemisphere and their combinations.

**Module 5**

Perspective Projection: Perspective projection of Prisms and Pyramids with axis perpendicular to the ground plane, axis perpendicular to picture plane.

Conversion of Pictorial Views: Conversion of pictorial views into orthographic views.

## SECTION B

*(To be conducted in CAD Lab)*

Introduction to Computer Aided Drawing: Role of CAD in design and development of new products, Advantages of CAD. Creating two dimensional drawing with dimensions using suitable software. (Minimum 2 exercises mandatory)

Introduction to Solid Modelling: Creating 3D models of various components using suitable modelling software. (Minimum 2 exercises mandatory)

**Text Books**

1. Bhatt, N.D., Engineering Drawing, Charotar Publishing House Pvt. Ltd.
2. John, K.C. Engineering Graphics, Prentice Hall India Publishers.

**Reference Books**

1. Anilkumar, K.N., Engineering Graphics, Adhyuth narayan Publishers
2. Agrawal, B. And Agrawal, C.M., Engineering Darwing, Tata McGraw Hill Publishers.
3. Benjamin, J., Engineering Graphics, Pentex Publishers- 3rd Edition, 2017
4. Duff, J.M. and Ross, W.A., Engineering Design and Visualisation, Cengage Learning.
5. Kulkarni, D.M., Rastogi, A.P. and Sarkar, A.K., Engineering Graphics with AutoCAD, PHI.
6. Luzaddff, W.J. and Duff, J.M., Fundamentals of Engineering Drawing, PHI.
7. Varghese, P.I., Engineering Graphics, V I P Publishers
8. Venugopal, K., Engineering Drawing and Graphics, New Age International Publishers.

**Course Contents and Lecture Schedule**

| No | **SECTION A** | No. of Hours |
|---|---|---|
| 1 | **MODULE I** | |
| 1.1 | Introduction to graphics, types of lines, Dimensioning | 1 |
| 1.2 | Concept of principle planes of projection, different quadrants, locating pointson different quadrants | 2 |
| 1.3 | Projection of lines, inclined to one plane. Lines inclined to both planes, trapezoid method of solving problems on lines. | 2 |
| 1.4 | Problems on lines using trapezoid method | 2 |
| 1.5 | Line rotation method of solving, problems on line rotation method | 2 |
| 2 | **MODULE II** | |
| 2.1 | Introduction of different solids, Simple position plan and elevation of solids | 2 |
| 2.2 | Problems on views of solids inclined to one plane | 2 |
| 2.3 | Problems on views of solids inclined to both planes | 2 |
| 2.4 | Practice problems on solids inclined to both planes | 2 |

| | | |
|---|---|---|
| 3 | **MODULE III** | |
| 3.1 | Introduction to section planes. AIP and AVP. Principle of locating cuttingpoints and finding true shape | 2 |
| 3.2 | Problems on sections of different solids | 2 |
| 3.3 | Problems when the true shape is given | 2 |
| 3.4 | Principle of development of solids, sectioned solids | 2 |
| 4 | **MODULE IV** | |
| 4.1 | Principle of Isometric View and Projection, Isometric Scale. Problems onsimple solids | 2 |
| 4.2 | Isometric problems on Frustum of solids, Sphere and Hemisphere | 2 |
| 4.3 | Problems on combination of different solids | 2 |
| 5 | **MODULE V** | |
| 5.1 | Introduction to perspective projection, different planes, station point etc. Perspective problems on pyramids | 2 |
| 5.2 | Perspective problems on prisms | 2 |
| 5.3 | Practice on conversion of pictorial views into orthographic views | 2 |
| | **SECTION B** *(To be conducted in CAD lab)* | |
| 1 | Introduction to CAD and software. Familiarising features of 2D software. Practice on making 2D drawings | 2 |
| 2 | Practice session on 2D drafting | 2 |
| 3 | Introduction to solid modelling and software | 2 |
| 4 | Practice session on 3D modelling | 2 |

| 22EST106 | BASICS OF CIVIL & MECHANICAL ENGINEERING | CATEGORY | L | T | P | CREDIT | YEAR OF INTRODUCTION |
|---|---|---|---|---|---|---|---|
| | | ESC | 4 | 0 | 0 | 4 | 2019 |

**Preamble:**

Objective of this course is to provide an insight and inculcate the essentials of Civil Engineering discipline to the students of all branches of Engineering and to provide the students an illustration of the significance of the Civil Engineering Profession in satisfying the societal needs.

To introduce the students to the basic principles of mechanical engineering

**Prerequisite:** NIL

**Course Outcomes:** After completion of the course, the student will be able to

| | |
|---|---|
| **CO 1** | Recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering. |
| **CO 2** | Explain different types of buildings, building components, building materials and building construction |
| **CO 3** | Describe the importance, objectives and principles of surveying. |
| **CO 4** | Summarise the basic infrastructure services MEP, HVAC, elevators, escalators andramps |
| **CO 5** | Discuss the Materials, energy systems, water management and environment for green buildings. |
| **CO 6** | Analyse thermodynamic cycles and calculate its efficiency |
| **CO 7** | Illustrate the working and features of IC Engines |
| **CO 8** | Explain the basic principles of Refrigeration and Air Conditioning |
| **CO 9** | Describe the working of hydraulic machines |
| **CO 10** | Explain the working of power transmission elements |
| **CO 11** | Describe the basic manufacturing, metal joining and machining processes |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | - | - | - | - | 3 | 2 | 2 | - | - | - | - |
| **CO2** | 3 | 2 | - | 1 | 3 | - | - | 3 | - | - | - | - |
| **CO3** | 3 | 2 | - | - | 3 | - | - | - | 2 | - | - | - |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO4** | 3 | 2 | - | - | 3 | - | - | - | 2 | - | - | - |
| **CO5** | 3 | 2 | - | - | 3 | 2 | 3 | - | 2 | - | - | - |
| **CO6** | 3 | 2 | | | | | | | | | | |
| **CO7** | 3 | 1 | | | | | | | | | | |
| **CO8** | 3 | 1 | | | | | | | | | | |
| **CO9** | 3 | 2 | | | | | | | | | | |
| **CO10** | 3 | 1 | | | | | | | | | | |
| **CO11** | 3 | | | | | | | | | | | |

**Assessment Pattern**

| | **Basic Civil Engineering** | | | **Basic Mechanical Engineering** | | |
|---|---|---|---|---|---|---|
| **Bloom's Category** | **Continuous Assessment** | | **End Semester Examination(marks)** | **Continuous Assessment** | | **End Semester Examination (marks)** |
| | **Test 1 marks** | **Test 2 marks** | | **Test 1 marks** | **Test 2 marks** | |
| Remember | 5 | 5 | 10 | 7.5 | 7.5 | 15 |
| Understand | 20 | 20 | 40 | 12.5 | 12.5 | 25 |
| Apply | | | | 5 | 5 | 10 |
| Analyse | | | | | | |
| Evaluate | | | | | | |
| Create | | | | | | |

**Mark distribution**

| **Total Marks** | **CIE (Marks)** | **ESE (Marks)** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:**

There will be two parts; Part I – Basic Civil Engineering and Part II – Basic Mechanical Engineering.Part I and PART II carries 50 marks each. For the end semester examination, part I contain 2 parts -

Part A and Part B. Part A contain 5 questions carrying 4 marks each (not exceeding 2 questions from each module). Part B contains 2 questions from each module out of which one to be answered. Each question carries 10 mark and can have maximum 2 sub-divisions. The pattern for end semester examination for part II is same as that of part I. **However, student should answer both part I and part 2 in separate answer booklets.**

**Course Level Assessment Questions:**

**Course Outcome CO1:** *To recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering.*

1.Explain relevance of Civil engineering in the overall infrastructural development of the country.
Course outcome 2 (CO2) (One question from each module and not more than two)

*Explain different types of buildings, building components, building materials and building construction*

1. Discuss the difference between plinth area and carpet area.

Course outcome 3 (CO3) (One question from each module and not more than two)

*Describe the importance, objectives and principles of surveying.*

1. Explain the importance of surveying in Civil Engineering

Course outcome 4 (CO4) (One question from each module and not more than two)

*Summarise the basic infrastructure services MEP, HVAC, elevators, escalators and ramps*

1. Explain the civil engineering aspects of elevators, escalators and ramps in buildings

Course outcome 5 (CO5) (One question from each module and not more than two)

*Discuss the Materials, energy systems, water management and environment for green buildings.*

1. Discuss the relevance of Green building in society

**Section II** *Answer any 1 full question from each module. Each full question carries 10 marks*

**Course Outcome 1 (CO1**) (Two full question from each module and each question can have maximum 2 sub-divisions)

*To recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering*

**CO Questions**

**1. a** List out the types of building as per occupancy. Explain any two, each in about five sentences.

**b.** Discuss the components of a building with a neat figure.

**2. a.**What are the major disciplines of civil engineering and explain their role in the infrastructural framework.

**b**. Explain the role of NBC, KBR & CRZ norms in building rules and regulations prevailing in ourcountry.

**Course Outcome 2 (CO2) & Course Outcome 3 (CO3) (Two full question from each module andeach question can have maximum 2 sub-divisions)**

*Explain different types of buildings, building components, building materials and building construction & Describe the importance, objectives and principles of surveying.*

**CO Questions**

1. **a.** What are the different kinds of cement available and what is their use.
   **b.** List the properties of good building bricks. Explain any five.
2. a. List and explain any five modern construction materials used for construction.
   **b.** Explain the objectives and principles of surveying

**Course outcome 4 (CO4) & Course outcome 5 (CO5) (Two full question from each module andeach question can have maximum 2 sub-divisions)**

*Summarise the basic infrastructure services MEP, HVAC, elevators, escalators and ramps & Discussthe Materials, energy systems, water management and environment for green buildings.*

**CO Questions**

1. **a**. Draw the elevation and plan of one brick thick wall with English bond
   **b.** Explain the energy systems and water management in Green buildings

2. **a.** Draw neat sketch of the following foundations: (i) Isolated stepped footing; (ii) Cantilever footing; and (iii) Continuous footing.

   **b.** Discuss the civil engineering aspect of MEP and HVAC in a commercial building

**Course Outcome 6 (CO6):**

1. In an air standard Otto cycle the compression ratio is 7 and compression begins at 35ºC, 0.1 MPa. The maximum temperature of the cycle is 1100ºC. Find
   i) Heat supplied per kg of air,
   ii) Work done per kg of air,
   iii) Cycle efficiency
   Take Cp = 1.005 kJ/kgK and Cv=0.718 kJ/kgK
2. A Carnot cycle works with adiabatic compression ratio of 5 and isothermal expansion ratio of 2. The volume of air at the beginning of isothermal expansion is 0.3 $m^3$. If the maximum temperature and pressure is limited to 550K and 21 bar, determine the minimum temperature in the cycle and efficiency of the cycle.
3. In an ideal diesel cycle, the temperature at the beginning and end of compression is 65ºC and 620ºC respectively. The temperature at the beginning and end of the expansion is 1850ºC and 850 ºC. Determine the ideal efficiency of the cycle.

4. Explain the concepts of CRDI and MPFI in IC Engines.

**Course Outcome 7 (CO7)**

1. With the help of a neat sketch explain the working of a 4 stroke SI engine
2. Compare the working of 2 stroke and 4 stroke IC engines
3. Explain the classification of IC Engines.

**Course Outcome 8(CO8):**

1. Explain the working of vapour compression refrigeration system.
2. With the help of suitable sketch explain the working of a split air conditioner.
3. Define: COP, specific humidity, relative humidity and dew point temperature.

**Course Outcome 9 (CO9):**

1. Explain the working of a single stage centrifugal pump with sketches.
2. With the help of a neat sketch, explain the working of a reciprocating pump.
3. A turbine is to operate under a head of 25 m at 200 rpm. The discharge is 9 $m^3/s$. If the overall efficiency of the turbine is 90%. Determine the power developed by the turbine.

**Course Outcome 10 (CO10):**

1. Explain the working of belt drive and gear drive with the help of neat sketches
2. Explain a single plate clutch.
3. Sketch different types of gear trains and explain.

**Course Outcome 11 (CO11):**

1. Describe the operations which can be performed using drilling machine.
2. Explain the functions of runners and risers used in casting.
3. With a neat sketch, explain the working and parts of a lathe.

**Model Question Paper**

**QP CODE**: 22EST106 page:3

Reg No:__________________

Name:_____________________________

**TKM COLLEGE OF ENGINEERING**

**FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

***Course Code: EST 120***

***Course Name: BASICS OF CIVIL AND MECHANICAL ENGINEERING***

Max. Marks: 100 Duration: 3 hours

**Answer both part I and part 2 in separate answer booklets**
**PART I: BASIC CIVIL**

**ENGINEERINGPART A**

(Answer all questions. Each question carries 4 marks)

1. Explain relevance of Civil engineering in the overall infrastructural development of the country.
2. Discuss the difference between plinth area and carpet area.
3. Explain different types of steel with their properties.
4. What are the different kinds of cement available and what is their use?
5. Define bearing capacity of soil.

(5 x 4 = 20)

**Part B**

Answer one full question from each module.

**MODULE I**

6a. List out the types of building as per occupancy. Explain any two, each in about five sentences. (5)

b. Discuss the components of a building with a neat figure. (5)

**OR**

7a. What are the major disciplines of civil engineering and explain their role in the infrastructural framework. (5)

b. Explain the role of NBC, KBR & CRZ norms in building rules and regulations prevailing in ourcountry. (5)

**MODULE II**

8a. What are the different kinds of cement available and what is their use. (5)

b. List the properties of good building bricks. Explain any five. (5)

**OR**

9a. List and explain any five modern construction materials used for construction. (5)

b. Explain the objectives and principles of surveying (5)

**PART II: BASIC MECHANICAL ENGINEERING PART A**

Answer all questions. Each question carries 4 marks

1. Sketch the P-v and T-s diagram of a Carnot cycle and List the processes.
2. Illustrate the working of an epicyclic gear train.
3. Explain cooling and dehumidification processes.
4. Differentiate between soldering and brazing.
5. Explain the principle of Additive manufacturing.

4 x 5 = 20 marks

**Part B**

Answer one full question from each module.

**MODULE I**

6. In an air standard Otto cycle the compression ratio is 7 and compression begins at 35$^o$C, 0.1MPa. The maximum temperature of the cycle is 1100$^o$C. Find

   i) Heat supplied per kg of air,
   ii) Work done per kg of air,
   iii)Cycle efficiency

   Take $C_p$ = 1.005 kJ/kgK and $C_v$=0.718 kJ/kgK 10 marks

**OR**

7. a) Explain the working of a 4 stroke SI engine with neat sketches. 7 marks
   b) Explain the fuel system of a petrol engine. 3 marks

**MODULE II**

8. a) Explain the working of a vapour compression system with help of a block diagram. 7 marks
   b) Define: Specific humidity, relative humidity and dew point temperature. 3 marks

**OR**

9. With the help of a neat sketch, explain the working of a centrifugal pump. 10 marks

**MODULE III**

10. Explain the two high, three high, four high and cluster rolling mills with neat sketches. 10 marks

**OR**

11. a) Describe the arc welding process with a neat sketch. 6 marks
    b) Differentiate between up-milling and down-milling operations. 4 marks

## SYLLABUS

### Module 1

**General Introduction to Civil Engineering:** Relevance of Civil Engineering in the overall infrastructural development of the country. Responsibility of an engineer in ensuring the safety of built environment. Brief introduction to major disciplines of Civil Engineering like Transportation Engineering, Structural Engineering, Geo-technical Engineering, Water Resources Engineering and Environmental Engineering.

**Introduction to buildings:** Types of buildings, selection of site for buildings, components of a residential building and their functions.

**Building rules and regulations:** Relevance of NBC, KBR & CRZ norms (brief discussion only).

**Building area:** Plinth area, built up area, floor area, carpet area and floor area ratio for a building as per KBR.

### Module 2

**Surveying:** Importance, objectives and principles.

**Construction materials,** Conventional construction materials**:** types, properties and uses of building materials: bricks, stones, cement, sand and timber

**Cement concrete:** Constituent materials, properties and types.

Steel: Steel sections and steel reinforcements, types and uses.

**Modern construction materials:-** Architectural glass, ceramics, Plastics, composite materials, thermal and acoustic insulating materials, decorative panels, waterproofing materials. Modern usesof gypsum, pre-fabricated building components (brief discussion only).

### Module 3

**Building Construction:** Foundations: Bearing capacity of soil (definition only), functions of foundations, types – shallow and deep (brief discussion only). Load bearing and framed structures (concept only).

**Brick masonry: -** Header and stretcher bond, English bond & Flemish bond random rubble masonry.

**Roofs and floors: -** Functions, types; flooring materials (brief discussion only).

**Basic infrastructure services:** MEP, HVAC, elevators, escalators and ramps (Civil Engineering aspectsonly), fire safety for buildings.

**Green buildings:-** Materials, energy systems, water management and environment for green buildings. (brief discussion only).

### Module 4

**Analysis of thermodynamic cycles:** Carnot, Otto, Diesel cycles, Derivation of efficiency of these cycles, Problems to calculate heat added, heat rejected, net work and efficiency. IC Engines: CI, SI, 2- Stroke, 4-Stroke engines. Listing the parts of different types of IC Engines. Efficiencies of IC Engines(Definitions only), Air, Fuel, cooling and lubricating systems in SI and CI Engines, CRDI, MPFI.Concept of hybrid engines.

**Module 5**

**Refrigeration:** Unit of refrigeration, reversed Carnot cycle,COP, vapour compression cycle (only description and no problems); Definitions of dry, wet & dew point temperatures, specific humidity and relative humidity, Cooling and dehumidification, Layout of unit and central air conditioners.
Description about working with sketches of: Reciprocating pump, Centrifugal pump, Pelton turbine, Francis turbine and Kaplan turbine. Overall efficiency, Problems on calculation of input and output power of pumps and turbines (No velocity triangles)
Description about working with sketches of: Belt and Chain drives, Gear and Gear trains, Single plate clutches.

**Module 6**

**Manufacturing Process:** Basic description of the manufacturing processes – Sand Casting, Forging, Rolling, Extrusion and their applications.
Metal Joining Processes: List types of welding, Description with sketches of Arc Welding, Soldering and Brazing and their applications
Basic Machining operations: Turning, Drilling, Milling and Grinding.
Description about working with block diagram of: Lathe, Drilling machine, Milling machine, CNC Machine. Principle of CAD/CAM, Rapid and Additive manufacturing.

**Text Books:**

1. Rangwala, S. C., Essentials of Civil Engineering, Charotar Publishing House
2. Mckay, W.B. and Mckay, J. K., Building Construction, Volumes 1 to 4, Pearson IndiaEducation Services

**References Books:**

1. Chen W.F and Liew J Y R (Eds), The Civil Engineering Handbook. II Edition CRC Press (Taylorand Francis)
2. Chudley, R and Greeno R, Building construction handbook, Addison Wesley, Longman group,England
3. Chudley, R, Construction Technology, Vol. I to IV, Longman group, England Course Plan
4. Kandya A A, Elements of Civil Engineering, Charotar Publishing house
5. Mamlouk, M. S., and Zaniewski, J. P., Materials for Civil and Construction Engineering, PearsonPublishers
6. Rangwala S.C and Dalal K B Building Construction Charotar Publishing house
7. Clifford, M., Simmons, K. and Shipway, P., An Introduction to Mechanical Engineering Part I -CRC Press
8. Roy and Choudhary, Elements of Mechanical Engineering, Media Promoters &Publishers Pvt.Ltd., Mumbai.
9. Sawhney, G. S., Fundamentals of Mechanical Engineering, PHI
10. G Shanmugam, M S Palanichamy, Basic Civil and Mechanical Engineering, McGraw HillEducation; First edition, 2018
11. Benjamin,J.,Basic Mechanical Engineering,Pentex Books,9th Edition,2018
12. Balachandran, P.Basic Mechanical Engineering,Owl Books

**Course Contents and Lecture Schedule:**

| No | Topic | Course outcomes addressed | No. of Lectures |
|---|---|---|---|
| **1** | **Module I** | | **Total: 7** |
| 1.1 | *General Introduction to Civil Engineering*: Relevance of Civil Engineering in the overall infrastructural development of the country. Responsibility of an engineer in ensuring the safety of built environment. | CO1 | 1 |
| 1.2 | Brief introduction to major disciplines of Civil Engineering like Transportation Engineering, Structural Engineering, Geo-technical Engineering, Water Resources Engineering and Environmental Engineering. | CO1 | 2 |
| 1.3 | *Introduction to buildings:* Types of buildings, selection of site forbuildings, components of a residential building and their functions. | CO2 | 2 |
| 1.4 | *Building rules and regulations:* Relevance of NBC, KBR & CRZ norms(brief discussion only) | CO2 | 1 |
| 1.5 | *Building area:* Plinth area, built up area, floor area, carpet area and floor area ratio for a building as per KBR. | CO2 | 1 |
| **2** | **Module 2** | | **Total: 7** |
| 2.1 | *Surveying:* Importance, objectives and principles. | CO3 | 1 |
| 2.2 | Bricks: - Classification, properties of good bricks, and tests on bricks | CO2 | 1 |
| 2.3 | Stones: - *Qualities* of good stones, types of stones and their uses.<br>Cement: - Good qualities of cement, types of cement and their uses. | CO2 | 1 |
| 2.4 | Sand: - Classification, qualities of good sand and sieve analysis(basics only).<br>Timber: - Characteristics, properties and uses. | CO2 | 1 |
| 2.5 | Cement concrete: - Constituent materials, properties and types,<br>Steel: - Steel sections and steel reinforcements, types and uses. | CO2 | 1 |
| 2.6 | Modern construction materials: - Architectural glass, ceramics, plastics, composite materials, thermal and acoustic insulating materials, decorative panels, waterproofing materials, modern uses of gypsum, pre-fabricated building components (brief discussion only) | CO2 | 2 |

| | | | |
|---|---|---|---|
| **3** | **Module 3** | | **Total: 7** |
| 3.1 | Foundations: - Bearing capacity of soil (definition only), functions of foundations, types – shallow and deep (brief discussion only).<br>Brick masonry: - Header and stretcher bond, English bond & Flemish bond– elevation and plan (one & one and a half brick wall only).<br>Random rubble masonry. | CO2 | 2 |
| 3.2 | Roofs: Functions, types; roofing materials (brief discussion only)<br>Floors: Functions, types; flooring materials (brief discussion only) | CO2 | 2 |
| 3.3 | *Basic infrastructure services:* MEP, HVAC, Elevators, escalators andramps (Civil Engineering aspects only) fire safety for buildings | CO4 | 2 |
| 3.4 | *Green buildings:*- Materials, energy systems, water management and environment for green buildings. (brief discussion only) | CO5 | 1 |
| 4 | **MODULE 4** | | |
| 4.1 | Analysis of thermodynamic cycles: Carnot, Otto, and Diesel cycle- Derivation of efficiency of these cycles, Problems to calculate heat added, heat rejected, net work and efficiency | 4 | |
| 4.2 | IC Engines: CI, SI, 2-Stroke, 4-Stroke engines. Listing the parts of different types of IC Engines, efficiencies of IC Engines(Description only) | 2 | |
| 4.3 | Air, Fuel, cooling and lubricating systems in SI and CI Engines, CRDI,MPFI. Concept of hybrid engines | 2 | |
| 5 | **MODULE 5** | | |
| 5.1 | Refrigeration: Unit of refrigeration, reversed Carnot cycle, COP, vapourcompression cycle (only description and no problems) | 1 | |
| 5.2 | Definitions of dry, wet & dew point temperatures, specific humidity and relative humidity, Cooling and dehumidification, Layout of unit and central air conditioners. | 1 | |

| | | |
|---|---|---|
| 5.3 | Description about working with sketches : Reciprocating pump, Centrifugal pump, Pelton turbine, Francis turbine and Kaplan turbine. Overall efficiency, Problems on calculation of input and output power of pumps and turbines (No velocity triangles) | 4 |
| 5.4 | Description about working with sketches of: Belt and Chain drives, Gear and Gear trains, Single plate clutches | 3 |
| 6 | **MODULE 6** | |
| 6.1 | Manufacturing Process: Basic description of the manufacturing processes – Sand Casting, Forging, Rolling, Extrusion and their applications. | 2 |
| 6.2 | Metal Joining Processes :List types of welding, Description with sketches of Arc Welding, Soldering and Brazing, and their applications | 1 |
| 6.3 | Basic Machining operations: Turning, Drilling, Milling and Grinding<br><br>Description about working with block diagrams of: Lathe, Drilling machine, Milling machine, CNC Machine | 3 |
| 6.4 | Principle of CAD/CAM, Rapid and Additive manufacturing | 1 |

| 22MNC108 | LIFE SKILLS | CATEGORY | L | T | P | CREDIT | YEAR OF INTRODUCTION |
|---|---|---|---|---|---|---|---|
| | | MNC | 2 | 0 | 2 | --- | 2019 |

**Preamble:** Life skills are those competencies that provide the means for an individual to be resourceful and positive while taking on life's vicissitudes. Development of one's personality by being aware of the self, connecting with others, reflecting on the abstract and the concrete, leading and generating change, and staying rooted in time-tested values and principles is being aimed at. This course is designed to enhance the employability and maximize the potential of the students by introducing them to the principles that underly personal and professional success, and help them acquire the skills needed to apply these principles in their lives and careers.

**Prerequisite:** None

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Define and Identify different life skills required in personal and professional life |
| **CO 2** | Develop an awareness of the self and apply well-defined techniques to cope with emotions and stress. |
| **CO 3** | Explain the basic mechanics of effective communication and demonstrate these through presentations. |
| **CO 4** | Take part in group discussions |
| **CO 5** | Use appropriate thinking and problem solving techniques to solve new problems |
| **CO 6** | Understand the basics of teamwork and leadership |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | | | | | | 2 | | 1 | 2 | 2 | 1 | 3 |
| **CO 2** | | | | | | | | | 3 | | | 2 |
| **CO 3** | | | | | | 1 | | | 1 | 3 | | |
| **CO 4** | | | | | | | | | | 3 | | 1 |
| **CO 5** | | 3 | 2 | 1 | | | | | | | | |
| **CO 6** | | | | | | 1 | | | 3 | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 50 | 50 | 2 hours |

**Continuous Internal**
**EvaluationTotal Marks: 50**

| | |
|---|---|
| Attendance | : 10 marks |
| Regular assessment | : 15 marks |
| Series test (one test only, should include first three modules) | : 25 marks |

**Regular assessment**

- Group Discussion (Marks: 9)

  Create groups of about 6 students each and engage them on a GD on a suitable topic for about 20 minutes. Parameters to be used for evaluation are as follows:

  - Communication Skills : 3 marks
  - Subject Clarity : 2 marks
  - Group Dynamics : 2 marks
  - Behaviours & Mannerisms : 2 marks

- Presentation Skills (Marks: 6)

  Identify a suitable topic and ask the students to prepare a presentation (preferably a power point presentation) for about 10 minutes. Parameters to be used for evaluation are as follows:

  - Communication Skills : 2 marks
  - Platform Skills : 2 marks
  - Subject Clarity/Knowledge : 2 marks

**End Semester Examination**
**Total Marks: 50** **Time: 2 hrs.**

**Part A: Short answer question (25 marks)**
There will be one question from each MODULE (five questions in total, five marks each). Each question should be written in about maximum of 400 words. Parameters to be used for evaluation are as follows:
(i) Content Clarity/Subject Knowledge
(ii) Presentation style
(iii) Organization of content

**Part B: Case Study (25 marks)**
The students will be given a case study with questions at the end. The students have to analyze thecase and answer the question at the end. Parameters to be used for evaluation are as follows:
(i) Analyze the case situation
(ii) Key players/characters of the case
(iii) Identification of the problem (both major & minor if exists)
(iv) Bring out alternatives
(v) Analyze each alternative against the problem
(vi) Choose the best alternative
(vii) Implement as solution
(viii) Conclusion

(ix) Answer the question at the end of the case

**Course Level Assessment**

**QuestionsCourse Outcome 1**

**(CO1):**

1. List 'life skills' as identified by WHO
2. What do you mean by effective communication?
3. What are the essential life skills required by a professional?

**Course Outcome 2 (CO2)**

1. Identify an effective means to deal with workplace stress.
2. How can a student apply journaling to stress management?
3. What is the PATH method? Describe a situation where this method can be used effectively.

**Course Outcome 3(CO3):**

1. Identify the communication network structure that can be observed in the given situations. Describe them.

   (a) A group discussion on development.

   (b) An address from the Principal regarding punctuality.

   (c) A reporter interviewing a movie star.

   (d) Discussing the answers of a test with a group of friends.

2. Elucidate the importance of non-verbal communication in making a presentation
3. Differentiate between kinesics, proxemics, and chronemics with examples.

**Course Outcome 4 (CO4):**

1. How can a participant conclude a group discussion effectively?
2. 'Listening skills are essential for effectively participating in a group discussion.' Do you agree? Substantiate your answer.

**Course Outcome 5 (CO5):**

1. Illustrate the creative thinking process with the help of a suitable example
2. Translate the following problem from verbal to graphic form and find the solution : *In a quiz, Ananth has 50 points more than Bimal, Chinmay has 60 points less than Ananth, and Dharini is 20 points ahead of Chinmay. What is the difference in points between Bimal and Dharini?*

3. List at least five ways in which the problem "How to increase profit?" can be redefined

**Course Outcome 6 (CO6):**

1. A group of engineers decided to brainstorm a design issue on a new product. Since no one wanted to disagree with the senior members, new ideas were not flowing freely. What group dynamics technique would you suggest to avoid this 'groupthink'? Explain the procedure.

2. “A group focuses on individual contribution, while a team must focus on synergy.” Explain.

3. Identify the type of group formed / constituted in each of the given situations

   a) A Police Inspector with subordinates reporting to him

   b) An enquiry committee constituted to investigate a specific incident

   c) The Accounts Department of a company

   d) A group of book lovers who meet to talk about reading

**Syllabus**

**Module 1**

Overview of Life Skills: Meaning and significance of life skills, Life skills identified by WHO: Self-awareness, Empathy, Critical thinking, Creative thinking, Decision making, problem solving, Effective communication, interpersonal relationship, coping with stress, coping with emotion.

Life skills for professionals: positive thinking, right attitude, attention to detail, having the big picture, learning skills, research skills, perseverance, setting goals and achieving them, helping others, leadership, motivation, self-motivation, and motivating others, personality development, IQ, EQ, and SQ

**Module 2**

Self-awareness: definition, need for self-awareness; Coping With Stress and Emotions, Human Values, tools and techniques of SA: questionnaires, journaling, reflective questions, meditation, mindfulness, psychometric tests, feedback.

Stress Management: Stress, reasons and effects, identifying stress, stress diaries, the four A's of stress management, techniques, Approaches: action-oriented, emotion-oriented, acceptance- oriented, resilience, Gratitude Training,

Coping with emotions: Identifying and managing emotions, harmful ways of dealing with emotions, PATH method and relaxation techniques.

Morals, Values and Ethics: Integrity, Civic Virtue, Respect for Others, Living Peacefully. Caring, Sharing, Honesty, Courage, Valuing Time, Time management, Co operation, Commitment, Empathy, Self-Confidence, Character, Spirituality, Avoiding Procrastination, Sense of Engineering Ethics.

**Module 3**

21st century skills: Creativity, Critical Thinking, Collaboration, Problem Solving, Decision Making, Need for Creativity in the 21st century, Imagination, Intuition, Experience, Sources of Creativity, Lateral Thinking, Myths of creativity, Critical thinking Vs Creative thinking, Functions of Left Brain &Right brain, Convergent & Divergent Thinking, Critical reading & Multiple Intelligence.

Steps in problem solving: Problem Solving Techniques, Six Thinking Hats, Mind Mapping, Forced Connections. Analytical Thinking, Numeric, symbolic, and graphic reasoning. Scientific temperament and Logical thinking.

**Module 4**

Group and Team Dynamics: Introduction to Groups: Composition, formation, Cycle, thinking, Clarifying expectations, Problem Solving, Consensus, Dynamics techniques, Group vs Team, Team Dynamics, Virtual Teams. Managing team performance and managing conflicts, Intrapreneurship.

**Module 5**

Leadership: Leadership framework, entrepreneurial and moral leadership, vision, cultural dimensions. Growing as a leader, turnaround leadership, managing diverse stakeholders, crisis management. Types of Leadership, Traits, Styles, VUCA Leadership, Levels of Leadership, Transactional vs Transformational Leaders, Leadership Grid, Effective Leaders.

**Lab Activities Verbal**

Effective communication and Presentation skills.
Different kinds of communication; Flow of communication; Communication networks, Types of barriers; Miscommunication
Introduction to presentations and group discussions.
Learning styles: visual, aural, verbal, kinaesthetic, logical, social, solitary; Previewing, KWL table, active listening, REAP method
Note-taking skills: outlining, non-linear note-taking methods, Cornell notes, three column note taking.
Memory techniques: mnemonics, association, flashcards, keywords, outlines, spider diagrams andmind maps, spaced repetition.
Time management: auditing, identifying time wasters, managing distractions, calendars andchecklists; Prioritizing - Goal setting, SMART goals; Productivity tools and apps, Pomodoro technique.

**Non Verbal:**
Non-verbal Communication and Body Language: Forms of non-verbal communication; Interpreting body-language cues; Kinesics; Proxemics; Chronemics; Effective use of body language, Communication in a multi cultural environment.

**Reference Books**


1. Shiv Khera, You Can Win, Macmillan Books, New York, 2003.
2. Barun K. Mitra, “Personality Development & Soft Skills”, Oxford Publishers, Third impression,2017.
3. ICT Academy of Kerala, "Life Skills for Engineers", McGraw Hill Education (India) Private Ltd.,2016.
4. Caruso, D. R. and Salovey P, “The Emotionally Intelligent Manager: How to Develop and Use the Four Key Emotional Skills of Leadership”, John Wiley & Sons, 2004.
5. Kalyana, “Soft Skill for Managers”; First Edition; Wiley Publishing Ltd, 2015.
6. Larry James, “The First Book of Life Skills”; First Edition, Embassy Books, 2016.
7. Shalini Verma, “Development of Life Skills and Professional Practice”; First Edition; SultanChand (G/L) & Company, 2014.
8. Daniel Goleman, "Emotional Intelligence"; Bantam, 2006.
9. Remesh S., Vishnu R.G., "Life Skills for Engineers", Ridhima Publications, First Edition, 2016.
10. Butterfield Jeff, “Soft Skills for Everyone”, Cengage Learning India Pvt Ltd; 1 edition, 2011.
11. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India; 6 edition, 2015.
12. The Ace of Soft Skills: Attitude, Communication and Etiquette for Success, Pearson Education; 1 edition, 2013.

| 22CYL110 | ENGINEERING CHEMISTRY LAB | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | BSC | 0 | 0 | 2 | 1 |

**Preamble:** To impart scientific approach and to familiarize with the experiments in chemistry relevant for research projects in higher semesters

**Prerequisite:** Experiments in chemistry introduced at the plus two levels in schools

**Course outcomes:** After the completion of the course the students will be able to

| | |
|---|---|
| **CO 1** | Understand and practice different techniques of quantitative chemical analysis to generate experimental skills and apply these skills to various analyses |
| **CO 2** | Develop skills relevant to synthesize organic polymers and acquire the practical skill to use TLC for the identification of drugs |
| **CO 3** | Develop the ability to understand and explain the use of modern spectroscopic techniques for analysing and interpreting the IR spectra and NMR spectra of some organic compounds |
| **CO 4** | Acquire the ability to understand, explain and use instrumental techniques for chemical analysis |
| **CO 5** | Learn to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments |
| **CO 6** | Function as a member of a team, communicate effectively and engage in further learning. Also understand how chemistry addresses social, economical and environmental problems and why it is an integral part of curriculum |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | | | 2 | | | | | | | 3 |
| **CO 2** | 3 | | | | 3 | | | | | | | 3 |
| **CO 3** | 3 | | | | 3 | | | | | | | 3 |
| **CO 4** | 3 | | | | 3 | | | | | | | 3 |
| **CO 5** | 3 | | | | 1 | | | | | | | 3 |
| **CO 6** | 3 | | | | 1 | | | | | | | 3 |

**Mark distribution**

| Total Marks | CIE marks | ESE marks | ESE Duration(Internal) |
|---|---|---|---|
| 100 | 100 | - | 1 hour |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 20 marks |
| Class work/ Assessment /Viva-voce | : 50 marks |
| End semester examination (Internally by college) | : 30 marks |

**End Semester Examination Pattern:** Written Objective Examination of one hour

## SYLLABUS

## LIST OF EXPERIMENTS (MINIMUM 8 MANDATORY)

1. Estimation of total hardness of water-EDTA method
2. Potentiometric titration
3. Determination of cell constant and conductance of solutions.
4. Calibration of pH meter and determination of pH of a solution
5. Estimation of chloride in water
6. Identification of drugs using TLC
7. Determination of wavelength of absorption maximum and colorimetric estimation of $Fe^{3+}$ in solution
8. Determination of molar absorptivity of a compound ($KMnO_4$ or any water soluble food colorant)
9. Synthesis of polymers (a) Urea-formaldehyde resin (b) Phenol-formaldehyde resin
10. Estimation of iron in iron ore
11. Estimation of copper in brass
12. Estimation of dissolved oxygen by Winkler's method
13. (a) Analysis of IR spectra (minimum 3 spectra) (b) Analysis of $^{1}H$ NMR spectra ( minimum 3 spectra)
14. Flame photometric estimation of $Na^{+}$ to find out the salinity in sand
15. Determination of acid value of a vegetable oil
16. Determination of saponification of a vegetable oil

**Reference Books**


1. G. Svehla, B. Sivasankar, “Vogel's Qualitative Inorganic Analysis”, Pearson, 2012.

2. R. K. Mohapatra, “Engineering Chemistry with Laboratory Experiments”, PHI Learning, 2017.

3. Muhammed Arif, “Engineering Chemistry Lab Manual”, Owl publishers, 2019.

4. Ahad J., “Engineering Chemistry Lab manual”, Jai Publications, 2019.

5. Roy K Varghese, “Engineering Chemistry Laboratory Manual”, Crownplus Publishers, 2019.

6. Soney C George, Rino Laly Jose, “Lab Manual of Engineering Chemistry”, S. Chand & Company Pvt Ltd, New Delhi, 2019.

| 22ESL111 | CIVIL & MECHANICAL WORKSHOP | CATEGORY | L | T | P | CREDIT | YEAR OF INTRODUCTION |
|---|---|---|---|---|---|---|---|
| | | | 0 | 0 | 2 | 1 | 2019 |

**Preamble:** The course is designed to train the students to identify and manage the tools, materials and methods required to execute an engineering project. Students will be introduced to a team working environment where they develop the necessary skills for planning, preparing and executing an engineering project.

To enable the student to familiarize various tools, measuring devices, practices and different methods of manufacturing processes employed in industry for fabricating components.

**Prerequisite:** None

**Course Outcomes:** After the completion of the course the student will be able to:

| Course Outcome | Course Outcome Description |
|---|---|
| **CO 1** | Name different devices and tools used for civil engineering measurements |
| **CO 2** | Explain the use of various tools and devices for various field measurements |
| **CO 3** | Demonstrate the steps involved in basic civil engineering activities like plot measurement, setting out operation, evaluating the natural profile of land, plumbing and undertaking simple construction work. |
| **CO 4** | Choose materials and methods required for basic civil engineering activities like field measurements, masonry work and plumbing. |
| **CO 5** | Compare different techniques and devices used in civil engineering measurements |
| **CO 6** | Identify Basic Mechanical workshop operations in accordance with the material and objects |
| **CO 7** | Apply appropriate Tools and Instruments with respect to the mechanical workshop trades |
| **CO 8** | Apply appropriate safety measures with respect to the mechanical workshop trades |

**Mapping of course outcomes with program outcomes:**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 1 | - | - | - | 1 | 1 | - | - | 2 | 2 | - | - |
| **CO 2** | 1 | - | - | - | 1 | 1 | - | - | 2 | 2 | - | - |
| **CO 3** | 1 | - | - | - | 1 | 1 | - | 2 | 2 | 2 | 1 | - |
| **CO 4** | 1 | - | - | - | 1 | 1 | - | 2 | 2 | 2 | 1 | 1 |
| **CO 5** | 1 | - | - | - | 1 | 1 | - | - | 2 | 2 | | 1 |
| **CO 6** | 2 | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 7** | 2 | | | | | | | | | | | |
| **CO 8** | 2 | | | | | | | | | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 70 | 30 | 1 hour |

**Assessment Procedure**: Total marks allotted for the course is 100 marks. CIE shall be conducted for 70 marks and ESE for 30 marks. CIE should be done for the work done by the student and also viva voce based on the work done on each practical session. ESE shall be evaluated by written examination of one hour duration conducted internally by the institute.

**Continuous Internal Evaluation Pattern:**

Attendance : 20 marks
Class work/ Assessment /Viva-voce : 50 marks
End semester examination (Internally by college) : 30 marks

**End Semester Examination Pattern:** Written Objective Examination of one hour

**SYLLABUSPART 1**

**CIVIL WORKSHOP**

Exercise 1. Calculate the area of a built-up space and a small parcel of land- Use standardmeasuring tape and digital distance measuring devices

Exercise 2. (a) Use screw gauge and vernier calliper to measure the diameter of a steel rod andthickness of a flat bar

(b) Transfer the level from one point to another using a water level

(c) Set out a one room building with a given plan and measuring tape

Exercise 3. Find the level difference between any two points using dumpy level

Exercise 5. (a) Introduce the students to plumbing tools, different types of pipes, type ofconnections, traps, valves ,fixtures and sanitary fittings.

(b) Install a small rainwater harvesting installation in the campus

**Reference Books:**


1. Khanna P.N, "Indian Practical Civil Engineering Handbook", Engineers Publishers.
2. Bhavikatti. S, "Surveying and Levelling (Volume 1)", I.K. International Publishing House
3. Arora S.P and Bindra S.P, " Building Construction", Dhanpat Rai Publications
4. S. C. Rangwala, "Engineering Materials," Charotar Publishing House.


**PART II MECHANICAL**

**WORKSHOP**

**LIST OF EXERCISES**

(Minimum EIGHT units mandatory and FIVE models from Units 2 to 8 mandatory)

UNIT 1:- General : Introduction to workshop practice, Safety precautions, Shop floor ethics, Basic First Aid knowledge.
Study of mechanical tools, components and their applications: (a) Tools: screw drivers, spanners, Allen keys, cutting pliers etc and accessories (b) bearings, seals, O-rings, circlips,keys etc.

UNIT 2:- Carpentry : Understanding of carpentry tools
Minimum any one model
1. T –Lap joint 2. Cross lap joint 3. Dovetail joint 4. Mortise joints

UNIT 3:- Foundry : Understanding of foundry tools
Minimum any one model
1. Bench Molding 2. Floor Molding 3. Core making 4. Pattern making

UNIT 4: - Sheet Metal : Understanding of sheet metal working tools
Minimum any one model
1. Cylindrical shape
2. Conical shape
3. Prismatic shaped job from sheet

metalUNIT 5: - Fitting : Understanding of tools used for fitting

Minimum any one model

1. Square Joint
2. V- Joint
3. Male and female fitting

UNIT 6: - Plumbing : Understanding of plumbing tools, pipe joints

Any one exercise on joining of pipes making use of minimum three types of pipe joints

UNIT 7: - Smithy: Understanding of tools used for smithy.

Demonstrating the forge-ability of different materials (MS, Al, alloy steel and cast steels)in cold and hot states.

Observing the qualitative difference in the hardness of these materialsMinimum any one exercise on smithy

1. Square prism
2. Hexagonal headed bolt
3. Hexagonal prism
4. Octagonal prism

UNIT 8: -Welding: Understanding of welding equipments

Minimum any one welding practice

Making Joints using electric arc welding. bead formation in horizontal, verticaland over head positions

UNIT 9: - Assembly: Demonstration only

Dissembling and assembling of

1. Cylinder and piston assembly
2. Tail stock assembly
3. Bicycle
4. Pump or any other machine

UNIT 10: - Machines: Demonstration and applications of the following machines

Shaping and slotting machine; Milling machine; Grinding Machine; Lathe; DrillingMachine.

UNIT 11: - Modern manufacturing methods: Power tools, CNC machine tools, 3D printing, Glass cutting.

**Course Contents and Lecture Schedule:**

| No | Topic | No of Sessions |
|---|---|---|
| 1 | **INTRODUCTION** | |
| 1.1 | Workshop practice, shop floor precautions, ethics and First Aid knowledge.<br><br>Studies of mechanical tools, components and their applications: (a) Tools: screw drivers, spanners, Allen keys, cutting pliers etc and accessories (b) bearings, seals, O-rings, circlips, keys etc | 1 |
| 2 | **CARPENTRY** | |

| | | |
|---|---|---|
| 2.1 | Understanding of carpentry tools and making minimum one model | 2 |
| 3 | **FOUNDRY** | |
| 3.1 | Understanding of foundry tools and making minimum one model | 2 |
| 4 | **SHEET METAL** | |
| 4.1 | Understanding of sheet metal working tools and making minimum one model | 2 |
| 5 | **FITTING** | |
| 5.1 | Understanding of fitting tools and making minimum one model | 2 |
| 6 | **PLUMBING** | |
| 6.1 | Understanding of pipe joints and plumbing tools and making minimum one model | 2 |
| 7 | **SMITHY** | |
| 7.1 | Understanding of smithy tools and making minimum one model | 2 |
| 8 | **WELDING** | |
| 8.1 | Understanding of welding equipments and making minimum one model | 2 |
| 9 | **ASSEMBLY** | |
| 9.1 | Demonstration of assembly and dissembling of multiple parts components | 1 |
| 10 | **MACHINES** | |
| 10.1 | Demonstration of various machines | 1 |
| 11 | **MODERN MANUFACTURING METHODS** | |
| 11.1 | Demonstrations of: power tools, CNC Machine tools, 3D printing,Glass cutting | 1 |

# SEMESTER II

| 22MAT 201 | VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS | CATEGORY | L | T | P | CREDIT | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | BSC | 3 | 1 | 0 | 4 | 2019 |

**Preamble:** This course introduces the concepts and applications of differentiation and integration of vector valued functions, differential equations, Laplace and Fourier Transforms. The objective of this course is to familiarize the prospective engineers with some advanced concepts and methods in Mathematics which include the Calculus of vector valued functions, ordinary differential equations and basic transforms such as Laplace and Fourier Transforms which are invaluable for any engineer's mathematical tool box. The topics treated in this course have applications in all branches of engineering.

**Prerequisite**: Calculus of single and multi variable functions.

**Course Outcomes**: After the completion of the course the student will be able to

| | |
|---|---|
| CO 1 | Compute the derivatives and line integrals of vector functions and learn their applications |
| CO 2 | Evaluate surface and volume integrals and learn their inter-relations and applications. |
| CO 3 | Solve homogeneous and non-homogeneous linear differential equation with constant coefficients |
| CO 4 | Compute Laplace transform and apply them to solve ODEs arising in engineering |
| CO 5 | Determine the Fourier transforms of functions and apply them to solve problems arising in engineering |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 3 | 3 | 3 | 2 | 1 | | | 1 | 2 | | 2 |
| CO 2 | 3 | 3 | 3 | 3 | 2 | 1 | | | 1 | 2 | | 2 |
| CO 3 | 3 | 3 | 3 | 3 | 2 | 1 | | | 1 | 2 | | 2 |
| CO 4 | 3 | 3 | 3 | 3 | 2 | 1 | | | 1 | 2 | | 2 |
| CO 5 | 3 | 3 | 3 | 3 | 2 | 1 | | | 1 | 2 | | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination (Marks) |
|---|---|---|---|
| | Test 1 (Marks | Test 2 (Marks) | |
| Remember | 10 | 10 | 20 |
| Understand | 20 | 20 | 40 |
| Apply | 20 | 20 | 40 |
| Analyse | | | |
| Evaluate | | | |

| | | | |
|---|---|---|---|
| Create | | | |

**Mark distribution**

| **Total Marks** | **CIE** (Marks) | **ESE** (Marks) | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks
**Assignments:** Assignment should include specific problems highlighting the applications of the methods introduced in this course in science and engineering.

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):** Compute the derivatives and line integrals of vector functions and learn their applications

1. How would you calculate the speed, velocity and acceleration at any instant of a particle moving in space whose position vector at time $t$is $\boldsymbol{r}(t)$?

2. Find the work done by the force field $F = (e^x - y^3)\boldsymbol{i} + (\cos y + x^3)$on a particle that travels once around the unit circle centred at origin having radius 1.

3. When do you say that a vector field is conservative? What are the implications if a vector field is conservative?

**Course Outcome 2 (CO2):** Evaluate surface and volume integrals and learn their inter-relations and applications

1. Write any one application each of line integral, double integral and surface integral.

2. Use the divergence theorem to find the outward flux of the vector field $F(x, y, z) = z\boldsymbol{k}$across the

$$x^2 + y^2 + z^2 = a^2$$

3. State Greens theorem. Use Green's theorem to express the area of a plane region bounded by a curve as a line integral.

**Course Outcome 3 (CO3):** Solve homogeneous and non-homogeneous linear differential equation with constant coefficients

1. If $y_1(x)$ and $y_2(x)$ are solutions of $y'' + py' + qy = 0$, where $p, q$ are constants, show that

   $y_1(x) + y_2(x)$ is also a solution.

2. Solve the differential equation $y'' + y = 0.001x^2$ using method of undetermined coefficient.

3. Solve the differential equation of $y''' - 3y'' + 3y' - y = e^x - x - 1$.

**Course Outcome 4 (CO4):** Compute Laplace transform and apply them to solve ODEs arising in engineering

1. What is the inverse Laplace Transformof $(s) = \frac{3s-137}{s^2+2s+4}$?

2. Find Laplace Transform of Unit step function.

3. Solve the differential equation of $y'' + 9y = \delta\left(t - \frac{\pi}{2}\right)$? Given $y(0) = 2,\ y'(0) = 0$

**Course Outcome 5(CO5):** Determine the Fourier transforms of functions and apply them to solve problems arising in engineering

1. Find the Fourier integral representation of function defined by $f(x) = e^{-x}$for$x > 0$ and $f(x) = 0$for$x < 0$.

2. What are the conditions for the existence of Fourier Transform of a function $f(x)$?

3. Find the Fourier transform of $f(x) = 1$ for $|x| < 1$ and $f(x) = 0$ otherwise.

**Model Question paper**

**QP CODE:** PAGES:3

Reg No:_______________

Name :_______________

**TKM COLLEGE OF ENGINEERING FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

***Course Code: 22MAT201***

**Max. Marks: 100** **Duration: 3 Hours**

**VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS**

**(2019-Scheme)**

**(Common to all branches)**

## PART A

**(Answer all questions. Each question carries 3 marks)**

1. Is the vector $\boldsymbol{r}$ **where** $\boldsymbol{r} = x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k}$ conservative. Justify your answer.
2. State Greens theorem including all the required hypotheses
3. What is the outward flux of $\boldsymbol{F}(\boldsymbol{x},\boldsymbol{y},\boldsymbol{z}) = x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k}$ across any unit cube**.**
4. What is the relationship between Green's theorem and Stokes theorem?
5. Solve $y'' + 4y' + 2.5y = 0$
6. Does the function $y = C_1 \cos x + C_2\, sinx$form a solution of$y'' + y = 0$?. Is it the general solution? Justify your answer.
7. Find the Laplace transform of $e^{-t}\sinh 4t$
8. Find the Laplace inverse transform of $\frac{1}{s\,(s^2+\omega^2)}$.
9. Given the Fourier transform $\frac{1}{\sqrt{2}}e^{-\frac{\omega^2}{4}}$ of $f(x) = e^{-x^2}$ , find the Fourier transform of $xe^{-x^2}$
10. State the convolution theorem for Fourier transform

## PART B

**(Answer one full question from each module. Each full question carries 14 marks)**

### MODULE 1

11a) Prove that the force field $\boldsymbol{F} = e^y\boldsymbol{i} + xe^y\boldsymbol{j}$is conservative in the entire xy-plane

b**)** Use Greens theorem to find the area enclosed by the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$

12 a) Find the divergence of the vector field$\boldsymbol{F} = \frac{c}{(x^2+y^2+z^2)^{3/2}}(x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k})$

b) Find the work done by the force field$\boldsymbol{F}(x,y,z) = xy\boldsymbol{i} + yz\boldsymbol{j} + xz\boldsymbol{k}$along C where

C is the curve$\boldsymbol{r}(t) = t\boldsymbol{i} + t^2\boldsymbol{j} + t^3\boldsymbol{k}$

### MODULE II

13 a) Use divergence theorem to find the outward flux of the vector field

$\boldsymbol{F} = 2x\boldsymbol{i} + 3y\boldsymbol{j} + z^3\boldsymbol{k}$acrossthe unit cube bounded by or $x = 0$, $y = 0, z = 0, x = 1, y = 1, z = 1$

b) Find the circulation of $\boldsymbol{F} = (x - z)\boldsymbol{i} + (y - x)\boldsymbol{j} + (\boldsymbol{z} - \boldsymbol{xy})\boldsymbol{k}$ using Stokes theorem around the triangle with vertices $A(1,0,0)$, $B(0,2,0)$and $C(0,0,1)$

14 a**)** Use divergence theorem to find the volume of the cylindrical solid bounded by $x^2 + 4x + y^2 = 7$, $z = -1$, $z = 4$, given the vector field $\boldsymbol{F} = \boldsymbol{x}i + \boldsymbol{y}j + \boldsymbol{z}k$ across surfaceof the cylinder

**b)** Use Stokes theorem to evaluate$\int_C \boldsymbol{F}.\boldsymbol{dr}$where$\boldsymbol{F} = x^2\boldsymbol{i} + 3x\boldsymbol{j} - y^3\boldsymbol{k}$where Cis the circle $x^2 + y^2 = 1$ in the xy- plane with counterclockwise orientation looking down the positive z-axis

**MODULE III**

15 a) Solve $y'' + 4y' + 4y = x^2 + e^{-x}\cos x$

b) Solve $y''' - 3y'' + 3y' - y = e^x - x - 1$

16 a) Solve $y''' + 3y'' + 3y' + y = 30e^{-x}$ given $y(0) = 3, y'(0) = -3$, $y''(0) = -47$

b) Using method of variation of parameters, solve $y'' + y = sec\, x$

**MODULE IV**

17 a) Find the inverse Laplace transform of $F(s) = \frac{2(e^{-s} - e^{-3s})}{s^2 - 4}$

b) Solve the differential equation $y'' + 16y = 4\delta(t - 3\pi)$; $y(0) = 2, y'(0) = 0$ using Laplace transform

18 a) Solve $y'' + 3y' + 2y = f(t)$ where $f(t) = 1$ for $0 < t < 1$ and $f(t) = 1$ for $t > 1$ using Laplace transform

b) Apply convolution theorem to find the Laplace inverse transform of $\frac{1}{s^2(s^2+\omega^2)}$

**MODULE V**

19 a) Find the Fourier cosine integral representation for $f(x) = e^{-kx}$ for $x > 0$ and $k > 0$ and hence evaluate $\int_0^\infty \frac{\cos wx}{k^2+w^2}$ the function

b) Does the Fourier sine transform $f(x) = x^{-1}\sin x$ for $0 < x < \infty$ exist? Justify your answer

20 a) Find the Fourier transform of $f(x) = |x|$ for $|x| < 1$ and $f(x) = 0$ otherwise

b) Find the Fourier cosine transform of $f(x) = e^{-ax}$ for a $> 0$

**Syllabus**

**Module 1 (Calculus of vector functions)**

**(Text 1: Relevant topics from sections 12.1, 12.2, 12.6, 13.6, 15.1, 15.2, 15.3)**

Vector valued function of single variable, derivative of vector function and geometrical interpretation, motion along a curve-velocity, speed and acceleration. Concept of scalar and vector fields , Gradient and its properties, directional derivative , divergence and curl, Line integrals of vector fields, work as line integral, Conservative vector fields , independence of path and potential function(results without proof).

**Module 2 ( Vector integral theorems)**

**(Text 1: Relevant topics from sections 15.4, 15.5, 15.6, 15.7, 15.8)**

Green's theorem (for simply connected domains, without proof) and applications to evaluating line integrals and finding areas. Surface integrals over surfaces of the form z = g(x, y), y = g(x, z) or x = g(y, z) , Flux integrals over surfaces of the form z = g(x, y), y = g(x, z) or x = g(y, z), divergence theorem (without proof) and its applications to finding flux integrals, Stokes' theorem (without proof) and its applications to finding line integrals of vector fields and work done.

**Module- 3 ( Ordinary differential equations)**

**(Text 2: Relevant topics from sections 2.1, 2.2, 2.5, 2.6, 2.7, 2.10, 3.1, 3.2, 3.3)**

Homogenous linear differential equation of second order, superposition principle,general solution, homogenous linear ODEs with constant coefficients-general solution. Solution of Euler-Cauchy equations (second order only).Existence and uniqueness (without proof). Non homogenous linear ODEs-general solution, solution by the method of undetermined coefficients (for the right hand side of the form $x^n$,$e^{kx}$,$sinax$,$cosax$,$e^{kx}sinax e^{kx}cosax$and their linear combinations), methods of variation of parameters. Solution of higher order equations-homogeneous and non-homogeneous with constant coefficient using method of undetermined coefficient.

**Module- 4 (Laplace transforms)**

**(Text 2: Relevant topics from sections 6.1,6.2,6.3,6.4,6.5)**

Laplace Transform and its inverse ,Existence theorem ( without proof) , linearity,Laplace transform of basic functions, first shifting theorem, Laplace transform of derivatives and integrals, solution of differential equations using Laplace transform, Unit step function, Second shifting theorems. Dirac delta function and its Laplace transform, Solution of ordinary differential equation involving unit step function and Dirac delta functions. Convolution theorem(without proof)and its application to finding inverse Laplace transform of products of functions.

**Module-5 (Fourier Tranforms)**

**(Text 2: Relevant topics from sections 11.7,11.8, 11.9)**

Fourier integral representation, Fourier sine and cosine integrals. Fourier sine and cosine transforms, inverse sine and cosine transform. Fourier transform and inverse Fourier transform, basic properties. The Fourier transform of derivatives. Convolution theorem (without proof)

**Text Books**


1. H. Anton, I. Biven S.Davis, "Calculus", Wiley, 10th edition, 2015.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley, 10th edition, 2015.


**Reference Books**


1. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9 th Edition, Pearson,Reprint, 2002.
3. Peter O Neil, Advanced Engineering Mathematics, 7th Edition, Thomson, 2007.
4. Louis C Barret, C Ray Wylie, "Advanced Engineering Mathematics", Tata McGraw Hill, 6th edition, 2003.
5. VeerarajanT."Engineering Mathematics for first year", Tata McGraw - Hill, 2008.
6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th edition , 2010.
7. Srimanta Pal, Subodh C. Bhunia, "Engineering Mathematics", Oxford University Press, 2015.
8. Ronald N. Bracewell, "The Fourier Transform and its Applications", McGraw – Hill International Editions, 2000.


**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Calculus of vector functions (9 hours)** | |
| 1.1 | Vector valued function of a scalar variable - derivative of vector valued function of scalar variable t-geometrical meaning | 2 |
| 1.2 | Motion along a curve-speed , velocity, acceleration | 1 |
| 1.3 | Gradient and its properties, directional derivative , divergent and curl | 3 |
| 1.4 | Line integrals with respect to arc length, line integrals of vector fields. Work done as line integral | 2 |
| 1.5 | Conservative vector field, independence of path, potential function | 1 |

| | | |
|---|---|---|
| **2** | **Vector integral theorems( 9 hours)** | |
| 2.1 | Green's theorem and it's applications | 2 |
| 2.2 | Surface integrals , flux integral and their evaluation | 3 |
| 2.3 | Divergence theorem and applications | 2 |
| 2.4 | Stokes theorem and applications | 2 |
| 3 | **Ordinary Differential Equations (9 hours)** | |
| 3.1 | Homogenous linear equation of second order, Superposition principle, general solution | 1 |
| 3.2 | Homogenous linear ODEs of second order with constant coefficients | 2 |
| 3.3 | Second order Euler-Cauchy equation | 1 |
| 3.4 | Non homogenous linear differential equations of second order with constant coefficient-solution by undetermined coefficients, variation of parameters. | 3 |
| 3.5 | Higher order equations with constant coefficients | 2 |
| **4** | **Laplace Transform (10 hours)** | |
| 4.1 | Laplace Transform , inverse Transform, Linearity, First shifting theorem, transform of basic functions | 2 |
| 4.2 | Transform of derivatives and integrals | 1 |
| 4.3 | Solution of Differential equations, Initial value problems by Laplace transform method. | 2 |
| 4.4 | Unit step function --- Second shifting theorem | 2 |
| 4.5 | Dirac Delta function and solution of ODE involving Dirac delta function | 2 |
| 4.6 | Convolution and related problems. | 1 |
| **5** | **Fourier Transform (8 hours)** | |
| 5.1 | Fourier integral representation | 1 |
| 5.2 | Fourier Cosine and Sine integrals and transforms | 2 |
| 5.3 | Complex Fourier integral representation, Fourier transform and its inverse transforms, basic properties | 3 |
| 5.4 | Fourier transform of derivatives, Convolution theorem | 2 |

| 22PHT 201 | ENGINEERING PHYSICS B<br>(FOR NON-CIRCUIT BRANCHES) | Category | L | T | P | CREDIT | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | BSC | 3 | 1 | 0 | 4 | 2019 |

**Preamble:** The aim of the Engineering Physics program is to offer students a solid background in the fundamentals of Physics and to impart that knowledge in engineering disciplines. The program is designed to develop scientific attitudes and enable the students to correlate the concepts of Physics with the core programmes

**Prerequisite:** Higher secondary level Physics, Mathematical course on vector calculus, differential equations and linear algebra

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| CO 1 | Compute the quantitative aspects of waves and oscillations in engineering systems. |
| CO 2 | Apply the interaction of light with matter through interference, diffraction and identify these phenomena in different natural optical processes and optical instruments. |
| CO 3 | Analyze the behaviour of matter in the atomic and subatomic level through the principles of quantum mechanics to perceive the microscopic processes in electronic devices. |
| CO 4 | Apply the knowledge of ultrasonics in non-destructive testing and use the principles of acoustics to explain the nature and characterization of acoustic design and to provide a safe and healthy environment |
| CO 5 | Apply the comprehended knowledge about laser and fibre optic communication systems in various engineering applications |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | | | | | | 1 | 2 | | | 1 |
| **CO 2** | 3 | 2 | | | | | | 1 | 2 | | | 1 |
| **CO 3** | 3 | 2 | | | | | | 1 | 2 | | | 1 |
| **CO 4** | 3 | | | | | | | 1 | 2 | | | 1 |
| **CO 5** | 3 | 2 | | | | | | 1 | 2 | | | 1 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination (Marks) |
|---|---|---|---|
| | Test 1 (Marks) | Test 2 (Marks) | |
| Remember | 15 | 15 | 30 |
| Understand | 25 | 25 | 50 |

| | | | |
|---|---|---|---|
| Apply | 10 | 10 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE MARKS | ESE MARKS | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the effect of damping force on oscillators.
2. Distinguish between transverse and longitudinal waves.
3. (a) Derive an expression for the fundamental frequency of transverse vibration in a stretched string.
   (b) Calculate the fundamental frequency of a string of length 2 m weighing 6 g kept stretched by a load of 600 kg.

**Course Outcome 2 (CO2):**

1. Explain colours in thin films.
2. Distinguish between Fresnel and Fraunhofer diffraction.
3. (a) Explain the formation of Newton's rings and obtain the expression for radii of bright and dark rings in reflected system. Also explain how it is used to determine the wavelength of a monochromatic source of light.
   (b) A liquid of refractive index μ is introduced between the lens and glass plate. What happens to the fringe system? Justify your answer.

**Course Outcome 3 (CO3):**

1. Give the physical significance of wave function?

2. What are excitons ?
3. (a) Solve Schrodinger equation for a particle in a one dimensional box and obtain its energy eigen values and normalised wave functions.
   (b) Calculate the first three energy values of an electron in a one dimensional box of width 1 $A^0$ in electron volt.

**Course Outcome 4 (CO4):**

1. Explain reverberation and reverberation time.
2. How ultrasonic waves are used in non-destructive testing.
3. (a) With a neat diagram explain how ultrasonic waves are produced by a piezoelectric oscillator.
   (b) Calculate frequency of ultrasonic waves that can be produced by a nickel rod of length 4 cm. (Young's Modulus = 207 G Pa, Density = 8900 Kg /$m^3$)

**Course Outcome 5 (CO 5):**

1. Distinguish between spontaneous emission and stimulated emission.
2. Explain optical resonators.
3. (a) Explain the construction and working of Ruby Laser.
   (b) Calculate the numerical aperture and acceptance angle of a fibre with a core refractive index of 1.54 and a cladding refractive index of 1.50 when the fibre is inside water of refractive index 1.33.

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**Model Question paper**

QP CODE: PAGES:3

Reg No:_______________

Name :_______________

**TKM COLLEGE OF ENGINEERING FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

***Course Code: 22PHT 201***

**Course Name: Engineering Physics B**

**Max.Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Compare electrical and mechanical oscillators.

2. Distinguish between longitudinal and transverse waves.

3. Write a short note on antireflection coating.

4. Diffraction of light is not as evident in daily experience as that of sound waves. Give reason.

5. State and explain Heisenberg's Uncertainty principle. With the help of it explain natural line broadening.

6. Explain surface to volume ratio of nanomaterials.

7. Define sound intensity level. Give the values of threshold of hearing and threshold of pain.

8. Describe the method of non-destructive testing using ultra sonic waves

9. Explain the condition of population inversion

10. Distinguish between step index and graded index fibre. (10x3=30)

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. (a) Derive the differential equation of damped harmonic oscillator and deduce its solution. Discuss the cases of over damped, critically damped and under damped cases. (10)

(b) The frequency of a tuning fork is 500 Hz and its Q factor is $7\times10^{4}$. Find the relaxation time. Also calculate the time after which its energy becomes 1/10 of its initial undamped value. (4)

12. (a) Derive an expression for the velocity of propagation of a transverse wave in a stretched string. Deduce laws of transverse vibrations. (10)

(b) The equation of transverse vibration of a stretched string is given by y =0.00327 sin (72.1x-2.72t ) m, in which the numerical constants are in S.I units. Evaluate (i) Amplitude (ii) Wavelength (iii) Frequency and (iv) Velocity of the wave. (4)

**Module 2**

13. (a) Explain the formation of Newton's rings and show that the radius of dark ring is proportional to the square root of natural numbers. How can we use Newton's rings experiment to determine the refractive index of a liquid? (10)

(b) Two pieces of plane glass are placed together with a piece of paper between two at one end. Find the angle of the wedge in seconds if the film is viewed with a monochromatic light of wavelength 4800Å. Given β = 0.0555 cm. (4)

14. (a) Explain the diffraction due to a plane transmission grating. Obtain the grating equation. (10)

(b) A grating has 6000 lines per cm. Find the angular separation of the two yellow lines of mercury of wavelengths 577 nm and 579 nm in the second order. (4)

**Module 3**

15. (a) Derive time dependent and independent Schrodinger equations. (10)

(b) An electron is confined to one dimensional potential box of length 2Å. Calculate the energies corresponding to the first and second quantum states in eV. (4)

16. (a) Classify nanomaterials based on dimensionality of quantum confinement and explain the following nanostructures. (i) nano sheets (ii) nano wires (iii) quantum dots. (10)

(b) Find the de Broglie wavelength of electron whose kinetic energy is 15 eV. (4)

**Module 4**

17. (a) Explain reverberation and reverberation time? What is the significance of Reverberation time. Explain the factors affecting the acoustics of a building and their corrective measures? (10)

(b) The volume of a hall is 3000 $m^3$. It has a total absorption of 100$m^2$ sabine. If the hall is filled with audience who add another 80 $m^2$sabine, then find the difference in reverberation time. (4)

18. (a) With a neat diagram explain how ultrasonic waves are produced by piezoelectric oscillator. Also discuss the piezoelectric method of detection of ultrasonic waves. (10)

(b) An ultrasonic source of 0.09 MHz sends down a pulse towards the sea bed which returns after 0.55 sec. The velocity of sound in sea water is 1800 m/s. Calculate the depth of the sea and the wavelength of the pulse. (4)

**Module 5**

19. (a) Outline the construction and working of Ruby laser. (8)

(b) What is the principle of holography? How is a hologram recorded? (6)

20. (a) Define numerical aperture of an optic fibre and derive an expression for the NA of a step index fibre with a neat diagram. (10)

(b) An optical fibre made with core of refractive index 1.5 and cladding with a fractional index difference of 0.0006. Find refractive index of cladding and numerical aperture. (4)

(14x5=70)

**SYLLABUS**

**ENGINEERING PHYSICS B (FOR NON-CIRCUIT BRANCHES)**

**Module 1**

**Oscillations and Waves**

Harmonic oscillations, Damped harmonic motion-Derivation of differential equation and its solution, Over damped, Critically damped and Under damped Cases, Quality factor-Expression, Forced oscillations-Differential Equation-Derivation of expressions for amplitude and phase of forced oscillations, Amplitude Resonance-Expression for Resonant frequency, Quality factor and Sharpness of Resonance, Electrical analogy of mechanical oscillators

Wave motion- Derivation of one dimensional wave equation and its solution, Three dimensional wave equation and its solution (no derivation), Distinction between transverse and longitudinal waves, Transverse vibration in a stretched string, Statement of laws of vibration

**Module 2**

**Wave Optics**

Interference of light-Principle of superposition of waves, Theory of thin films - Cosine law (Reflected system), Derivation of the conditions of constructive and destructive Interference, Interference due to wedge shaped films -Determination of thickness and test for optical planeness, Newton's rings - Measurement of wavelength and refractive index, Antireflection coatings

Diffraction of light, Fresnel and Fraunhofer classes of diffraction, Diffraction grating-Grating equation, Rayleigh criterion for limit of resolution, Resolving and Dispersive power of a grating with expression (no derivation)

**Module 3**

**Quantum Mechanics & Nanotechnology**

Introduction for the need of Quantum mechanics, Wave nature of Particles, Uncertainty principle, Applications-Absence of electrons inside a nucleus and Natural line broadening Mechanism, Formulation of time dependent and independent Schrodinger wave equations-Physical Meaning of wave function, Particle in a one dimensional box- Derivation for normalised wave function and energy eigen values, Quantum Mechanical Tunnelling (Qualitative)

Introduction to nanoscience and technology, Increase in surface to volume ratio for nanomaterials, Quantum confinement in one dimension, two dimension and three dimension-Nano sheets, Nano wires and Quantum dots, Properties of nanomaterials-mechanical, electrical and optical, Applications of nanotechnology (qualitative ideas)

**Module 4**

**Acoustics & Ultrasonics**

Acoustics, Classification of sound-Musical sound-Noise, Characteristics of Musical Sounds-Pitch or frequency-Loudness or Intensity-Measurement of Intensity level-Decibel-Quality or timbre, Absorption coefficient, Reverberation-Reverberation time-Significance- Sabine's formula (no derivation), Factors affecting architectural acoustics and their remedies

Ultrasonics-Production- Magnetostriction effect and Piezoelectric effect, Magnetostriction oscillator and Piezoelectric oscillator –Working, Detection of ultrasonic waves - Thermal and Piezoelectric methods, Ultrasonic diffractometer- Expression for the velocity of ultrasonic waves in a liquid , Applications of ultrasonic waves -SONAR,NDT and Medical

**Module 5**

**Laser and Fibre optics**

Properties of laser, Absorption and emission of radiation, Spontaneous and stimulated emission, Einstein's coefficients (no derivation), Population inversion, Metastable states, basic components of laser, Active medium, Pumping mechanism, Optical resonant cavity, working principle, Construction and working of Ruby laser and Helium neon laser ,Construction and working of semiconductor laser(Qualitative) ,Applications of laser, Holography, Difference between hologram and photograph, Recording of hologram and reconstruction of image, Applications

Optic fibre-Principle of propagation of light, Types of fibres-Step index and Graded index fibres, Numerical aperture –Derivation, Fibre optic communication system (block diagram), Industrial, Medical and Technological applications, Fibre optic sensors-Intensity Modulated and Phase modulated sensors

**Text Books**

1. M.N.Avadhanulu, P.G.Kshirsagar,TVS Arun Murthy "A Text book of Engineering Physics", S.Chand &Co., Revised Edition, 2019.

2. H.K.Malik , A.K. Singh, "Engineering Physics" McGraw Hill Education, Second Edition, 2017.

**Reference Books**

1. Arthur Beiser, "Concepts of Modern Physics ", Tata McGraw Hill Publications, 6th Edition 2003
2. D.K. Bhattacharya, Poonam Tandon, "Engineering Physics", Oxford University Press, 2015
3. Md.N.Khan & S.Panigrahi "Principles of Engineering Physics 1&2", Cambridge University Press, 2016
4. Aruldhas G., "Engineering Physics", PHI Pvt. Ltd., 2015
5. Ajoy Ghatak, "Optics", Mc Graw Hill Education, Sixth Edition, 2017
6. T. Pradeep, "Nano:The Essentials'', McGraw Hill India Ltd, 2007
7. B. B. Laud, "Lasers and Non linear optics", New age International Publishers, 2nd Edition ,2005
8. Premlet B., "Advanced Engineering Physics", Phasor Books,10th edition ,2017
9. I. Dominic and. A. Nahari, "A Text Book of Engineering physics", Owl Books Publishers, Revised edition, 2016

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Oscillations and Waves ( 9 hours)** | |
| 1.1 | Harmonic oscillations, Damped harmonic motion-Derivation of differential equation and its solution, Over damped, Critically damped and Under damped Cases, Quality factor-Expression | 2 hrs |
| 1.2 | Forced oscillations-Differential Equation-Derivation of expressions for amplitude and phase of forced oscillations, Amplitude Resonance-Expression for Resonant frequency, Quality factor and Sharpness of Resonance, Electrical analogy of mechanical oscillators | 3hrs |
| 1.3 | Wave motion- Derivation of one dimensional wave equation and its solution, Three dimensional wave equation and its solution (no derivation) | 2 hrs |
| 1.4 | Distinction between transverse and longitudinal waves, Transverse vibration in a stretched string, Statement of laws of vibration | 2 hrs |
| 2 | **Wave Optics (9 hours)** | |
| 2.1 | Interference of light-Principle of superposition of waves, Theory of thin films - Cosine law (Reflected system), Derivation of the conditions of constructive and destructive Interference | 2 hrs |
| 2.2 | Interference due to wedge shaped films -Determination of thickness and test for optical planeness, Newton's rings - Measurement of wavelength and refractive index, Antireflection coatings | 4 hrs |
| 2.3 | Diffraction of light, Fresnel and Fraunhofer classes of diffraction, Diffraction grating-Grating equation | 2 hrs |
| 2.4 | Rayleigh criterion for limit of resolution, Resolving and Dispersive power of a grating with expression (no derivation) | 1 hr |
| 3 | **Quantum Mechanics &Nanotechnology (9hours)** | |
| 3.1 | Introduction for the need of Quantum mechanics, Wave nature of Particles, Uncertainty principle, Applications-Absence of electrons inside a nucleus and Natural line broadening mechanism | 2 hrs |
| 3.2 | Formulation of time dependent and independent Schrodinger wave equations-Physical Meaning of wave function, Particle in a one dimensional box- Derivation for normalised wave function and energy eigen values, Quantum Mechanical Tunnelling (Qualitative) | 4 hrs |
| 3.3 | Introduction to nanoscience and technology, Increase in surface to volume ratio for nanomaterials, Quantum confinement in one dimension, two dimension and three dimension-Nano sheets, Nano wires and Quantum dots | 2 hrs |
| 3.4 | Properties of nanomaterials-mechanical, electrical and optical Applications of nanotechnology (qualitative ideas) | 1 hr |
| 4 | **Acoustics & Ultrasonics (9hrs)** | |
| 4.1 | Acoustics, Classification of sound-Musical sound-Noise, Characteristics | 3 hrs |

| | | |
|---|---|---|
| | of Musical Sounds-Pitch or frequency-Loudness or Intensity-Measurement of Intensity level-Decibel-Quality or timbre, Absorption coefficient, Reverberation-Reverberation time-Significance- Sabine's formula (no derivation) | |
| 4.2 | Factors affecting architectural acoustics and their remedies | 1 hr |
| 4.3 | Ultrasonics-Production- Magnetostriction effect and Piezoelectric effect, Magnetostriction oscillator and Piezoelectric oscillator – Working, Detection of ultrasonic waves - Thermal and Piezoelectric methods | 3hrs |
| 4.4 | Ultrasonic diffractometer- Expression for the velocity of ultrasonic waves in a liquid ,Applications of ultrasonic waves -SONAR,NDT and Medical. | 2 hr |
| 5 | **Laser and Fibre optics ( 9hours)** | |
| 5.1 | Properties of laser, Absorption and emission of radiation, Spontaneous and stimulated emission, Einstein's coefficients (no derivation), Population inversion, Metastable states, basic components of laser, Active medium, Pumping mechanism, Optical resonant cavity, working principle | 2 hrs |
| 5.2 | Construction and working of Ruby laser and Helium neon laser ,Construction and working of semiconductor laser(Qualitative) Applications of laser | 3 hrs |
| 5.3 | Holography, Difference between hologram and photograph, Recording of hologram and reconstruction of image, Applications | 1 hr |
| 5.4 | Optic fibre-Principle of propagation of light, Types of fibres-Step index and Graded index fibres, Numerical aperture –Derivation, Fibre optic communication system (block diagram), Industrial, Medical and Technological applications, Fibre optic sensors-Intensity Modulated and Phase modulated sensors | 3 hrs |

| 22EST 204 | ENGINEERING MECHANICS | CATEGORY | L | T | P | CREDIT | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | ESC | 2 | 1 | 0 | 3 | 2019 |

**Preamble:** Goal of this course is to expose the students to the fundamental concepts of mechanics and enhance their problem-solving skills. It introduces students to the influence of applied force system and the geometrical properties of the rigid bodies while stationary or in motion. After this course students will be able to recognize similar problems in real-world situations and respond accordingly.

**Prerequisite:** Nil

**Course Outcomes:** After completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Recall principles and theorems related to rigid body mechanics |
| **CO 2** | Identify and describe the components of system of forces acting on the rigid body |
| **CO 3** | Apply the conditions of equilibrium to various practical problems involving different force system. |
| **CO 4** | Choose appropriate theorems, principles or formulae to solve problems of mechanics. |
| **CO 5** | Solve problems involving rigid bodies, applying the properties of distributed areas and masses |

**Mapping of course outcomes with program outcomes (Minimum requirement)**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 2 | - | - | - | - | - | - | - | - | - | - |
| **CO 2** | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| **CO 3** | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| **CO 4** | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| **CO 5** | 3 | 3 | - | - | - | - | - | - | - | - | - | - |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination (Marks) |
|---|---|---|---|
| | Test 1 (Marks) | Test 2 (Marks) | |
| Remember | 10 | 10 | 15 |
| Understand | 10 | 10 | 15 |
| Apply | 30 | 30 | 70 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**<u>End Semester Examination Pattern:</u>** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**<u>Course Level Assessment Questions:</u>**

**Part A**

**Course Outcome 1 (CO1): (One question from each module to meet the course objective 1**: *To recall principles and theorems related to rigid body mechanics***)**

1. Explain D'Alembert's principle

2. Distinguish static and dynamic friction

3. State and explain perpendicular axis theorem

**Course Outcome 2 (CO2) (One question from each module to meet the course objective 2:** *To identify and describe the components of system of forces acting on the rigid body***)**

1. A simply supported beam AB of span 5 m is carrying point loads 5 kN, 3 kN and 2 kN at 1m, 3m and 4m respectively from support A. Calculate the support reaction at B.

2. A gymnast holding onto a bar, is suspended motionless in mid-air. The bar is supported by two ropes that attach to the ceiling. Diagram the forces acting on the combination of gymnast and bar

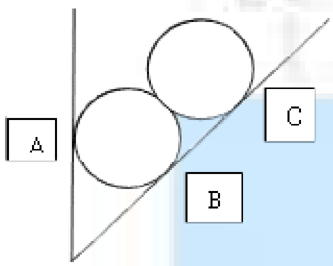
3. While you are riding your bike, you turn a corner following a circular arc. Illustrate the forces that act on your bike to keep you along the circular path ?

**Part B**

All the questions under this section shall assess the learning levels corresponding to the course outcomes listed below.

| | |
|---|---|
| **CO 3** | To apply the conditions of equilibrium to various practical problems involving different force system. |
| **CO 4** | To choose appropriate theorems, principles or formulae to solve problems of mechanics. |
| **CO 5** | To solve problems involving rigid bodies, applying the properties of distributed areas and masses |

1. Two rollers each of weight 100 N are supported by an inclined plane and a vertical wall. Find the reaction at the points of contact A, B, C. Assume all the surfaces to be smooth.

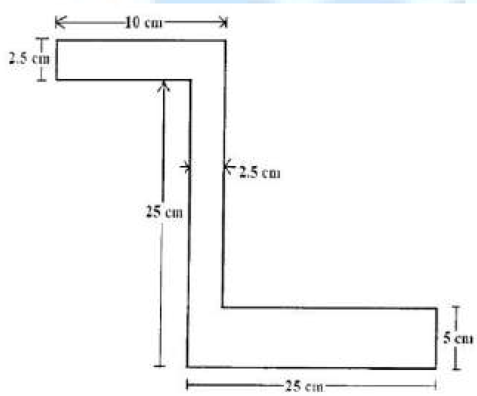



| Course outcome identifier | Description of course outcome | Learning level assessed | Marks allocated |
|---|---|---|---|
| **CO 3** | To apply the conditions of equilibrium to various practical problems involving different force system. | Applying – (Sketch the free body diagram that represent equilibrium state of the body ) | 4 |
| **CO 4** | To choose appropriate theorems, principles or formulae to solve problems of mechanics. | Applying (Choose the equations and formulae required for calculation) | 4 |
| **CO 5** | To solve problems involving rigid bodies, applying the properties of distributed areas and masses | Applying ( Solve the problem based on the descriptions given in CO3 and CO4) | 6 |
| Total | | | 14 |

2. A cylindrical disc, 50 cm diameter and  cm thickness,  is in contact with a horizontal conveyor belts running at uniform speeds of 5 m/s. Assuming there is no slip at points of contact determine (i) angular velocity of disc (ii) Angular acceleration of disc if velocity of conveyor changes to 8 m/s. Also compute the moment acting about the axis of the disc in both cases.

| Course outcome identifier | Description of course outcome | Learning level assessed | Marks allocated |
|---|---|---|---|
| **CO 3** | To apply the conditions of equilibrium to various practical problems involving different force system. | Applying – (Sketch the free body diagram that represent state of the body ) | 4 |
| **CO 4** | To choose appropriate theorems, principles or formulae to solve problems of mechanics. | Applying (Choose the equations and formulae required for calculation) | 4 |
| **CO 5** | To solve problems involving rigid bodies, applying the properties of distributed areas and masses | Applying ( Solve the problem based on the descriptions given in CO3 and CO4) | 6 |
| Total | | | 14 |

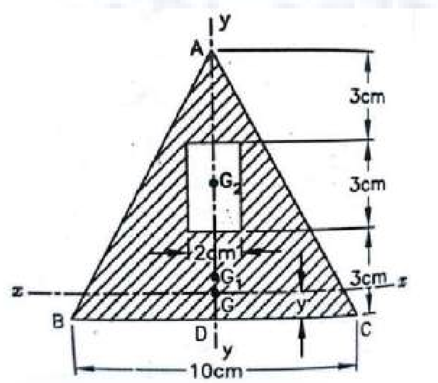
3. Determine the centroid of the given section




| Course outcome identifier | Description of course outcome | Learning level assessed | Marks allocated |
|---|---|---|---|
| **CO 3** | To apply the conditions of equilibrium to various practical problems involving different force system. | Applying – (Illustrate the computation of centroid for the given geometrical shape) | 4 |
| **CO 4** | To choose appropriate theorems, principles or formulae to solve problems of mechanics. | Applying (Choose the equations and formulae required for calculation) | 4 |
| **CO 5** | To solve problems involving rigid bodies, applying the properties of distributed | Applying ( Solve the problem based on the descriptions | 6 |

| | | | |
|---|---|---|---|
| | areas and masses | given in CO3 and CO4) | |
| Total | | | 14 |

4. A rectangular hole is made in a triangular section as shown. Find moment of inertia about the section x-x passing through the CG of the section and parallel to BC.




| Course outcome identifier | Description of course outcome | Learning level assessed | Marks allocated |
|---|---|---|---|
| **CO 3** | To apply the conditions of equilibrium to various practical problems involving different force system. | Applying – (Illustrate the computation of moment of inertia for the given geometrical shape) | 4 |
| **CO 4** | To choose appropriate theorems, principles or formulae to solve problems of mechanics. | Applying (Choose the equations and formulae required for calculation) | 4 |
| **CO 5** | To solve problems involving rigid bodies, applying the properties of distributed areas and masses | Applying ( Solve the problem based on the descriptions given in CO3 and CO4) | 6 |
| Total | | | 14 |

**Model Question Paper**

**QP CODE**:

Reg No.:_______________

Name:___________________________ ___

**TKM COLLEGE OF ENGINEERING FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

***Course Code: 22EST 204***

***ENGINEERING MECHANICS***

Max. Marks: 100 Duration: 3 hours

Part A

(Answer all questions; each question carries 3 marks)

1. Explain D'Alembert's principle

2. Distinguish static and dynamic frictioni.

3. State and explain perpendicular axis theorem.

4. A simply supported beam AB of span 5 m is carrying point loads 5 kN, 3 kN and 2 kN at 1m, 3m and 4m respectively from support A. Calculate the support reaction at B.

5. A gymnast holding onto a bar, is suspended motionless in mid-air. The bar is supported by two ropes that attach to the ceiling. Diagram the forces acting on the combination of gymnast and bar

6. While you are riding your bike, you turn a corner following a circular arc. Illustrate the forces that act on your bike to keep you along the circular path ?

7. Compare damped and undamped free vibrations.

8. State the equation of motion of a rotating rigid body, rotating about its fixed axis.

9. Illustrate the significance of instantaneous centre in the analysis of rigid body undergoing rotational motion.

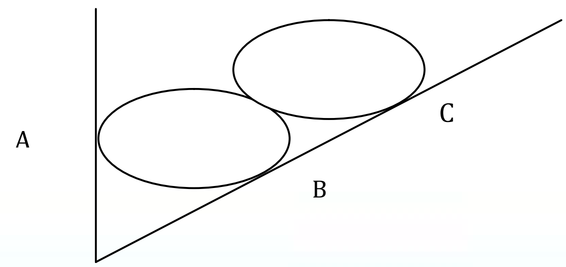
10. Highlight the principles of mechanics applied in the evaluation of elastic collusion of rigid bodies.

**PART B**

(Answer **one full** question from each module, each question carries **14** marks)

**Module -I**

11. Two identical rollers each of weight 100 N are supported by an inclined plane, making an angle of $30^{o}$ with the vertical, and a vertical wall. Find the reaction at the points of contact A, B, C. Assume all the surfaces to be smooth. (14 marks)

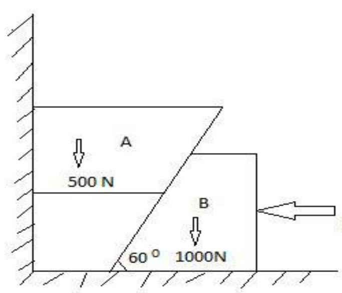



12. A string tied to a wall is made to pass over a pulley placed 2m away from it. A weight P is attached to the string such that the string stretches by 2m from the support on the wall to the location of attachment of weight. Determine the force P required to maintain 200 kg body in position for $\theta = 30^{o}$, The diameter of pulley B is negligible. (14 marks)

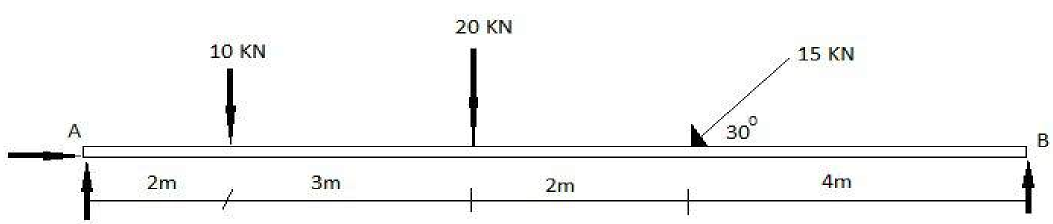
**Module – 2**

**13.** Two blocks A & B are resting against a wall and the floor as shown in figure below. Find the value of horizontal force P applied to the lower block that will hold the system in equilibrium. Coefficient of friction are : 0.25 at the floor, 0.3 at the wall and 0.2 between the blocks.

(14 marks)

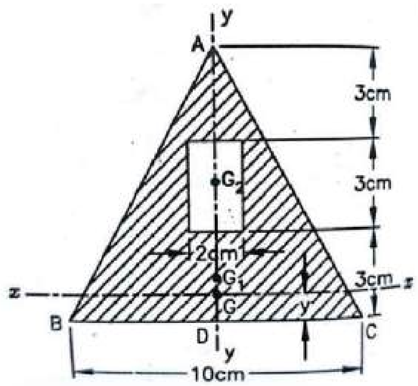



14. A beam is hinged at A and roller supported at B. It is acted upon by loads as shown below.
Find the reactions at A & B. (14 marks)

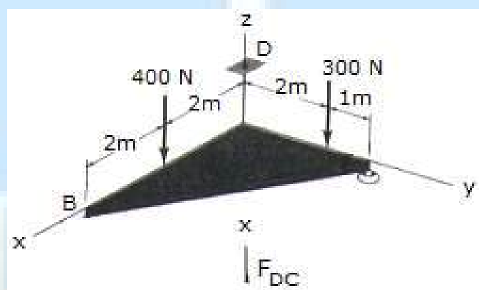



**Module – 3**

**15.** A rectangular hole is made in a triangular section as shown. Find moment of inertia about the section x-x passing through the CG of the section and parallel to BC. (14 marks)




16. Support A has ball and socket connection. Roller support at B prevents motion in the —z direction. Corner *C* is tied to *D* by a rope. The triangle is weightless. Determine the unknown force components acting at *A*, *B*, and *C*. (14 marks)




**Module - 4**

17. A cricket ball is thrown by a fielder from a height of 2m at an angle of $30^0$ to the horizontal with an initial velocity of 20 m/s , hits the wickets at a height of 0.5 m from the ground. How far was the fielder from the wicket? (14 marks)

18. An engine of weight 500 kN pull a train weighing 1500 kN up an incline of 1 in 100. The train starts from rest and moves with constant acceleration against a resistance of 5 N/kN. It attains a maximum speed of 36 kmph in 1 km distance. Determine the tension in the coupling between train and engine and the traction force developed by the engine. (14marks)

**Module – 5**

19. A cylindrical disc, 50 cm diameter and 10 cm thickness having mass of 10 kg, is in contact with a horizontal conveyor belt running at uniform speeds of 5 m/s. Assuming there is no slip at points of contact determine (i) angular velocity of disc (ii) Angular acceleration of disc if velocity of conveyor changes to 8 m/s in 10 seconds. Also compute the moment acting about the axis of the disc in both cases. (14 marks)

20. A wheel rotating about fixed axis at 20 rpm is uniformly accelerated for 70 seconds during which time it makes 50 revolutions. Find the (i) angular velocity at the end of this interval and (ii) time required for the velocity to reach 100 revolutions per minute. (14 marks)

**SYLLABUS**

**Module 1**

Introduction to Engineering Mechanics-statics-basic principles of statics-Parallelogram law, equilibrium law, principles of superposition and transmissibility, law of action and reaction(review) free body diagrams.

Concurrent coplanar forces-composition and resolution of forces-resultant and equilibrium equations – methods of projections – methods of moments – Varignon's Theorem of moments.

**Module 2**

Friction – sliding friction - Coulomb's laws of friction – analysis of single bodies –wedges, ladder-analysis of connected bodies .

Parallel coplanar forces – couple - resultant of parallel forces – centre of parallel forces – equilibrium of parallel forces – Simple beam subject to concentrated vertical loads. General coplanar force system - resultant and equilibrium equations.

**Module 3**

Centroid of composite areas- – moment of inertia-parallel axis and perpendicular axis theorems. Polar moment of inertia,radius of gyration,mass moment of inertia-ring,cylinder and disc.

Theorem of Pappus Guldinus(demonstration only)

Forces in space - vectorial representation of forces, moments and couples –resultant and equilibrium equations – concurrent forces in space (simple problems only)

**Module 4**

Dynamics – rectilinear translation - equations of kinematics(review)

kinetics – equation of motion – D'Alembert's principle. – motion on horizontal and inclined surfaces, motion of connected bodies. Impulse momentum equation and work energy equation (concepts only).

Curvilinear translation - equations of kinematics –projectile motion(review), kinetics – equation of motion. Moment of momentum and work energy equation (concepts only).

**Module 5**

Rotation – kinematics of rotation- equation of motion for a rigid body rotating about a fixed axis – rotation under a constant moment.

Plane motion of rigid body – instantaneous centre of rotation (concept only).

Simple harmonic motion – free vibration –degree of freedom- undamped free vibration of spring mass system-effect of damping(concept only)

**Text Books**

1. Timoshenko and Young, Engineering Mechanics, McGraw Hill Publishers
2. Shames, I. H., Engineering Mechanics - Statics and Dynamics, Prentice Hall of India.
3. R. C. Hibbeler and Ashok Gupta, Engineering Mechanics, Vol. I statics, Vol II Dynamics, Pearson Education.

**References**


**1.** Merriam J. L and Kraige L. G., Engineering Mechanics - Vols. 1 and 2, John Wiley.

2. Tayal A K, Engineering Mechanics – Statics and Dynamics, Umesh Publications

3. Bhavikkatti, S.S., Engineering Mechanics, New Age International Publishers

4. F.P.Beer abd E.R.Johnston (2011), Vector Mechanics for Engineers, Vol.I-Statics, Vol.II-Dynamics, 9th Ed, Tata McGraw Hill

5. Rajasekaran S and Sankarasubramanian G, Engineering Mechanics - Statics and Dynamics, Vikas Publishing House Pvt Ltd.


**Course Contents and Lecture Schedule:**

| Module | Topic | Course outcomes addressed | No. of Hours |
|---|---|---|---|
| **1** | **Module 1** | | **Total: 7** |
| 1.1 | Introduction to engineering mechanics – introduction on statics and dynamics - Basic principles of statics – Parellogram law, equilibrium law – Superposition and transmissibility, law of action and reaction (review the topics) | CO1 and CO2 | 1 |
| 1.2 | Free body diagrams.<br>Degree of freedom-types of supports and nature of reactions - exercises for free body diagram preparation – composition and resolution of forces, resultant and equilibrium equations (review the topics) - numerical exercises for illustration. | CO1 and CO2 | 1 |
| 1.3 | Concurrent coplanar forces - analysis of concurrent forces -methods of projections – illustrative numerical exercise – teacher assisted problem solving. | CO1 and CO2 | 1 |
| 1.4 | Analysis of concurrent forces -methods of moment-Varignon's Theorem of Moments - illustrative numerical exercise– teacher assisted problem solving. | CO1 and CO2 | 1 |
| 1.5 | Analysis of concurrent force systems – extended problem solving - Session I. | CO3,CO4 and CO5 | 1 |
| 1.6 | Analysis of concurrent force systems – extended problem solving - Session II – learning review quiz. | CO3,CO4 and CO5 | 1 |
| 1.7 | Analysis of concurrent force systems – extended problem solving - Session III. | CO3,CO4 and CO5 | 1 |
| **2** | **Module 2** | | **Total: 7** |
| 2.1 | Friction – sliding friction - Coulomb's laws of friction – analysis of single bodies –illustrative examples on wedges and ladder-teacher | CO1 and CO2 | 1 |

| | | | |
|---|---|---|---|
| | assisted problem solving tutorials using problems from wedges and ladder. | | |
| 2.2 | Problems on friction - analysis of connected bodies. illustrative numerical exercise– teacher assisted problem solving. | CO3, CO4 and CO5 | 1 |
| 2.3 | Problems on friction-extended problem solving | CO3,C04 and CO5 | 1 |
| 2.4 | Parallel coplanar forces – couple - resultant of parallel forces – centre of parallel forces – equilibrium of parallel forces – Simple beam subject to concentrated vertical loads. | CO1 and CO2 | 1 |
| 2.5 | General coplanar force system - resultant and equilibrium equations - illustrative examples- teacher assisted problem solving. | CO1 and CO2 | 1 |
| 2.6 | General coplanar force system-resultant and equilibrium equations - illustrative examples | CO3, CO4 and CO5 | 1 |
| 2.7 | General coplanar force system - Extended problem solving - Quiz to evaluate learning level. | CO3, CO4 and CO5 | 1 |
| **3** | **Module 3** | | **Total: 7** |
| 3.1 | Centroid of simple and regular geometrical shapes – centroid of figures in combination - composite areas- examples for illustration – problems for practice to be done by self. | CO1 and CO2 | 1 |
| 3.2 | Moment of inertia- parallel axis theorem –examples for illustration - problems for practice to be done by self. | CO1 and CO2 | 1 |
| 3.3 | Moment of inertia - perpendicular axis theorem - example for illustration to be given as hand out and discussion on the solved example. | CO1 and CO2 | 1 |
| 3.4 | Solutions to practice problems – problems related to centroid and moment of inertia - problems for practice to be done by self. | CO3, CO4 and CO5 | 1 |
| 3.5 | Polar moment of inertia, Radius of gyration.<br>Mass moment of inertia of ring, cylinder and uniform disc.<br>Theorem of Pappus Guldinus - Demonstration | CO1 and CO2 | 1 |
| 3.6 | Introduction to forces in space – vectorial representation of forces, moments and couples – simple problems to illustrate vector representations of forces, moments and couples to be done in class. | CO1,and CO2 | 1 |
| 3.7 | Solution to practice problems - resultant and equilibrium equations for concurrent forces in space – concurrent forces in space - 2 simple problems to illustrate the application of resultant and equilibrium equations for concurrent forces in space. | CO3,CO4 and CO5 | 1 |
| **4** | **Module 4** | | **Total: 7** |

| | | | |
|---|---|---|---|
| 4.1 | Introduction to dynamics – review of rectilinear translation - equations of kinematics – problems to review the concepts – additional problems involving extended application as exercises . | CO1 and CO2 | 1 |
| 4.2 | Solutions to exercises with necessary explanation given as hand out – introduction to kinetics – equation of motion – D'Alembert's principle – illustration of the concepts using one numerical exercise from motion on horizontal and inclined surfaces. | CO1 and CO2 | 1 |
| 4.3 | Motion of connected bodies - example for illustration to be given as hand out and discussion on the solved example – problems for practice to be done by self. | CO3, CO4 and CO5 | 1 |
| 4.4 | Motion of connected bodies-extended problem solving. | CO3, CO4 & CO5 | 1 |
| 4.5 | Curvilinear translation - Review of kinematics –projectile motion – simple problems to review the concepts – introduction to kinetics – equation of motion – illustration of the concepts using numerical exercises. | CO3, CO4 & CO5 | 1 |
| 4.6 | Extended problem solving – rectilinear and curvilinear translation. | CO3, CO4 & CO5 | 1 |
| 4.7 | Concepts on Impulse momentum equation and work energy equation (rectilinear translation – discussions to bring out difference between elastic and inelastic collusions).<br>Concepts on Moment of momentum and work energy equation (curvilinear translation). | CO1 and CO2 | 1 |
| **5** | **Module 5** | | **Total: 7** |
| 5.1 | Rotation – kinematics of rotation- equation of motion for a rigid body rotating about a fixed axis – simple problems for illustration. | CO1 and CO2 | 1 |
| 5.2 | Rotation under a constant moment – teacher assisted problem solving. | CO3,CO4 and CO5 | 1 |
| 5.3 | Rotation under a constant moment - extended problem solving. | CO3, CO4 and CO5 | 1 |
| 5.4 | Plane motion of rigid body- instantaneous centre of rotation (concept only). | CO1 and CO2 | 1 |
| 5.5 | Introduction to harmonic oscillation –free vibrations - simple harmonic motion – differential equation and solution.<br>Degree of freedom – examples of single degree of freedom (SDOF) systems – Idealisation of mechanical systems as spring-mass systems (concept only). | CO1 and CO2 | 1 |

| | | | |
|---|---|---|---|
| 5.6 | SDOF spring mass system –equation of motion – undamped free vibration response - concept of natural frequency.<br>Free vibration response due to initial conditions.<br>Simple problems on determination of natural frequency and free vibration response to test the understanding level. | CO1 and CO2 | 1 |
| 5.7 | Free vibration analysis of SDOF spring-mass systems – Problem solving<br>Effect of damping on free vibration response (concept only). | CO1and CO2 | 1 |

| 22EST 207 | BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING | CATEGORY | L | T | P | CREDIT | YEAR OF INTRODUCTION |
|---|---|---|---|---|---|---|---|
| | | ESC | 4 | 0 | 0 | 4 | 2019 |

**Preamble:**

This course aims to (1) equip the students with an understanding of the fundamental principles of electrical engineering(2) provide an overview of evolution of electronics, and introduce the working principle and examples of fundamental electronic devices and circuits (3) provide an overview of evolution of communication systems, and introduce the basic concepts in radio communication.

**Prerequisite:** Physics and Mathematics (Pre-university level)

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Apply fundamental concepts and circuit laws to solve simple DC electric circuits |
| **CO 2** | Develop and solve models of magnetic circuits |
| **CO 3** | Apply the fundamental laws of electrical engineering to solve simple ac circuits in steady state |
| **CO 4** | Describe working of a voltage amplifier |
| **CO 5** | Outline the principle of an electronic instrumentation system |
| **CO 6** | Explain the principle of radio and cellular communication |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | - | - | - | - | - | - | - | - | - | 2 |
| **CO 2** | 3 | 1 | - | - | - | - | - | - | - | - | - | 2 |
| **CO 3** | 3 | 1 | - | - | - | - | - | - | - | - | - | 2 |
| **CO 4** | 2 | - | - | - | - | - | - | - | - | - | - | - |
| **CO 5** | 2 | - | - | - | - | - | - | - | - | - | - | 2 |
| **CO 6** | 2 | - | - | - | - | - | - | - | - | - | - | 2 |

**Assessment Pattern**

| Bloom's Category | Basic Electrical Engineering | | | Basic Electronics Engineering | | |
|---|---|---|---|---|---|---|
| | Continuous Assessment Tests | | End Semester Examination (Marks) | Continuous Assessment Tests | | End Semester Examination (Marks) |
| | Test 1 (Marks) | Test 2 (Marks) | | Test 1 (Marks) | Test 2 (Marks) | |
| Remember | 0 | 0 | 10 | 10 | 10 | 20 |
| Understand | 12.5 | 12.5 | 20 | 15 | 15 | 30 |
| Apply | 12.5 | 12.5 | 20 | | | |
| Analyse | | | | | | |
| Evaluate | | | | | | |
| Create | | | | | | |

**Mark distribution**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part I – Basic Electrical Engineering and Part II – Basic Electronics Engineering. Part I and PART II carries 50 marks each. For the end semester examination, part I contain 2 parts - Part A and Part B. Part A contain 5 questions carrying 4 marks each (not exceeding 2 questions from each module). Part B contains 2 questions from each module out of which one to be answered. Each question carries 10 mark and can have maximum 2 sub-divisions. The pattern for end semester examination for part II is same as that of part I. **However, student should answer both part I and part 2 in separate answer booklets.**

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Solve problems based on current division rule.

2. Solve problems with Mesh/node analysis.

3. Solve problems on Wye-Delta Transformation.

**Course Outcome 2 (CO2):**

1. Problems on series magnetic circuits

2. Problems on parallel magnetic circuits

3. Problems on composite magnetic ciruits

4. **Course Outcome 3 (CO3):**

1. problems on self inductance, mutual inductance and coefficient of coupling

2. problems on rms and average values of periodic waveforms

3. problems on series ac circuits

4. Compare star and Delta connected 3 phase AC systems.

**Course Outcome 4 (CO4):** Describe working of a voltage amplifier

1.What is the need of voltage divider biasing in an RC coupled amplifier?

2. Define operating point in the context of a BJT amplifier.

3. Why is it required to have a voltage amplifier in a public address system?

**Course Outcome 5 (CO5):** Outline the principle of an electronic instrumentation system

1. Draw the block diagram of an electronic instrumentation system.

2. What is a transducer?

3. Explain the working principle of operation of digital multimeter.

**Course Outcome 6 (CO6):** Explain the principle of radio and cellular communication

1. What is the working principle of an antenna when used in a radio transmitter?

2. What is the need of two separate sections RF section and IF section in a super heterodyne receiver?

3. What is meant by a cell in a cellular communication?

**Model Question Paper**

**QP CODE**: Pages: 3

Reg No.:________________

Name:__________________

**TKM COLLEGE OF ENGINEERING FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

***Course Code: 22EST 207***

***Course Name: BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING***

Max. Marks: 100 Duration: 3 hours

**Answer both part I and part 2 in separate answer booklets**

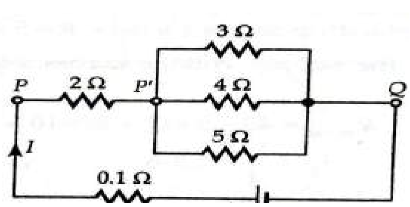
**PART I**

**BASIC ELECTRICAL ENGINEERING**

**PART A**

***Answer all questions; each question carries 4 marks.***

1. Calculate the current through the $4\Omega$ resistor in the circuit shown, applying current division rule:



2. Calculate the RMS and average values of a purely sinusoidal current having peak value 15A.

3. An alternating voltage of (80+j60)V is applied to an RX circuit and the current flowing through the circuit is (-4+j10)A. Calculate the impedance of the circuit in rectangular and polar forms. Also determine if X is inductive or capacitive.

4. Derive the relation between line and phase values of voltage in a three phase star connected system.

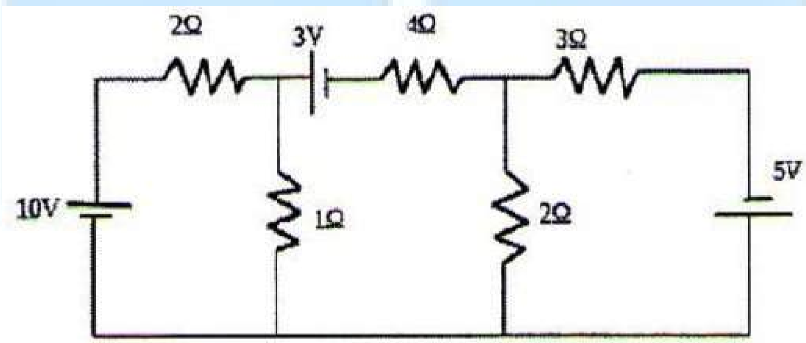
5. Compare electric and magnetic circuits. *(5x4=20)*

**PART B**

***Answer one question from each module; each question carries 10 marks.***

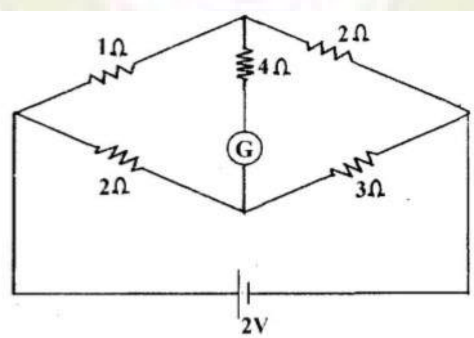
**Module 1**

6. . Calculate the node voltages in the circuit shown, applying node analysis:




7. (a) State and explain Kirchhoff's laws. (4 marks)

(b) Calculate the current through the galvanometer (G) in the circuit shown:




(6 marks)

**Module 2**

8. (a) State and explain Faraday's laws of electromagnetic induction with examples. (4 marks)

(b) Differentiate between statically and dynamically induced emf. A conductor of length 0.5m moves in a uniform magnetic field of flux density 1.1T at a velocity of 30m/s. Calculate the emf induced in the conductor if the direction of motion of the conductor is inclined at $60^0$ to the direction of field. (6 marks)

9. (a) Derive the amplitude factor and form factor of a purely sinusoidal waveform. (5 marks)

(b) A current wave is made up of two components-a 5A dc component and a 50Hz ac component, which is a sinusoidal wave with a peak value of 5A. Sketch the resultant waveform and determine its RMS and average values. (5 marks)

**Module 3**

10. Draw the power triangle and define active, reactive and apparent powers in ac circuits. Two coils A and B are connected in series across a 240V, 50Hz supply. The resistance of A is 5 $\Omega$ and the inductance of B is 0.015H. If the input from the supply is 3kW and 2kVAR, find the inductance of A and the resistance of B. Also calculate the voltage across each coil.

11. A balanced three phase load consists of three coils each having resistance of 4$\Omega$ and inductance 0.02H. It is connected to a 415V, 50Hz, 3-phase ac supply. Determine the phase voltage, phase current, power factor and active power when the loads are connected in (i) star (ii) delta.

*(3x10=30)*

**PART II**

**BASIC ELECTRONICS ENGINEERING**

**PART A**

***Answer all questions; each question carries 4 marks.***

1. Give the specifications of a resistor. The colour bands marked on a resistor are Blue, Grey, Yellow and Gold. What are the minimum and maximum resistance values expected from that resistance?
2. What is meant by avalanche breakdown?
3. Explain the working of a full-wave bridge rectifier.
4. Discuss the role of coupling and bypass capacitors in a single stage RC coupled amplifier.
5. Differentiate AM and FM communication systems.

*(5x4=20)*

**PART B**

***Answer one question from each module; each question carries 10 marks.***

**Module 4**

6. a) Explain with diagram the principle of operation of an NPN transistor. (5)
   b) Sketch and explain the typical input-output characteristics of a BJT when connected in common emitter configuration. (5)

**OR**

7. a) Explain the formation of a potential barrier in a P-N junction diode. (5)
   b) What do you understand by Avalanche breakdown? Draw and explain the V-I characteristics of a P-N junction and Zener diode. (5)

**Module 5**

8. a) With a neat circuit diagram, explain the working of an RC coupled amplifier. (6)
   b) Draw the frequency response characteristics of an RC coupled amplifier and state the reasons for the reduction of gain at lower and higher frequencies. (4)

**OR**

9. a) With the help of block diagram, explain how an electronic instrumentation system. (6)
   b) Explain the principle of an antenna. (4)

**Module 6**

10. a) With the help of a block diagram, explain the working of Super hetrodyne receiver. (6)
    b) Explain the importance of antenna in a communication system. (4)

**OR**

11. a) With neat sketches explain a cellular communication system. (5)
    b) Explain GSM communication with the help of a block diagram. (5)

*(3x10=30)*

## SYLLABUS

### MODULE 1: Elementary Concepts of Electric Circuits

**Elementary concepts of DC electric circuits:** Basic Terminology including voltage, current, power, resistance, emf; Resistances in series and parallel; Current and Voltage Division Rules; Capacitors & Inductors: V-I relations and energy stored. Ohms Law and Kirchhoff's laws-Problems; Star-delta conversion (resistive networks only-derivation not required)-problems.

**Analysis of DC electric circuits:** Mesh current method - Matrix representation - Solution of network equations. Node voltage methods-matrix representation-solution of network equations by matrix methods. Numerical problems.

### MODULE 2: Elementary Concepts of Magnetic circuits, Electromagnetic Induction and AC fundamentals

**Magnetic Circuits:** Basic Terminology: MMF, field strength, flux density, reluctance - comparison between electric and magnetic circuits- Series and parallel magnetic circuits with composite materials, numerical problems.

**Electromagnetic Induction:** Faraday's laws, problems, Lenz's law- statically induced and dynamically induced emfs - Self-inductance and mutual inductance, coefficient of coupling

**Alternating Current fundamentals:** Generation of alternating voltages-Representation of sinusoidal waveforms: frequency, period, Average, RMS values and form factor of waveforms-Numerical Problems.

### MODULE 3: AC Circuits

**AC Circuits:** Phasor representation of sinusoidal quantities. Trignometric, Rectangular, Polar and complex forms. Analysis of simple AC circuits: Purely resistive, inductive & capacitive circuits; Inductive and capacitive reactance, concept of impedance. Average Power Power factor. Analysis of RL, RC and RLC series circuits-active, reactive and apparent power. Simple numerical problems.

**Three phase AC systems:** Generation of three phase voltages; advantages of three phase systems, star and delta connections (balanced only), relation between line and phase voltages, line and phase currents- Numerical problems

### MODULE 4

**Introduction to Semiconductor devices:** Evolution of electronics – Vacuum tubes to nano electronics. Resistors, Capacitors and Inductors (constructional features not required): types, specifications. Standard values, color coding. PN Junction diode: Principle of operation, V-I characteristics, principle of avalanche breakdown. Bipolar Junction Transistors: PNP and NPN structures, Principle of operation, relation between current gains in CE, CB and CC, input and output characteristics of common emitter configuration.

**MODULE 5**

**Basic electronic circuits and instrumentation:** Rectifiers and power supplies: Block diagram description of a dc power supply, Working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple zener voltage regulator. Amplifiers: Block diagram of Public Address system, Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response, Concept of voltage divider biasing. Electronic Instrumentation: Block diagram of an electronic instrumentation system.

**MODULE 6**

**Introduction to Communication Systems:** Evolution of communication systems – Telegraphy to 5G. Radio communication: principle of AM & FM, frequency bands used for various communication systems, block diagram of super heterodyne receiver, Principle of antenna – radiation from accelerated charge. Mobile communication: basic principles of cellular communications, principle and block diagram of GSM.

**Text Books**

1. D P Kothari and I J Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
2. D C Kulshreshtha, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
3. ChinmoySaha, Arindham Halder and Debarati Ganguly, Basic Electronics - Principles and Applications, Cambridge University Press, 2018.
4. M.S.Sukhija and T.K.Nagsarkar, Basic Electrical and Electronics Engineering, Oxford University Press, 2012.
5. Wayne Tomasi and Neil Storey, A Textbook On Basic Communication and Information Engineering, Pearson, 2010.

**Reference Books**

1. Del Toro V, "Electrical Engineering Fundamentals", Pearson Education.
2. T. K. Nagsarkar, M. S. Sukhija, "Basic Electrical Engineering", Oxford Higher Education.
3. Hayt W H, Kemmerly J E, and Durbin S M, "Engineering Circuit Analysis", Tata McGraw-Hill
4. Hughes, "Electrical and Electronic Technology", Pearson Education.
5. V. N. Mittle and Arvind Mittal, "Basic Electrical Engineering," Second Edition, McGraw Hill.
6. Parker and Smith, "Problems in Electrical Engineering", CBS Publishers and Distributors.
7. S. B. Lal Seksena and Kaustuv Dasgupta, "Fundamentals of Electrical Engineering", Cambridge University Press.
8. Anant Agarwal, Jeffrey Lang, Foundations of Analog and Digital Electronic Circuits, Morgan Kaufmann Publishers, 2005.
9. Bernard Grob, Ba sic Electronics, McGraw Hill.
10. A. Bruce Carlson, Paul B. Crilly, Communication Systems: An Introduction to Signals and Noise in Electrical Communication, Tata McGraw Hill, 5th Edition.

COURSE CONTENTS AND LECTURE SCHEDULE

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | ***Elementary Concepts of Electric Circuits*** | |
| 1.1 | **Elementary concepts of DC electric circuits:**<br><br>Basic Terminology including voltage, current, power, resistance, emf; Resistances in series and parallel; Current and Voltage Division Rules; Capacitors & Inductors: V-I relations and energy stored.<br><br>Ohms Law and Kirchhoff's laws-Problems;<br><br>Star-delta conversion (resistive networks only-derivation not required)-problems. | <br><br>1<br><br>2<br><br>1 |
| 1.2 | **Analysis of DC electric circuits:** Mesh current method - Matrix representation - Solution of network equations.<br><br>Node voltage methods-matrix representation-solution of network equations by matrix methods.<br><br>Numerical problems. | 1<br><br>1<br><br>2 |
| **2** | **Elementary Concepts of Magnetic circuits, Electromagnetic Induction and AC fundamentals** | |
| 2.1 | **Magnetic Circuits:** Basic Terminology: MMF, field strength, flux density, reluctance - comparison between electric and magnetic circuits-<br><br>Series and parallel magnetic circuits with composite materials, numerical problems. | 1<br><br>2 |
| 2.2 | **Electromagnetic Induction:** Faraday's laws, problems, Lenz's law-statically induced and dynamically induced emfs -<br>Self-inductance and mutual inductance, coefficient of coupling | 1<br><br>2 |
| 2.3 | **Alternating Current fundamentals:** Generation of alternating voltages-Representation of sinusoidal waveforms: frequency, period, Average, RMS values and form factor of waveforms-Numerical Problems. | 2 |
| **3** | **AC Circuits** | |

| | | |
|---|---|---|
| 3.1 | **AC Circuits:** Phasor representation of sinusoidal quantities. Trigonometric, Rectangular, Polar and complex forms.<br><br>Analysis of simple AC circuits: Purely resistive, inductive & capacitive circuits; Inductive and capacitive reactance, concept of impedance. Average Power, Power factor.<br><br>Analysis of RL, RC and RLC series circuits-active, reactive and apparent power.<br><br>Simple numerical problems. | 1<br><br>2<br><br>1<br><br>2 |
| 3.2 | **Three phase AC systems:** Generation of three phase voltages; advantages of three phase systems, star and delta connections (balanced only), relation between line and phase voltages, line and phase currents- Numerical problems. | 2 |
| **4** | **Introduction to Semiconductor devices** | |
| 4.1 | Evolution of electronics – Vacuum tubes to nano electronics (In evolutional perspective only) | 1 |
| 4.2 | Resistors, Capacitors and Inductors: types, specifications. Standard values, color coding (No constructional features) | 2 |
| 4.3 | **PN Junction diode**: Principle of operation, V-I characteristics, principle of avalanche breakdown | 2 |
| 4.4 | **Bipolar Junction Transistors:** PNP and NPN structures, Principle of operation, relation between current gains in CE, CB and CC, input and output characteristics of common emitter configuration | 3 |
| **5** | **Basic electronic circuits and instrumentation** | |
| 5.1 | **Rectifiers and power supplies:** Block diagram description of a dc power supply, Working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple zener voltage regulator | 3 |
| 5.2 | **Amplifiers:** Block diagram of Public Address system, Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response, Concept of voltage divider biasing | 4 |
| 5.3 | **Electronic Instrumentation:** Block diagram of an electronic instrumentation system | 2 |
| **6** | **Introduction to Communication Systems** | |
| 6.1 | Evolution of communication systems – Telegraphy to 5G | 1 |

| | | |
|---|---|---|
| 6.2 | **Radio communication:** principle of AM & FM, frequency bands used for various communication systems, block diagram of super heterodyne receiver, Principle of antenna – radiation from accelerated charge | 4 |
| 6.3 | **Mobile communication:** basic principles of cellular communications, principle and block diagram of GSM. | 2 |

**Suggested Simulation Assignments for Basic Electronics Engineering**

1. Plot V-I characteristics of Si and Ge diodes on a simulator
2. Plot Input and Output characteristics of BJT on a simulator
3. Implementation of half wave and full wave rectifiers
4. Simulation of RC coupled amplifier with the design supplied
5. Generation of AM signal

Note: The simulations can be done on open tools such as QUCS, KiCad, GNURadio or similar software to augment the understanding.

| 22HUT 208 | PROFESSIONAL COMMUNICATION | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | MNC | 2 | 0 | 2 | -- |

**Preamble:** Clear, precise, and effective communication has become a *sine qua non* in today's information-driven world given its interdependencies and seamless connectivity. Any aspiring professional cannot but master the key elements of such communication. The objective of this course is to equip students with the necessary skills to listen, read, write, and speak so as to comprehend and successfully convey any idea, technical or otherwise, as well as give them the necessary polish to become persuasive communicators.

**Prerequisite:** None

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Develop vocabulary and language skills relevant to engineering as a profession |
| **CO 2** | Analyze, interpret and effectively summarize a variety of textual content |
| **CO 3** | Create effective technical presentations |
| **CO 4** | Discuss a given technical/non-technical topic in a group setting and arrive at generalizations/consensus |
| **CO 5** | Identify drawbacks in listening patterns and apply listening techniques for specific needs |
| **CO 6** | Create professional and technical documents that are clear and adhering to all the necessary conventions |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | | | | | | | | | | 3 | | 2 |
| **CO 2** | | | | | | | | | | 1 | | 3 |
| **CO 3** | | | | | | 1 | | | 1 | 3 | | |
| **CO 4** | | | | | | | | | | 3 | | 1 |
| **CO 5** | | 1 | | | | | | | 2 | 3 | | |
| **CO 6** | 1 | | | | | 1 | | | 1 | 3 | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 100 | 50 | 50 | 2 hours |

**Continuous Internal Evaluation**

**Total Marks: 50**

| | |
|---|---|
| Attendance | : 10 marks |
| Regular assessment | : 25 marks |
| Series test (one test only, should include verbal aptitude for placement and higher studies, this test will be conducted for 50 marks and reduced to 15) | : 15 marks |

**Regular assessment**

| | |
|---|---|
| Project report presentation and Technical presentation through PPT | : 7.5 marks |
| Listening Test | : 5 marks |
| Group discussion/mock job interview | : 7.5 marks |
| Resume submission | : 5 marks |

**End Semester Examination**

**Total Marks: 50, Time: 2 hrs.**

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. List down the ways in which gestures affect verbal communication.
2. Match the words and meanings

   | | |
   |---|---|
   | Ambiguous | promotion |
   | Bona fide | referring to whole |
   | Holistic | not clear |
   | Exaltation | genuine |

3. Expand the following Compound Nouns - a. Water supply. b. Object recognition. c. Steam turbine

**Course Outcome 2 (CO2)**

1. Read the passage below and prepare notes:

*Mathematics, rightly viewed, possesses not only truth, but supreme beauty—a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as in poetry. What is best in mathematics deserves not merely to be learnt as a task, but to be assimilated as a part of daily thought, and brought again and again before the mind with ever-renewed encouragement. Real life is, to most men, a long second-best, a perpetual compromise between the ideal and the possible; but the world of pure reason knows no compromise, no practical limitations, no barrier to the creative activity embodying in splendid edifices the passionate aspiration after the perfect from which all great work springs. Remote from human passions, remote even from the pitiful facts of nature, the generations have gradually created an ordered cosmos, where pure thought can dwell as in its natural home, and where one, at least, of our nobler impulses can escape from the dreary exile of the actual world.*

*So little, however, have mathematicians aimed at beauty, that hardly anything in their work has had this conscious purpose. Much, owing to irrepressible instincts, which were better than avowed* *beliefs, has been moulded by an unconscious taste; but much also has been spoilt by false notions of what was fitting. The characteristic excellence of mathematics is only to be found where the reasoning is rigidly logical: the rules of logic are to mathematics what those of structure are to architecture. In the most beautiful work, a chain of argument is presented in which every link is important on its own account, in which there is an air of ease and lucidity throughout, and the premises achieve more than would have been thought possible, by means which appear natural and inevitable. Literature embodies what is general in particular circumstances whose universal significance shines through their individual dress; but mathematics endeavours to present whatever is most general in its purity, without any irrelevant trappings.*

*How should the teaching of mathematics be conducted so as to communicate to the learner as much as possible of this high ideal? Here experience must, in a great measure, be our guide; but some maxims may result from our consideration of the ultimate purpose to be achieved.*

- From "On the teaching of mathematics" – Bertrand Russell

**2.** Enumerate the advantages and disadvantages of speed reading. Discuss how it can impact comprehension.

**Course Outcome 3(CO3):**

1. What are the key elements of a successful presentation?
2. Elucidate the importance of non-verbal communication in making a presentation
3. List out the key components in a technical presentation.

**Course Outcome 4 (CO4):**

1. Discuss: 'In today's world, being a good listener is more important than being a good Speaker.'
2. Listen to a video/live group discussion on a particular topic, and prepare a brief summary of the proceedings.
3. List the do's and don'ts in a group discussion.

**Course Outcome 5 (CO5):**

1. Watch a movie clip and write the subtitles for the dialogue.
2. What do you mean by barriers to effective listening? List ways to overcome each of these.
3. What are the different types of interviews? How are listening skills particularly important in Skype/telephonic interviews?

**Course Outcome 6 (CO6):**

1. Explain the basic structure of a technical report.
2. You have been offered an internship in a much sought-after aerospace company and are very excited about it. However, the dates clash with your series tests. Write a letter to the Manager – University Relations of the company asking them if they can change the dates to coincide with your vacation.
3. You work in a well-reputed aerospace company as Manager – University Relations. You are in charge of offering internships. A student has sent you a letter requesting you to change the dates allotted to him since he has series exams at that time. But there are no vacancies available during the period he has requested for. Compose an e-mail informing him of this and suggest that he try to arrange the matter with his college.

**Syllabus**

**Module 1**

Use of language in communication: Significance of technical communication Vocabulary Development: technical vocabulary, vocabulary used in formal letters/emails and reports, sequence words, misspelled words, compound words, finding suitable synonyms, paraphrasing, verbal analogies. Language Development: subject-verb agreement, personal passive voice, numerical adjectives, embedded sentences, clauses, conditionals, reported speech, active/passive voice.

Technology-based communication: Effective email messages, slide presentations, editing skills using software. Modern day research and study skills: search engines, repositories, forums such as Git Hub, Stack Exchange, OSS communities (MOOC, SWAYAM, NPTEL), and Quora; Plagiarism

**Module 2**

Reading, Comprehension, and Summarizing: Reading styles, speed, valuation, critical reading, reading and comprehending shorter and longer technical articles from journals, newspapers, identifying the various transitions in a text, SQ3R method, PQRST method, speed reading. Comprehension: techniques, understanding textbooks, marking and underlining, Note-taking: recognizing non-verbal cues.

**Module 3**

Oral Presentation: Voice modulation, tone, describing a process, Presentation Skills: Oral presentation and public speaking skills, business presentations, Preparation: organizing the material, self-Introduction, introducing the topic, answering questions, individual presentation practice, presenting visuals effectively.

Debate and Group Discussions: introduction to Group Discussion (GD), differences between GD and debate; participating GD, understanding GD, brainstorming the topic, questioning and clarifying, GD strategies, activities to improve GD skills

**Module 4**

Listening and Interview Skills Listening: Active and Passive listening, listening: for general content, to fill up information, intensive listening, for specific information, to answer, and to understand. Developing effective listening skills, barriers to effective listening, listening to longer technical talks, listening to classroom lectures, talks on engineering /technology, listening to documentaries and making notes, TED talks.

Interview Skills: types of interviews, successful interviews, interview etiquette, dress code, body language, telephone/online (skype) interviews, one-to-one interview & panel interview, FAQs related to job interviews

## Module 5

Formal writing: Technical Writing: differences between technical and literary style. Letter Writing (formal, informal and semi formal), Job applications, Minute preparation, CV preparation (differences between Bio-Data, CV and Resume), and Reports. Elements of style, Common Errors in Writing: describing a process, use of sequence words, Statements of Purpose, Instructions, Checklists.

Analytical and issue-based Essays and Report Writing: basics of report writing; Referencing Style (IEEE Format), structure of a report; types of reports, references, bibliography.

**Lab Activities**

**Written:** Letter writing, CV writing, Attending a meeting and Minute Preparation, Vocabulary Building
**Spoken:** Phonetics, MMFS (Multimedia Feedback System), Mirroring, Elevator Pitch, telephone etiquette, qualities of a good presentation with emphasis on body language and use of visual aids.
**Listening**: Exercises based on audio materials like radio and podcasts. Listening to Song. practice and exercises.
**Reading**: Speed Reading, Reading with the help of Audio Visual Aids, Reading Comprehension Skills
**Mock interview and Debate/Group Discussion:** concepts, types, Do's and don'ts- intensive practice

**Reference Books**


1. English for Engineers and Technologists (Combined edition, Vol. 1 and 2), Orient Blackswan 2010.
2. Meenakshi Raman and Sangeetha Sharma,"Technical Communication: Principles and Practice", 2nd Edition, Oxford University Press, 2011
3. Stephen E. Lucas, "The Art of Public Speaking", 10th Edition; McGraw Hill Education, 2012.
4. Ashraf Rizvi, "Effective Technical Communication", 2nd Edition, McGraw Hill Education, 2017.
5. William Strunk Jr. & E.B. White, "The Elements of Style", 4th Edition, Pearson, 1999.
6. David F. Beer and David McMurrey, Guide to writing as an Engineer, John Willey. New York, 2004.
7. Goodheart-Willcox, "Professional Communication", First Edition , 2017.
8. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India, 6 edition, 2015.
9. The Ace of Soft Skills: Attitude, Communication and Etiquette for Success, Pearson Education; 1 edition, 2013.
10. Anand Ganguly, "Success in Interview", RPH, 5th Edition, 2016.
11. Raman Sharma, "Technical Communications", Oxford Publication, London, 2004.

| 22EST209 | PROGRAMING IN C | CATEGORY | L | T | P | CREDIT | YEAR OF INTRODUCTION |
|---|---|---|---|---|---|---|---|
| | | ESC | 2 | 1 | 2 | 4 | 2019 |

**Preamble:** The syllabus is prepared with the view of preparing the Engineering Graduates capable of writing readable C programs to solve computational problems that they may have to solve in their professional life. The course content is decided to cover the essential programming fundamentals which can be taught within the given slots in the curriculum. This course has got 2 Hours per week for practicing programming in C. A list showing 24 mandatory programming problems are given at the end. The instructor is supposed to give homework/assignments to write the listed programs in the rough record as and when the required theory part is covered in the class. The students are expected to come prepared with the required program written in the rough record for the lab classes.

**Prerequisite: NIL**

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Analyze a computational problem and develop an algorithm/flowchart to find its solution |
| **CO 2** | Develop readable* C programs with branching and looping statements, which uses Arithmetic, Logical, Relational or Bitwise operators. |
| **CO 3** | Write readable C programs with arrays, structure or union for storing the data to be processed |
| **CO 4** | Divide a given computational problem into a number of modules and develop a readable multi-function C program by using recursion if required, to find the solution to the computational problem |
| **CO 5** | Write readable C programs which use pointers for array processing and parameter passing |
| **CO 6** | Develop readable C programs with files for reading input and storing output |
| readable* - readability of a program means the following:<br>1. Logic used is easy to follow<br>2. Standards to be followed for indentation and formatting<br>3. Meaningful names are given to variables<br>4. Concise comments are provided wherever needed | |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | ✔ | ✔ | ✔ | ✔ | | ✔ | | | | ✔ | ✔ | ✔ |
| **CO2** | ✔ | ✔ | ✔ | ✔ | ✔ | | | | | ✔ | | ✔ |
| **CO3** | ✔ | ✔ | ✔ | ✔ | ✔ | | | | | ✔ | | ✔ |
| **CO4** | ✔ | ✔ | ✔ | ✔ | ✔ | | | | | ✔ | ✔ | ✔ |
| **CO5** | ✔ | ✔ | | | ✔ | | | | | ✔ | | ✔ |
| **CO6** | ✔ | ✔ | | | ✔ | | | | | ✔ | | ✔ |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination Marks** |
|---|---|---|---|
| | **Test 1 (Marks)** | **Test 2 (Marks)** | |
| Remember | 15 | 10 | 25 |
| Understand | 10 | 15 | 25 |
| Apply | 20 | 20 | 40 |
| Analyse | 5 | 5 | 10 |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| **Total Marks** | **CIE Marks** | **ESE Marks** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test 1 (for theory, for 2 hrs) | : 20 marks |
| Continuous Assessment Test 2 (for lab, internal examination, for 2 hrs) | : 20 marks |

**Internal Examination Pattern:** There will be two parts; Part A and Part B. Part A contains 5 questions with 2 questions from each module (2.5 modules x 2 = 5), having 3 marks for each question. Students should answer all questions. Part B also contains 5 questions with 2 questions from each module (2.5 modules x 2 = 5), of which a student should answer any one. The questions should not have sub-divisions and each one carries 7 marks.

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Sample Course Level Assessment Questions**

**Course Outcome 1 (CO1):** Write an algorithm to check whether largest of 3 natural numbers is prime or not. Also, draw a flowchart for solving the same problem.

**Course Outcome 2 (CO2):** Write an easy to read C program to process a set of n natural numbers and to find the largest even number and smallest odd number from the given set of numbers. The program should not use division and modulus operators.

**Course Outcome 3(CO3):**Write an easy to read C program to process the marks obtained by n students of a class and prepare their rank list based on the sum of the marks obtained. There are 3 subjects for which examinations are conducted and the third subject is an elective where a student is allowed to take any one of the two courses offered.

**Course Outcome 4 (CO4):** Write an easy to read C program to find the value of a mathematical function f which is defined as follows. f(n) = n! / (sum of factors of n), if n is not prime and f(n) = n! / (sum of digits of n), if n is prime.

**Course Outcome 5 (CO5):** Write an easy to read C program to sort a set of n integers and to find the number of unique numbers and the number of repeated numbers in the given set of numbers. Use a function which takes an integer array of n elements, sorts the array using the Bubble Sorting Technique and returns the number of unique numbers and the number of repeated numbers in the given array.

**Course Outcome 6 (CO6):** Write an easy to read C program to process a text file and to print the Palindrome words into an output file.

**Model Question paper**

**QP CODE:** PAGES:3

Reg No:______________

Name :______________

**TKM COLLEGE OF ENGINEERING FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

***Course Code:*** **22EST209**

**Course Name: Programming in C (Common to all programs)**

**Max.Marks:100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Write short note on processor and memory in a computer.
2. What are the differences between compiled and interpreted languages? Give example for each.
3. Write a C program to read a Natural Number through keyboard and to display the reverse of the given number. For example, if "3214567" is given as input, the output to be shown is "7654123".
4. Is it advisable to use *goto* statements in a C program? Justify your answer.
5. Explain the different ways in which you can *declare & initialize* a single dimensional array.
6. Write a C program to read a sentence through keyboard and to display the count of white spaces in the given sentence.
7. What are the advantages of using functions in a program?
8. With a simple example program, explain *scope* and *life time* of variables in C.
9. Write a function in C which takes the address of a single dimensional array (containing a finite sequence of numbers) and the number of numbers stored in the array as arguments and stores the numbers in the same array in reverse order. Use pointers to access the elements of the array.
10. With an example, explain the different modes of opening a file. (10x3=30)

**Part B**

**Answer any one Question from each module. Each question carries 14 Marks**

11. (a) Draw a flow chart to find the position of an element in a given sequence, using linear searching technique. With an example explain how the flowchart finds the position of a given element. **(10)**

    (b) Write a pseudo code representing the flowchart for linear searching. **(4)**

**OR**

12. (a) With the help of a flow chart, explain the bubble sort operation. Illustrate with an example. **(10)**

(b) Write an algorithm representing the flowchart for bubble sort. **(4)**

13. (a) Write a C program to read an English Alphabet through keyboard and display whether the given Alphabet is in upper case or lower case. **(6)**

(b) Explain how one can use the builtin function in C, *scanf*to read values of different data types. Also explain using examples how one can use the builtin function in C, *printf*for text formatting. **(8)**

**OR**

14. (a) With suitable examples, explain various operators in C. (10)

(b) Explain how characters are stored and processed in C. **(4)**

15. (a) Write a function in C which takes a 2-Dimensional array storing a matrix of numbers and the order of the matrix (number of rows and columns) as arguments and displays the sum of the elements stored in each row. **(6 )**

(b) Write a C program to check whether a given matrix is a diagonal matrix. **(8)**

**OR**

16. (a) Without using any builtin string processing function like *strlen*, *strcat* etc., write a program to concatenate two strings. **(8)**

(b) Write a C program to perform bubble sort. **(6)**

17. (a) Write a function namely *myFact* in C to find the factorial of a given number. Also, write another function in C namely*nCr* which accepts two positive integer parameters *n* and *r* and returns the value of the mathematical function*C(n,r)*( n! / ( r! x (n - r)!) ). The function *nCr* is expected to make use of the factorial function *myFact.* *(10)*

*(b)* What is recursion? Give an example. **(4)**

**OR**

18. (a) With a suitable example, explain the differences between a structure and a union in C. **(6)**

**(b)** Declare a structure namely *Student* to store the details (*roll number, name, mark_for_C*) of a student. Then, write a program in C to find the average mark obtained by the students in a class for the subject *Programming in C* (using the field *mark_for_C*). Use array of structures to store the required data **(8)**

19. (a) With a suitable example, explain the concept of pass by reference. **(6)**

(b) With a suitable example, explain how pointers can help in changing the content of a single dimensionally array passed as an argument to a function in C. **(8)**

**OR**

20. (a) Differentiate between sequential files and random access files? **(4)**

(b) Using the prototypes explain the functionality provided by the following functions. (10)

*rewind()*

i. *fseek()*

ii. *ftell()*

iii. *fread()*

**iv.** *fwrite()* ***(14X5=70)***

**SYLLABUS**

**Programming in C (Common to all disciplines)**

**Module 1**

**Basics of Computer Hardware and Software**

Basics of Computer Architecture: processor, Memory, Input& Output devices

Application Software & System software: Compilers, interpreters, High level and low level languages

Introduction to structured approach to programming, Flow chart Algorithms, Pseudo code (*bubble sort, linear search - algorithms and pseudocode*)

**Module 2**

**Program Basics**

Basic structure of C program: Character set, Tokens, Identifiers in C, Variables and Data Types , Constants, Console IO Operations, printf and scanf

Operators and Expressions: Expressions and Arithmetic Operators, Relational and Logical Operators, Conditional operator, size of operator, Assignment operators and Bitwise Operators. Operators Precedence

Control Flow Statements: If Statement, Switch Statement, Unconditional Branching using goto statement, While Loop, Do While Loop, For Loop, Break and Continue statements.(Simple programs covering control flow)

**Module 3**

**Arrays and strings**

Arrays Declaration and Initialization, 1-Dimensional Array, 2-Dimensional Array

String processing: In built String handling functions (strlen, strcpy, strcat and strcmp, puts, gets)

Linear search program, bubble sort program, simple programs covering arrays and strings

**Module 4**

**Working with functions**

Introduction to modular programming, writing functions, formal parameters, actual parameters Pass by Value, Recursion, Arrays as Function Parameters structure, union, Storage Classes, Scope and life time of variables, *simple programs using functions*

## Module 5

**Pointers and Files**

Basics of Pointer: declaring pointers, accessing data though pointers, NULL pointer,array access using pointers, pass by reference effect

File Operations: open, close, read, write, append

Sequential access and random access to files: In built file handlingfunctions (*rewind() ,fseek(), ftell(), feof(), fread(), fwrite()*), *simple programs covering pointers and files.*

**Text Books**

1. Schaum Series, Gottfried B.S.,Tata McGraw Hill,Programming with C
2. E. Balagurusamy, Mcgraw Hill,Programming in ANSI C
3. Asok N Kamthane, Pearson,Programming in C
4. Anita Goel, Pearson, Computer Fundamentals

**Reference Books**

1. Anita Goel and Ajay Mittal, Pearson, Computer fundamentals and Programming in C
2. Brian W. Kernighan and Dennis M. Ritchie, Pearson, C Programming Language
3. Rajaraman V, PHI, Computer Basics and Programming in C
4. Yashavant P, Kanetkar, BPB Publications, Let us C

**Course Contents and Lecture Schedule**

| | | |
|---|---|---|
| | **Module 1: Basics of Computer Hardware and Software** | **(7 hours)** |
| **1.1** | **Basics of Computer Architecture:** Processor, Memory, Input& Output devices | **2 hours** |
| **1.2** | **Application Software & System software:** Compilers, interpreters, High level and low level languages | **2 hours** |
| **1.3** | Introduction to structured approach to programming, Flow chart | **1 hours** |
| **1.4** | Algorithms, Pseudo code (*bubble sort, linear search - algorithms and pseudocode*) | **2 hours** |
| **Module 2: Program Basics** | | **(8 hours)** |
| **2.1** | **Basic structure of C program:** Character set, Tokens, Identifiers in C, Variables and Data Types , Constants, Console IO Operations, printf and scanf | **2 hours** |
| **2.2** | **Operators and Expressions:** Expressions and Arithmetic Operators, Relational and Logical Operators, Conditional operator, sizeof operator, Assignment operators and Bitwise Operators. Operators Precedence | **2 hours** |

| | | |
|---|---|---|
| **2.3** | **Control Flow Statements:** If Statement, Switch Statement, Unconditional Branching using goto statement, While Loop, Do While Loop, For Loop, Break and Continue statements.*(Simple programs covering control flow)* | **4 hours** |
| **Module 3: Arrays and strings:** | | **(6 hours)** |
| **3.1** | Arrays Declaration and Initialization, 1-Dimensional Array, 2-Dimensional Array | **2 hours** |
| **3.2** | **String processing:** In built String handling functions(*strlen, strcpy, strcat and strcmp, puts, gets*) | **2 hours** |
| **3.3** | Linear search program, bubble sort program, *simple programs covering arrays and strings* | **3 hours** |
| **Module 4: Working with functions** | | **(7 hours)** |
| **4.1** | Introduction to modular programming, writing functions, formal parameters, actual parameters | **2 hours** |
| **4.2** | Pass by Value, Recursion, Arrays as Function Parameters | **2 hours** |
| **4.3** | structure, union, Storage Classes,Scope and life time of variables, *simple programs using functions* | **3 hours** |
| **Module 5: Pointers and Files** | | **(7 hours)** |
| **5.1** | **Basics of Pointer**: declaring pointers, accessing data though pointers, NULL pointer,array access using pointers, pass by reference effect | **3 hours** |
| **5.2** | **File Operations**: open, close, read, write, append | 1 **hours** |
| **5.3** | **Sequential access and random access to files:** In built file handlingfunctions (*rewind() ,fseek(), ftell(), feof(), fread(), fwrite()*)**,** *simple programs covering pointers and files.* | **2 hours** |

**C PROGRAMMING LAB (Practical part of EST 102, Programming in C)**

**Assessment Method**: The Academic Assessment for the Programming lab should be done internally by the College. The assessment shall be made on 50 marks and the mark is divided as follows: Practical Records/Outputs - 20 marks (internal by the College), Regular Lab Viva - 5 marks (internal by the College), Final Practical Exam – 25 marks (internal by the College).

**The mark obtained out of 50 will be converted into equivalent proportion out of 20 for CIE computation.**

## LIST OF LAB EXPERIMENTS

**1**. Familiarization of Hardware Components of a Computer

**2**. Familiarization of Linux environment – How to do Programming in C with Linux

**3**. Familiarization of console I/O and operators in C

i) Display "Hello World"

ii) Read two numbers, add them and display theirsum

iii) Read the radius of a circle, calculate its area and display it

iv)Evaluate the arithmetic expression ((a -b / c * d + e) * (f +g)) and display its solution.Read the values of the variables from the user through console.

**4**. Read 3 integer values and find the largest amoung them.

**5**. Read a Natural Number and check whether the number is prime or not

**6.** Read a Natural Number and check whether the number is Armstrong or not

**7.** Read n integers, store them in an array and find their sum and average

**8**. Read n integers, store them in an array and search for an element in the array using an algorithm for Linear Search

**9**. Read n integers, store them in an array and sort the elements in the array using Bubble Sort algorithm

10**.** Read a string (word), store it in an array and check whether it is a palindrome word or not.

**11.**Read two strings (each one ending with a $ symbol), store them in arrays and concatenate them without using library functions.

12. Read a string (ending with a $ symbol), store it in an array and count the number of vowels, consonants and spaces in it.

**13.** Read two input each representing the distances between two points in the Euclidean space, store these in structure variables and add the two distance values.

**14**. Using structure, read and print data of n employees (*Name, Employee Id and Salary*)

**15.** Declare a union containing 5 string variables (*Name, House Name, City Name, State and Pin code*) each with a length of C_SIZE (user defined constant). Then, read and display the address of a person using a variable of the union.

**16.** Find the factorial of a given Natural Number n usingrecursive and non recursive functions

**17. R**ead a string (word), store it in an array and obtain its reverse by using a user defined function.

**18**. Write a menu driven program for performing matrix addition, multiplication and finding the transpose. Use functions to (i) read a matrix, (ii) find the sum of two matrices, (iii) find the product of two matrices, (i) find the transpose of a matrix and (v) display a matrix.

**19.** Do the following using pointers

**i)** add two numbers

**ii)** swap two numbers using a user defined function

**20.** Input and Print the elements of an array using pointers

**21.** Compute sum of the elements stored in an array using pointers and user defined function.

**22**. Create a file and perform the following

**iii)** Write data to the file

**iv)** Read the data in a given file & display the file content on console

**v)** append new data and display on console

**23**. Open a text input file and count number of characters, words and lines in it; and store the results in an output file.

| 22PHL210 | ENGINEERING PHYSICS LAB | CATEGORY | L | T | P | CREDIT | YEAR OF INTRODUCTION |
|---|---|---|---|---|---|---|---|
| | | BSC | 0 | 0 | 2 | 1 | 2019 |

**Preamble:** The aim of this course is to make the students gain practical knowledge to co-relate with the theoretical studies and to develop practical applications of engineering materials and use the principle in the right way to implement the modern technology.

**Prerequisite:** Higher secondary level Physics

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Develop analytical/experimental skills and impart prerequisite hands on experience for engineering laboratories |
| **CO 2** | Understand the need for precise measurement practices for data recording |
| **CO 3** | Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations |
| **CO 4** | Analyze the techniques and skills associated with modern scientific tools such as lasers and fiber optics |
| **CO 5** | Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | | | 3 | | | 1 | 2 | | | 1 |
| **CO 2** | 3 | | | | 3 | | | 1 | 2 | | | 1 |
| **CO 3** | 3 | | | | 3 | | | 1 | 2 | | | 1 |
| **CO 4** | 3 | | | | 3 | | | 1 | 2 | | | 1 |
| **CO 5** | 3 | | | | 3 | | | 1 | 2 | | | 1 |

**Mark distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration(Internal) |
|---|---|---|---|
| 100 | 100 | - | 1 hour |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 20 marks |
| Class work/ Assessment /Viva-voce | : 50 marks |
| End semester examination (Internally by college) | : 30 marks |

**End Semester Examination Pattern:** Written Objective Examination of one hour

**SYLLABUS**

**LIST OF EXPERIMENTS**

**(Minimum 8 experiments should be completed)**

1. CRO-Measurement of frequency and amplitude of wave forms
2. Measurement of strain using strain gauge and wheatstone bridge
3. LCR Circuit – Forced and damped harmonic oscillations
4. Melde's string apparatus- Measurement of frequency in the transverse and longitudinal mode
5. Wave length measurement of a monochromatic source of light using Newton's Rings method.
6. Determination of diameter of a thin wire or thickness of a thin strip of paper using air wedge method.
7. To measure the wavelength using a millimeter scale as a grating.
8. Measurement of wavelength of a source of light using grating.
9. Determination of dispersive power and resolving power of a plane transmission grating
10. Determination of the particle size of lycopodium powder
11. Determination of the wavelength of He-Ne laser or any standard laser using diffraction grating
12. Calculate the numerical aperture and study the losses that occur in optical fiber cable.
13. I-V characteristics of solar cell.
14. LED Characteristics.
15. Ultrasonic Diffractometer- Wavelength and velocity measurement of ultrasonic waves in a liquid
16. Deflection magnetometer-Moment of a magnet- Tan A position.

**Reference books**


1. S.L.Gupta and Dr.V.Kumar, "Practical physics with viva voice", Pragati PrakashanPublishers, Revised Edition, 2009

2. M.N.Avadhanulu, A.A.Dani and Pokely P.M, "Experiments in Engineering Physics", S.Chand&Co,2008

3. S. K. Gupta, "Engineering physics practicals", Krishna Prakashan Pvt. Ltd., 2014

4. P. R. Sasikumar "Practical Physics", PHI Ltd., 2011.

| 22ESL213 | **ELECTRICAL & ELECTRONICS WORKSHOP** | CATEGORY | L | T | P | CREDIT | YEAR OF INTRODUCTION |
|---|---|---|---|---|---|---|---|
| | | ESC | 0 | 0 | 2 | 1 | 2019 |

**Preamble:** Electrical Workshop is intended to impart skills to plan and carry out simple electrical wiring. It is essential for the practicing engineers to identify the basic practices and safety measures in electrical wiring.

**Prerequisite:** NIL

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Demonstrate safety measures against electric shocks. |
| **CO 2** | Identify the tools used for electrical wiring, electrical accessories, wires, cables, batteries and standard symbols |
| **CO 3** | Develop the connection diagram, identify the suitable accessories and materials necessary for wiring simple lighting circuits for domestic buildings |
| **CO 4** | Identify and test various electronic components |
| **CO 5** | Draw circuit schematics with EDA tools |
| **CO 6** | Assemble and test electronic circuits on boards |
| **CO 7** | Work in a team with good interpersonal skills |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | - | - | - | - | - | 3 | - | - | - | - | - | 1 |
| **CO 2** | 2 | - | - | - | - | - | - | - | - | 1 | - | - |
| **CO 3** | 2 | - | - | 1 | - | 1 | - | 1 | 2 | 2 | - | 2 |
| **CO 4** | 3 | - | - | - | - | - | - | - | - | - | - | 2 |
| **CO 5** | 3 | - | - | - | 2 | - | - | - | - | - | - | 2 |
| **CO 6** | 3 | - | - | - | 2 | - | - | - | - | - | - | 1 |
| **CO 7** | - | - | - | - | - | - | - | - | 3 | 2 | - | 2 |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration(Internal) |
|---|---|---|---|
| 100 | 100 | - | 1 hour |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 20 marks |
| Class work/ Assessment /Viva-voce | : 50 marks |
| End semester examination (Internally by college) | : 30 marks |

**End Semester Examination Pattern:** Written Objective Examination of one hour

## Syllabus

## PART 1

## ELECTRICAL

### List of Exercises / Experiments

1. a) Demonstrate the precautionary steps adopted in case of Electrical shocks.

   b)Identify different types of cables, wires, switches, fuses, fuse carriers, MCB, ELCB and MCCB with ratings.
2. Wiring of simple light circuit for controlling light/ fan point (PVC conduit wiring)
3. Wiring of light/fan circuit using Two way switches . (Staircase wiring)
4. Wiring of Fluorescent lamps and light sockets (6A) with a power circuit for controlling power device. (16A socket)
5. Wiring of power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter.
6. a)Identify different types of batteries with their specifications.

   b)Demonstrate the Pipe and Plate Earthing Schemes using Charts/Site Visit.

## PART II

## ELECTRONICS

### List of Exercises / Experiments (Minimum of 7 mandatory)

1. Familiarization/Identification of electronic components with specification (Functionality, type, size, colour coding, package, symbol, cost etc. [Active, Passive, Electrical, Electronic, Electro-mechanical, Wires, Cables, Connectors, Fuses, Switches, Relays, Crystals, Displays, Fasteners, Heat sink etc.)

2. Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools (such as Dia or XCircuit), Interpret data sheets of discrete components and IC's, Estimation and costing.

3. Familiarization/Application of testing instruments and commonly used tools. [Multimeter, Function generator, Power supply, DSO etc.] [Soldering iron, De-soldering pump, Pliers, Cutters, Wire strippers, Screw drivers, Tweezers, Crimping tool, Hot air soldering and de- soldering station etc.]

4. Testing of electronic components [Resistor, Capacitor, Diode, Transistor and JFET using multimeter.]

5. Inter-connection methods and soldering practice. [Bread board, Wrapping, Crimping, Soldering - types - selection of materials and safety precautions, soldering practice in connectors and general purpose PCB, Crimping.]

6. Printed circuit boards (PCB) [Types, Single sided, Double sided, PTH, Processing methods, Design and fabrication of a single sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.]
7. Assembling of electronic circuits using SMT (Surface Mount Technology) stations.
8. Assembling of electronic circuit/system on general purpose PCB, test and show the functioning (**Any Two circuits).**

    1. Fixed voltage power supply with transformer, rectifier diode, capacitor filter, zener/IC regulator.
    2. Square wave generation using IC 555 timer in IC base.
    3. Sine wave generation using IC 741 OP-AMP in IC base.
    4. RC coupled amplifier with transistor BC107.

# SEMESTER III

**Syllabus**

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| 22EET 302 | CIRCUITS AND NETWORKS | PCC | 2 | 2 | 0 | 4 |

**Preamble** : This course introduces circuit analysis techniques applied to dc and ac electric circuits. Analyses of electric circuits in steady state and dynamic conditions are discussed. Network analysis is introduced with network parameters and transfer functions. This course serves as the most important prerequisite of all many advanced courses in electrical engineering.

**Prerequisite** : **Basics of Electrical Engineering / Introduction to Electrical Engineering**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Apply circuit theorems to simplify and solve complex DC and AC electric networks. |
| **CO 2** | Analyse dynamic DC and AC circuits and develop the complete response to excitations. |
| **CO 3** | Solve dynamic circuits by applying transformation to s-domain. |
| **CO 4** | Analyse three-phase networks in Y and Δ configurations. |
| **CO 5** | Solve series /parallel resonant circuits. |
| **CO 6** | Develop the representation of two-port networks using network parameters and analyse. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | 2 |
| **CO 5** | 3 | 3 | | | | | | | | | | 2 |
| **CO 6** | 3 | 3 | | | | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**
**Course Outcome 1 (CO1):**

1. State and explain network theorems (K1)
2. Problems on solving circuits using network theorems. (K2, K3)

**Course Outcome 2 (CO2):**

1. Distinguish between the natural response and forced response. (K2, K3)
2. Problems on steady state and transient analysis of RL, RC and RLC series circuits with DC excitation and initial conditions. (K2, K3)
3. Problems on steady state and transient analysis of RL, RC and RLC series circuits with sinusoidal excitation. (K2, K3)

**Course Outcome 3 (CO3):**

1. Problems on mesh analysis and node analysis of transformed circuits in s-domain (K2, K3).
2. Problems on solution of transformed circuits including mutually coupled circuits in s-domain (K2, K3).

**Course Outcome 4 (CO4):**

1. Problems on analysis of unbalanced Y and Δ configurations. (K2, K3)
2. Evaluation of neutral shift voltage in unbalanced systems. (K2, K3).

**Course Outcome 5 (CO5):**

1. Define Bandwidth, and draw the frequency dependence of impedance of an RLC network. (K1).
2. Develop the impedance/admittance Vs frequency plot for the given RLC network. (K2).
3. Evalutate the parameters such as quality factor, bandwidth,

**Course Outcome 6 (CO6):**

1. Problems on finding Z, Y, h and T parameters of simple two port networks. (K2).
2. Derive the expression for Z parameters in terms of T parameters. (K1).
3. Show that the overall transmission parameter matrix for cascaded 2 port network is simply the matrix product of transmission parameters for each individual 2 port network in cascade. (K1).

**Model Question paper**

**QP CODE:**

PAGES:4

Reg. No:_______________
Name:_______________

**TKM COLLEGE OF ENGINEERING**
**THIRD SEMESTER B. TECH DEGREE EXAMINATION,**
**MONTH & YEAR**

**Course Code: 22EET 302**

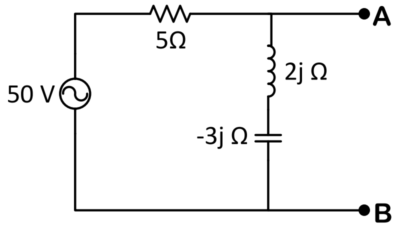
**Course Name: CIRCUITS AND NETWORKS**

Max. Marks: 100 Duration: 3 Hours

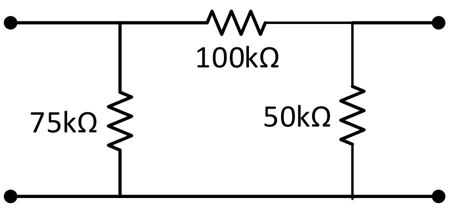
**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. State and explain superposition theorem using an example.
2. Obtain Thevenin's equivalent for the following circuit w.r.t terminals A and B:



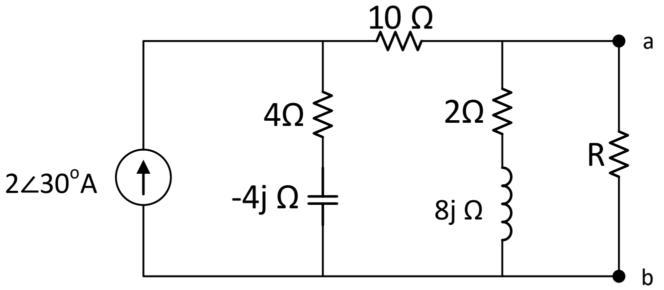

3. Define time constant of a circuit. What is the time constant of an RL circuit?
4. How are RLC networks classified according to damping ratios? Sketch the various responses when an RLC series circuit is excited by a DC source.
5. Explain the dot convention used in coupled circuits.
6. Derive the s-domain equivalent circuit of an inductor carrying an initial current of Io.
7. Describe the variation of impedance and phase angle as a function of frequency in a series RLC circuit.
8. Define quality factor. Derive quality factor for inductive and capacitive circuits.
9. Derive the condition for symmetry & reciprocity in terms of T parameters.
10. Obtain Y parameters of the following network:



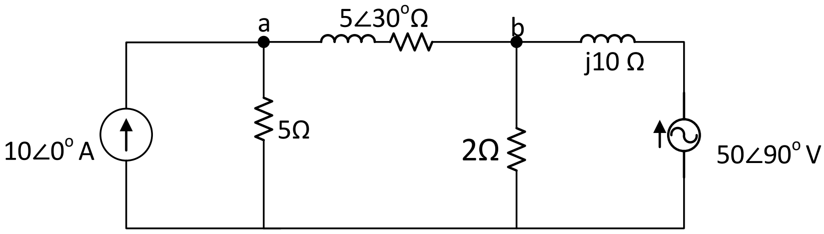
**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. With respect to the following circuit,
   a) Find the value of Resistor 'R' that results in maximum power transfer to it. **(10)**
   b) Find the value of maximum power transferred to 'R'. **(4)**

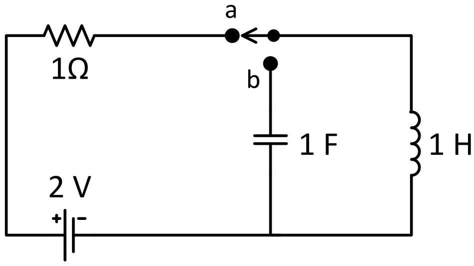



12. With respect to the following circuit,
   a) Find the voltages at 'a' and 'b' using superposition theorem. **(10)**
   b) Obtain the active power dissipated in $5\angle 30^{o}\Omega$ impedance. **(4)**

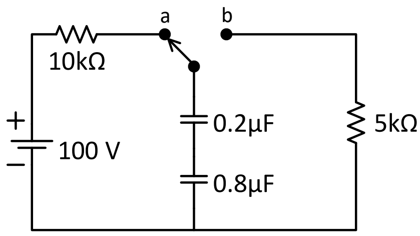



**Module 2**

13. a) In the following circuit, steady state exits when switch is in position 'a'. At time t = 0, the switch is moved to position 'b' .Obtain an expression for inductor current for time t > 0 **(6)**

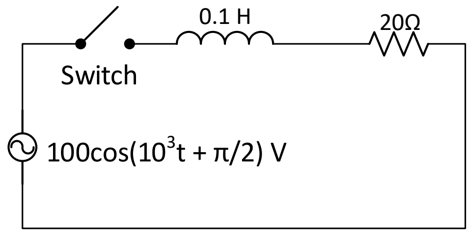



   b) For the following circuit, switch 'S' is in position 'a' for a very long time. At time t = 0, the switch is thrown to position 'b'. Find the expression for current through 5kΩ. **(8)**



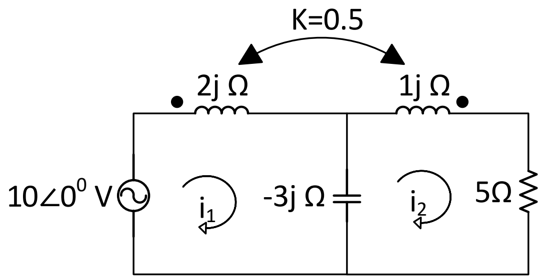
14. a) Given an RC circuit with zero initial charge on capacitor. Find the expression forcurrent after a DCsource '$V_{DC}$' is applied to the RC network. Also determine thetime constantofthe circuit. **(4)**

b) Obtain an expression for current in the following circuit after switch is closed attime t=0. Use Laplace transform method. **(10)**

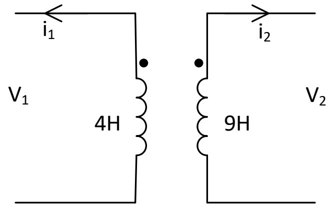



**Module 3**

15. a) For the following coupled circuit, the coupling coefficient, K =0.5. Write the KVL equations for currents $i_1$ and $i_2$. Also obtain the voltage drop across 5Ω resistor. **(10)**



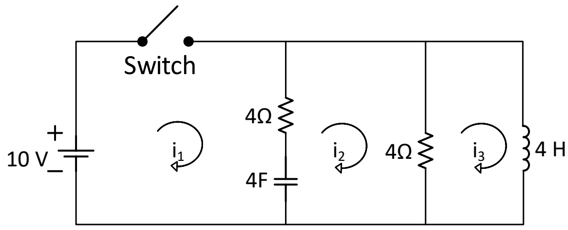

b) In figure, $L_1$=4H, $L_2$=9H, coefficient of coupling K=0.5,$i_1$ = 5 cos(50t-300) Amps, $i_2$ = 2cos(50t-300) Amps. Write the KVL equations for $V_1$ and $V_2$. Find their values at t=0 **(4)**




16. In the circuit shown, at time t = 0, the switch was closed.

a. Model the circuit in s-domain for time t > 0. **(4)**

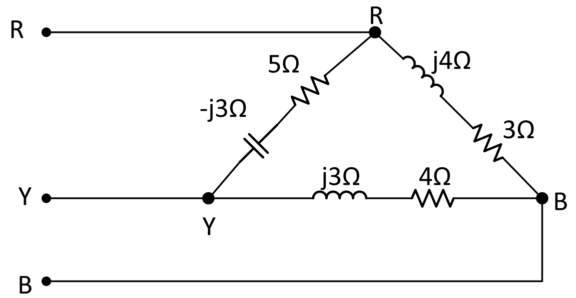
b. Through mesh analysis, obtain the time domain values of values of $i_1$, $i_2$ and $i_3$ Given that the capacitor and inductor were initially relaxed. **(10)**



## Module 4

17. The following load is delta connected to a 100V three phase system. Find the phase currents, line currents and total power consumed by the load.

**(14)**




18. An unbalanced 4 wire, star connected load is connected to a balanced voltage of 400V.

The loads are: $Z_1 = (3 + 6j)\Omega; Z_2 = (2 + 2j)\Omega; Z_3 = (14 + 18j)\Omega$

Calculatea) Line currents **(4)**

b) Current in neutral wire **(4)**

c) Total power **(6)**

## Module 5

19. a) Discuss series and parallel interconnection of 2-port networks.

**(7)**

b) Derive the inter-relationship between Z and Y parameters.

**(7)**

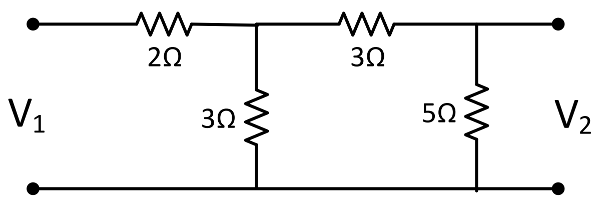
20. a) A network is given as $I_1 = 2.5V_1 - V_2; I_2 = -V_1 + 5V_2$

Draw its equivalent $\pi$ network.

**(4)**

b) Obtain h parameters of the following network:

**(10)**



## Syllabus

### Module 1

**Circuit theorems:** DC and Sinusoidal steady state analysis of circuits with dependent and independent sources applying Superposition principle, Source transformation, Thevenin’s, Norton’s and Maximum Power Transfer theorems - Reciprocity theorem.

### Module 2

**Analysis of first and second order dynamic circuits:** Formulation of dynamic equations of RL, RC and RLC series and parallel networks with dc excitation and initial conditions and complete solution using Laplace Transforms - Time constant - Complete solution of RL, RC and RLC circuits with sinusoidal excitation using Laplace Transforms – Damping ratio – Over damped, under damped, critically damped and undamped RLC networks.

### Module 3

**Transformed circuits in s-domain:** Transform impedance/admittance of R, L and C - Mesh analysis and node analysis of transformed circuits in s-domain. Transfer Function representation – Poles and zeros.

**Analysis of Coupled Circuits:** – Dot polarity convention – Sinusoidal steady state analysis of coupled circuits - Linear Transformer as a coupled circuit - Analysis of coupled circuits in s-domain.

### Module 4

**Three phase networks and resonance:**Complex Power in sinusoidal steady state. Steady state analysis of three-phase three-wire and four-wire unbalanced Y circuits, Unbalanced Delta circuit, Neutral shift.

Resonance in Series and Parallel RLC circuits – Quality factor – Bandwidth – Impedance Vs Frequency, Admittance Vs Frequency, Phase angle Vs frequency for series resonant circuit.

### Module 5

**Two port networks**: Driving point and transfer functions – Z, Y, h and T parameters **-** Conditions for symmetry & reciprocity – relationship between parameter sets – interconnections of two port networks (series, parallel and cascade) — T-π transformation.

### Text Books


1. Joseph A. Edminister and MahmoodNahvi, "Theory and Problems in Electric circuits", McGraw Hill, 5th Edition, 2010.
2. Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013

**References:**


1. Hayt and Kemmerly, “Engineering Circuit Analysis”, McGraw Hill Education, New Delhi, 8th Ed, 2013.
2. Van Valkenberg, "Network Analysis", Prentice Hall India Learning Pvt. Ltd., 3 edition, 1980.
3. K. S. Suresh Kumar, “Electric Circuit Analysis”, Pearson Publications, 2013.
4. Chakrabarti, "Circuit Theory Analysis and Synthesis", DhanpatRai& Co., Seventh - Revised edition, 2018
5. R. Gupta, "Network Analysis and Synthesis", S. Chand & Company Ltd, 2010.


**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Network theorems - DC and AC steady state analysis (12 hours)** | |
| 1.1 | Linearity and Superposition principle - Application to the analysis of DC and AC (sinusoidal excitation) circuits. Application of source transformation in electric circuit analysis. | 2 |
| 1.2 | Thevenin’s theorem - Application to the analysis of DC and AC circuits with dependent and independent sources. | 3 |
| 1.3 | Norton’s theorem - Application to the analysis of DC and AC circuits with dependent and independent sources. | 3 |
| 1.4 | Maximum power transfer theorem - DC and AC steady state analysis with dependent and independent sources. | 2 |
| 1.5 | Reciprocity Theorem - Application to the analysis of DC and AC Circuits. | 2 |
| **2** | **First order and second order dynamic circuits. (9 hours)** | |
| 2.1 | Review of Laplace Transforms – Formulae of Laplace Transforms of common functions/signals, Initial value theorem and final value theorem, Inverse Laplace Transforms – partial fraction method. *(Questions to evaluate the Laplace/inverse transforms of any function / partial fractions method shall not be given in tests/final examination. Problems with application to circuits can be given).* | 2 |
| 2.2 | Formulation of dynamic equations of RL series and parallel networks and solution using Laplace Transforms – with DC excitation and initial conditions. Natural response and forced response. Time constant. | 1 |

| | | |
|---|---|---|
| 2.3 | Formulation of dynamic equations of RC series networks and solution using Laplace Transforms – with DC excitation and initial conditions. Natural response and forced response. Time constant. | 1 |
| 2.4 | Formulation of dynamic equations of RLC series networks with DC excitation and initial conditions, and solution using Laplace Transforms – Natural response and forced response. Damping coefficient. Underdamped, Overdamped, critically damped and undamped cases. | 1 |
| 2.5 | Formulation of dynamic equations of RL, RC and RLC series networks and solution with sinusoidal excitation. Complete solution (Solution using Laplace transforms). | 2 |
| 2.6 | Formulation of dynamic equations of RL, RC and RLC parallel networks and solution using Laplace Transforms – with DC and Sinusoidal excitations. Damping ratio. | 2 |
| **3** | **Transformed Circuits in s-domain and Coupled circuits (9 Hours)** | |
| 3.1 | Transformed circuits in s-domain: Transformation of elements (R, L, and C) with and without initial conditions. | 2 |
| 3.2 | Mesh analysis of transformed circuits in s-domain. | 1 |
| 3.3 | Node analysis of transformed circuits in s-domain. | 1 |
| 3.4 | Transfer Function representation – Poles and zeros. | 1 |
| 3.5 | Analysis of coupled circuits: mutual inductance – Coupling Coefficient-Dot polarity convention –– Conductively coupled equivalent circuits. Linear Transformer as a coupled circuit. | 2 |
| 3.6 | Analysis of coupled circuits in s-domain. | 2 |
| **4** | **Three phase networks and resonance. (6 Hours)** | |
| 4.1 | Review of power, power factor, reactive and active power in sinusoidally excited circuits. Concept of complex power. | 1 |
| 4.2 | Steady state analysis of three-phase unbalanced 3-wire and 4-wire Y circuits, Unbalanced Δ circuits, Neutral shift. | 2 |
| 4.3 | Resonance in Series and Parallel RLC circuits – Quality factor – Bandwidth – Impedance Vs Frequency, Admittance Vs Frequency and Phase angleVs frequency for series resonant circuit. | 3 |

| 5 | **Two port networks (9 Hours)** | |
|---|---|---|
| 5.1 | Two port networks: Terminals and Ports, Driving point and transfer functions. Voltage transfer ratio, Current transfer ratio, transfer impedance, transfer admittance, poles and zeros. | 2 |
| 5.2 | Z –parameters. Equivalent circuit representation. | 1 |
| 5.3 | Y parameters. Equivalent circuit representation. | 1 |
| 5.4 | h parameters. Equivalent circuit representation. | 1 |
| 5.5 | T parameters. | 1 |
| 5.6 | Conditions for symmetry & reciprocity, relationship between network parameter sets. | 1 |
| 5.7 | Interconnections of two port networks (series, parallel and cascade). | 1 |
| 5.8 | T-π Transformation. | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET 303** | **MEASUREMENTS AND INSTRUMENTATION** | PCC | **3** | **1** | **0** | **4** |

**Preamble** : This course introduces principle of operation and construction of basic instruments for measurement of electrical quantities. Measurement of basic circuit parameters, magnetic quantities, and passive parameters by using bridge circuits, sensors and transducers will be discussed.Familiarization of modern digital measurement systems are also included.

**Prerequisite** **:Nil**

**Course Outcomes** **:**After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Identify and analysethe factors affecting performance of measuring system |
| **CO 2** | Choose appropriate instruments for the measurement of voltage, current in ac and dc measurements |
| **CO 3** | Explain the operating principle of power and energy measurement |
| **CO 4** | Outline the principles of operation of Magnetic measurement systems |
| **CO 5** | Describe the operating principle of DC and AC bridges, transducersbased systems. |
| **CO 6** | Understand the operating principles of basic building blocks of digital systems, recording and display units |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 1 | - | - | - | - | - | - | - | - | - | - |
| **CO 2** | 3 | 1 | - | - | - | - | - | - | - | - | - | - |
| **CO 3** | 3 | 1 | - | - | - | - | - | - | - | - | - | - |
| **CO 4** | 3 | - | - | - | - | - | - | - | - | - | - | - |
| **CO 5** | 3 | - | - | - | 1 | - | - | - | - | - | - | 2 |
| **CO 6** | 3 | - | - | - | 2 | - | - | - | - | - | - | 2 |

**Assessment Pattern**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 15 | 20 | 30 |
| Understand | 20 | 20 | 50 |
| Apply | 15 | 10 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1)**

1. Explain static characteristics of measuring systems.
2. Problems related to measurement errors.
3. Concept of calibration of measuring instruments

**Course Outcome 2 (CO2):**

1. Explain the construction and working indicating Instruments.
2. Problems related to extension of range of meters

**Course Outcome 3(CO3):**

1. Describe the principle of operation and construction of energy meter
2. Describe the principle of operation and construction of wattmeter
3. Problems related to two and three wattmeter method of power measurement.

**Course Outcome 4 (CO4):**

1. Explain the principle of operation of ballistic galvanometer.
2. Describe the procedure for plotting the B-H curve of a magnetic specimen.

**Course Outcome 5 (CO5):**

1. Explain classification of Transducers
2. Measurement of frequency using Wien bridge.
3. Explain the operation of basic ac/dc bridges
4. Illustrate the principle of temperature measurement using thermocouple.

**Course Outcome 6 (CO6):**

1. Block diagram of DMM, CRO, DSO, PMU
2. Basic ideas on simulation softwares and virtual instrumentation.
3. Explain the operation of basic ac/dc bridges

**Model Question paper**

**QPCODE:22EET 303** PAGES:3

Reg.No:______________

Name :_______________

**TKM COLLEGE OF ENGINEERING**

**THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH &YEAR**

**Course Code: 22EET 303**

**Course Name: Measurements and Instrumentation**

**Max.Marks:100** **Duration: 3Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. What are the different standards of measurement?
2. State and briefly explain the classification of electrical measuring instruments.
3. What are the special features incorporated in low power factor wattmeter?
4. Write short note on three phase energy meter.
5. Describe the working of hall effect sensors.
6. With the help of a diagram indicate the calibration of wattmeter using DC potentiometer.
7. Describe the method of determination of BH curve of a magnetic material.
8. What are the main requirements in magnetic measurements?
9. Explain briefly about digital voltmeter.
10. What is lissajouspattern. Indicate the factors on which shape of these figures depends.

**(10x3=30)**

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

1. (a) Explain the essentials of indicating instruments and what are the different methods of producing controlling torque in an analog instrument? **(6)**

(b) Explain with the help of neat sketches, the construction and working of attraction type moving iron instruments. Give the equation for torque of the MI instrument and the merits and demerits. **(8)**

2. (a) Discuss different types of damping. What is the necessity of damping and how damping is provided in PMMC instrument? **(8)**

   (b) A moving coil ammeter has fixed shunt of 0.01Ω. With a coil resistance of 750Ω and a voltage drop of 500mV across it, the full scale deflection is obtained. (1) Calculate current through shunt (2) Calculate resistance of meter to give full scale deflection if shunted current is 60A. **(6)**

**Module 2**

3. (a) Derive the expression for transformation ratio and phase angle of a current transformer using its equivalent circuit and phasor diagram. **(14)**

4. (a) Explain the construction and operation of dynamometer type wattmeter. **(7)**

   (b) With a neat block diagram, explain the working of electronic energy meter. What are its merits compared to induction type energy meter. **(7)**

**Module 3**

5. (a) Draw the circuit and phasor diagram of schering bridge for the measurement of capacitance, Derive the expression for the unknown capacitance.**(10)**

   (b) Explain loss of charge method for the measurement of high resistance. **(4)**

6. (a) Explain with the help of neat connection diagram how you would determine the value of low resistance by kelvin's double bridge method. Derive the formula used. **(7)**

   (b) Describe the method of measurement of earth resistance and what are the factors which affect the value of earth resistance? **(7)**

**Module 4**

7. (a)Explain the method of measurement of permeability. **(5)**

   (b) What is the principle of temperature measurement using thermistors and compare temperature measurement using RTD and thermistor. **(9)**

8. (a) Explain the working of flux meter. **(4)**

   (b) What is a Llyod- Fisher square. Explain the measurement of iron losses in a magnetic material employing Llyod- Fisher square using wattmeter method. **(10)**

## Module 5

9. (a) With the help of a neat sketch explain the working of LVDT. Also draw its characteristics. **(6)**

   (b) Explain how CRO can be used to measure the frequency and phase angle. **(8)**

10. (a) How strain is measured using strain gauge. **(4)**

    (b) With a neat diagram, explain the working of a digital storage oscilloscope.

**(10)**

**(14x5=70)**

**Syllabus**

**Module 1**

Measurement standards–Errors-Types of Errors- Statistics of errors, Need for calibration.

Classification of instruments, secondary instruments–indicating, integrating and recording-operating forces - essentials of indicating instruments - deflecting, damping, controlling torques.

Ammeters and voltmeters - moving coil, moving iron, constructional details and operation, principles shunts and multipliers – extension of range.

**Module 2**

Measurement of power: Dynamometer type wattmeter –Construction and working - 3-phase power measurement-Low Powerfactor wattmeters.

Measurement of energy: Induction type watt-hour meters- Single phase energy meter – construction and working, two element three phase energy meters,

Digital Energymeters -Time of Day(TOD) and Smart metering (description only).

Current transformers and potential transformers – principle of working -ratio and phase angle errors.

Extension of range using instrument transformers, Hall effect multipliers.

**Module 3**

Classification, measurement of low, medium and high resistance- Ammeter voltmeter method(for low and medium resistance measurements)-Kelvin's double bridge-Wheatstones bridge- loss of charge method, measurement of earth resistance.

Measurement of self inductance-Maxwell's Inductance bridge, Measurement of capacitance –Schering's, Measurement of frequency-Wien's bridge.

Calibration of Ammeter, Voltmeter and Wattmeter using DC potentiometers.

High voltage and high current in DC measurements- voltmeters, Sphere gaps, DC Hall effect sensors.

**Module 4**

Magnetic Measurements: Measurement of flux and permeability - flux meter, BH curve and permeability measurement - hysteresis measurement- ballistic galvanometer – principle-determination of BH curve - hysteresis loop. Lloyd Fisher square — measurement of iron losses.

Measurement luminous intensity-Photoconductive Transducers-Photovoltaic cells

Temperature sensors-Resistance temperature detectors-negative temperature coefficient Thermistors-thermocouples-silicon temperature sensors.

**Module 5**

Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers-modes of operation-force transducer, Load cell, Strain gauge.

Oscilloscopes- Principal of operation of general purpose CRO-basics of vertical and horizontal deflection system, sweep generator etc. DSO-Characteristics-Probes and Probing techniques.

Digital voltmeters and frequency meters using electronic counters, DMM, Clamp on meters.

Phasor Measurement Unit (PMU) (description only).

Introduction to Virtual Instrumentation systems- Simulation software's (description only)

**Text Books**


1. Sawhney A.K., A course in Electrical and Electronic Measurements & instrumentation, DhanpatRai.
2. J. B. Gupta, A course in Electrical & Electronic Measurement & Instrumentation., S K Kataria& Sons
3. Kalsi H. S., Electronic Instrumentation, 3/e, Tata McGraw Hill, New Delhi, 2012
4. S Tumanski, Principles of electrical measurement, Taylor & Francis.
5. David A Bell, Electronic Instrumentation and Measurements,3/e, Oxford


**Reference Books**


1. Golding E.W., Electrical Measurements & Measuring Instruments, Wheeler Pub.
2. Cooper W.D., Modern Electronics Instrumentation, Prentice Hall of India
3. Stout M.B., Basic Electrical Measurements, Prentice Hall
4. Oliver & Cage, Electronic Measurements & Instrumentation, McGraw Hill
5. E.O Doebelin and D.N Manik, Doebelin's Measurements Systems, sixth edition, McGraw Hill Education (India) Pvt. Ltd.
6. P.Purkait, B.Biswas, S.Das and C. Koley, Electrical and Electronics Measurements and Instrumentation, McGraw Hill Education (India) Pvt. Ltd.,2013


**Course Contents and Lecture Schedule**

| **Module** | **Topic coverage** | **No. of Lectures** | **No of hours** |
|---|---|---|---|
| **1** | **General principles of measurements and classification of meters** | | |
| 1.1 | Measurement standards–Errors-Types of Errors- Statistics of errors, Need for calibration. | 3 | **10** |

| | | | |
|---|---|---|---|
| 1.2 | Classification of instruments, secondary instruments–indicating, integrating and recording- operating forces - | 1 | |
| 1.3 | Essentials of indicating instruments - deflecting, damping, controlling torques. | 3 | |
| 1.4 | Ammeters and voltmeters - moving coil, moving iron, constructional details and operation, principles shunts and multipliers – extension of range. | 3 | |
| **2** | **Measurement of Resistance, Power and Energy** | | |
| 2.1 | Measurement of power: Dynamometer type wattmeter – Construction and working - 3-phase power measurement- Low Powerfactorwattmeters. | 3 | **09** |
| 2.2 | Measurement of energy: Induction type watt-hour meters- Single phase energy meter – construction and working, two element three phase energy meters, Digital Energymeters - Time of Day (TOD) and Smart metering (description only). | 3 | |
| 2.3 | Current transformers and potential transformers – principle of working -ratio and phase angle errors. Extension of range using instrument transformers, Hall effect multipliers. | 3 | |
| **3** | **Measurement of circuit parameters using bridges, High voltage and high current measurements** | | |
| 3.1 | Classification of resistance, low resistance, Ammeter voltmeter method, Kelvin's double bridge Medium resistance- Ammeter voltmeter method - Wheatstones bridge High resistance- loss of charge method- measurement of earth resistance. | 3 | **09** |
| 3.2 | Measurement of self inductance-Maxwell's Inductance bridgeMeasurement of capacitance–Schering's bridge Measurement of frequency-Wien's bridge. | 2 | |
| 3.3 | Calibration of Ammeter, Voltmeter and Wattmeter using DC potentiometers. | 2 | |
| 3.4 | High voltage and high current in DC measurements- voltmeters, Sphere gaps, DC Hall effect sensors. | 2 | |
| **4** | **Magnetic, Lumen and Temperature Measurements** | | |
| 4.1 | Measurement of flux and permeability - flux meter, BH curve and permeability measurement - hysteresis measurement | 2 | **08** |
| 4.2 | Ballistic galvanometer – principle- determination of BH curve - hysteresis loop. Lloyd Fisher square - measurement of iron losses. | 2 | |

| | | | |
|---|---|---|---|
| 4.3 | Measurement luminous intensity-Photoconductive Transducers-Photovoltaic cells | 2 | |
| 4.4 | Temperature sensors-Resistance temperature detectors-negative temperature coefficient Thermistors-thermocouples-silicon temperature sensors. | 2 | |
| **5** | **Transducers and Digital instruments including modern recording and displaying instruments** | | |
| 5.1 | Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers-modes of operation-force transducer, Load cell, Strain gauge. | 2 | **09** |
| 5.2 | Oscilloscopes- Principal of operation of general purpose CRO-basics of vertical and horizontal deflection system, sweep generator etc.<br>DSO-Characteristics-Probes and Probing techniques. | 3 | |
| 5.3 | Digital voltmeters and frequency meters using electronic counters, DMM, Clamp on meters. | 2 | |
| 5.4 | Phasor Measurement Unit (PMU) (description only).<br>Introduction to Virtual Instrumentation systems-Simulation software's (description only) | 2 | |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET 304** | **ANALOG ELECTRONICS** | PCC | 3 | 1 | 0 | 4 |

**Prerequisite:** Fundamentals of Electronics and semiconductor devices

| | |
|---|---|
| **CO 1** | Design biasing scheme for transistor circuits. |
| **CO 2** | Model BJT and FET amplifier circuits. |
| **CO 3** | Identify a power amplifier with appropriate specifications for electronic circuit applications. |
| **CO 4** | Describe the operation of oscillator circuits using BJT. |
| **CO 5** | Explain the basic concepts of Operational amplifier(OPAMP) |
| **CO 6** | Design and develop various OPAMP application circuits. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 2 | 2 | | | | | | | | | |
| **CO 2** | 2 | 2 | 2 | | | | | | | | | |
| **CO 3** | | | 1 | 2 | | | | | | | | |
| **CO 4** | 2 | 2 | 2 | | | | | | | | | |
| **CO 5** | | | 1 | 2 | | | | | | | | |
| **CO 6** | 2 | 2 | 2 | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 10 |
| Understand | 20 | 20 | 50 |
| Apply | 20 | 20 | 40 |
| Analyse | - | - | - |
| Evaluate | - | - | - |
| Create | - | - | - |

**End Semester Examination Pattern :**

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 5 marks for each question. Students should answer all questions. Part B contains Fivesections, Each section have 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 10 marks.

Part A : 10 Questions x 5 marks=50 marks,
Part B : 5 Questions x 10 marks =50 marks

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Discuss the different types of biasing methods.( K1,K2)
2. Comment on the effect of Bandwidth and slew rate in Op-amp performance.
3. Draw the Small signal equivalent of differential amplifier and derive the equations for Input resistance, Voltage gain, CMRR.

**Course Outcome 2 (CO2):**

1. Analyse JFET and MOSFET characteristics.
2. Choose a power amplifier with appropriate specifications for electronic circuit applications.
3. List the features of Instrumentation amplifier.
4. What are the various op-amp feedback configurations? Explain each.
5. Explain the following op-amp circuits with neat sketches also find the output voltage equations
   **a.** Summing amplifiers
   **b.** Scaling amplifiers
   **c.** Averaging amplifiers

**Course Outcome 3(CO3):**

1. Discuss the different feedback topologies.
2. Analyse the properties of an ideal op-amp.
3. Describe the working of Voltage to current converter using op-amp.
4. Draw the circuit diagrams for Log and antilog amplifier and obtain its output equations.
5. With necessary waveforms and neat diagram explain the working of Schmitt Trigger.
6. Design a Wein Bridge oscillator for a gain of 3 and oscillating frequency of 2kHz.

**Course Outcome 4 (CO4):**

1. Draw the Small signal equivalent of differential amplifier and derive the equations for Input resistance, Voltage gain, CMRR. (K1, K2)
2. Design various basic op-amp circuits. (K2)
3. Explain the following op-amp circuits with neat sketches also find the output voltage equations
   **a.** Summing amplifiers
   **b.** Scaling amplifiers(K2,K3)

**Course Outcome 5 (CO5):**

1. Generate different desired waveforms using op-amp.( K2,K3)
2. Draw the internal block diagram of 555 Timer IC and explain.(K1)

3. Realise multivibrators using 555 IC. (K2,K3)

**Course Outcome 6 (CO6):**

1. Design and set up an opamp integrator circuit and plot the input and output waveforms. (K3)
2. Explain the working of a ramp generator circuit using opamp. (K2)

**Model Question paper**

PAGES: 2

Reg No.:_______________

Name:_________________

**TKM COLLEGE OF ENGINEERING**

**THIRD SEMESTER B. TECH DEGREE EXAMINATION, MONTH AND YEAR**

**Course Code: 22EET 304**

**Course Name: ANALOG ELECTRONICS**

Max. Marks: 100 Duration: 3 Hours

**PART A**

**Answer all questions, each carries 3 marks**

1. With neat diagrams explain DC load lines in transistor. What is the significance of Q point?
2. Draw and explain the h parameter small signal low frequency model for BJT.
3. Explain the construction and operation of Enhancement type metal oxide semiconductor FET with neat diagrams.
4. Explain the drain characteristics of JFET and mark the pinch-off voltage
5. Discuss the advantages of negative feedback amplifier.
6. State and explain Barkhausen's criterion of oscillation.
7. Compare the Ideal and Practical characteristics of an op-amp
8. Design a three input summing amplifier using op-amp having gains 2, 3and 5 respectively for each input
9. Show the circuit diagram of an Ideal Differentiator using op-amp with corresponding input and output waveform.
10. Explain the operation of a square wave generator using op-amp.

**PART B**

**Answeranyonefullquestionfromeachmodule.Eachquestioncarries14 Marks**

**Module1**

11. Design a voltage divider bias circuit to operate from a 18V supply in which bias conditions are to be $V_{CE}=V_E=6V$ and $I_C=1.5mA$. $\beta=90$. Also calculate the stability factor S. **(14)**
12. A CE amplifier has the h-parameters given by $h_{ie}= 1000\Omega$, $h_{re} = 2*10^{-4}$, $h_{fe}=50$, $h_{0e}= 25\mu\Omega$. If both the load and source resistances are $1k\Omega$, determine the a) current gain and b) voltage gain. **(14)**

## Module 2

13. (a) Sketch the frequency response curve of RC coupled amplifier and discuss methods to improve gain bandwidth product **(7)**

    (b) List the four parameters of JFET. Also obtain the mathematical expression for transconductance. **(7)**

14. (a) How a JFET common drain amplifier is designed using voltage divider biasing? **(5)**

    (b) Which are the internal capacitances of a BJT? How these are incorporated in the high frequency hybid pi model of BJT? **(9)**

## Module 3

15. Define conversion efficiency of power amplifier. Prove that the maximum conversion efficiency of a series fed class A amplifier is 25%. **(14)**

16. With neat circuit diagrams, explain the working of a two-stage RC coupled amplifier and derive the output relation of each stage. **(14)**

## Module 4

17. How do the open-loop voltage gain and closed loop voltage gain of an op-amp differ? What is the limiting value of output voltage of op amp circuit? **(14)**

18. (a) An input of 3V is fed to the non inverting terminal of an op-amp. The amplifier has $R_1$=10kΩ and $R_f$=10kΩ.Find the output voltage. **(7)**

    (b) Explain briefly about the following (i) CMRR (ii) Slew Rate **(7)**

## Module 5

19. (a) What is the significance of UTP and LTP in Schmitt trigger circuits? **(7)**

    (b) What is a zero crossing detector? **(7)**

20. (a) Explain the functional block diagram of Timer IC555. **(7)**

    (b) Design an astable multivibrator using 555 Timer for an output wave of 65% duty ratio at 1kHz frequency. **(7)**

## Syllabus

**Module 1**

BipolarJunction Transistors: ReviewofBJT characteristics- Operating pointofBJT – Factors affectingstabilityofQpoint.DCBiasing–Biasing circuits:fixed bias, collector to base bias, voltagedivider bias, role of emitter resistance in bias stabilisation.Stability factor (Derivationofstability factorsfor VoltageDivider Biasingonly).Numerical problems.Biascompensation using diode and thermistor.

BJT Model- h-parameter modelof BJT in CE configuration. Small signal low frequency ac equivalent circuitof CEamplifier –Roleof coupling capacitors and emitter bypasscapacitor.Calculation of amplifier gains and impedances using h parameter equivalent circuit.

**Module 2**

FieldEffectTransistors: ReviewofJFETandMOSFET(enhancement mode only) construction, working and characteristics- JFET common drain amplifier-Design using voltage divider biasing.

Frequencyresponse ofAmplifiers:InternalCapacitancesathighfrequency operations of BJT-Hybrid Pi model of BJT. Low and high frequency responseofCommonEmitter amplifier.Frequencyresponse of CE amplifier, Gainbandwidth product.

**Module 3**

**Multistage amplifiers**: Direct, RC, transformer coupledAmplifiers, Applications.

**Poweramplifiers usingBJT**: Class A, Class B, Class AB, Class C and Class D. Conversion efficiency – derivation(Class A and Class B). Distortion in power amplifiers.FeedbackinAmplifiers-Effect of positive and negative feedbacks.
Oscillators:Barkhausen'scriterion–
RCoscillators(RCPhaseshiftoscillatorandWeinBridgeoscillator) –LC oscillators(Hartley and Colpitt's)– Derivation of frequency of oscillation- Crystal oscillator.

**Module 4**

Operational Amplifiers: Fundamental differential amplifier- Modes of operation.

Properties of ideal and practical Op-amp - Gain, CMRR and Slew rate. Parameters of a typical Op-amp IC 741.

Open loop and Closed loop Configurations-Concept of virtual short. Negative feedback in Op-amps.Inverting and non- inverting amplifiercircuits.Summing anddifference amplifiers, Instrumentation amplifier.

**Module 5**

OP-AMP Circuits: Differentiator and Integrator circuits-practical circuits – Design –

Comparators: Zerocrossing and voltage level detectors, Schmitt trigger. Comparator IC: LM311.

Wave form generation using Op-Amps: Square, triangular and rampgenerator circuits using Op-Amp- Effect of slew rate on waveform generation.

Timer 555IC: Internal diagram of 555 IC–Astable and Monostable multi-vibrators using 555 IC.

**Text Books**


1. Bell D. A., Electronic Devices and Circuits, Prentice Hall ofIndia, 2007.
2. Malvino A. and D. J. Bates, Electronic Principles7/e, Tata McGraw Hill, 2010.
3. Boylestad R. L. and L. Nashelsky,Electronic Devices and CircuitTheory, 10/e, PearsonEducation India, 2009.
4. Choudhury R.,LinearIntegrated Circuits, New AgeInternational Publishers. 2008.


**Reference Books**


3. Floyd T.L., Fundamentals of Analog Circuits,, Pearson Education, 2012.
4. Robert T. PaynterandJohn Clemons, Paynter'sIntroductoryelectronic devices & circuits, Prentice Hall Career & Technology, New Jersey.
5. Millman J. and C. C. Halkias,Integrated Electronics: Analog and Digital Circuits andSystems, Tata McGraw-Hill, 2010.
6. Streetman B. G. and S. Banerjee,Solid State Electronic Devices, Pearson Education Asia,2006.
7. Gayakward R. A., Op-Amps and LinearIntegrated Circuits, PHILearning Pvt.Ltd., 2012.


**Course Contents and Lecture Schedule**

| **No** | **Topic** | **No. of Lectures** |
|---|---|---|
| **1** | | **9** |
| 1.1 | Bipolar Junction Transistors: Review of BJT characteristics | 1 |
| 1.2 | Operating point of BJT – Factors affecting stability of Q point. | 1 |
| 1.3 | Biasing circuits: fixed bias, collector to base bias, voltage divider bias, role of emitter resistance in bias stabilisation. Stability factor (Derivation of stability factors for Voltage Divider Biasing only). Numerical problems. | 3 |
| 1.4 | Bias compensation using diode and thermistor. | 1 |
| 1.5 | BJT Model- h-parameter model of BJT in CE configuration. Small signal low frequency ac equivalent circuit of CE amplifier | 1 |

| | | |
|---|---|---|
| 1.6 | Role of coupling capacitors and emitter bypass capacitor. | 1 |
| 1.7 | Calculation of amplifier gains and impedances using h parameter equivalent circuit. | 1 |
| **2** | | **7** |
| 2.1 | Field Effect Transistors: Review of JFET and MOSFET (enhancement mode)-construction, working and characteristics | 2 |
| 2.2 | JFET common drain amplifier-Design using voltage divider biasing. | 1 |
| 2.3 | FET as switch and voltage controlled resistance. | 1 |
| 2.4 | Frequency response of Amplifiers: Internal Capacitances at high frequency operations of BJT- Hybrid Pi model of BJT. Low and high frequency response of Common Emitter amplifier | 2 |
| 2.5 | Frequency response of CE amplifier, Gain bandwidth product | 1 |
| **3** | | **8** |
| 3.1 | Multistage amplifiers: Direct, RC, Applications. | 1 |
| 3.2 | Transformer coupled Amplifiers, Applications. | 1 |
| 3.3 | Derivation of conversion efficiency of Class A and Class B amplifiers. | 2 |
| 3.4 | Class AB, Class C and Class D amplifiers. Distortion in power amplifiers(Class A, Class B, Class AB, Class C and Class D) | 1 |
| 3.5 | Oscillators: Barkhausen's criterion–RC oscillators (RC Phase shift oscillator and Wein Bridge oscillator) Derivation of frequency of oscillation | 2 |
| 3.6 | LC oscillators (Hartley and Colpitt's) – Derivation of frequency of oscillation- Crystal oscillator. | 1 |
| **4** | | **10** |
| 4.1 | Operational Amplifiers: Fundamental differential amplifier- Modes of operation. | 2 |
| 4.2 | Properties of ideal and practical Op-amp - Gain, CMRR and Slew rate. Parameters of a typical Op-amp IC 741. | 3 |
| 4.3 | Open loop and Closed loop Configurations-Concept of virtual short. | 2 |

| | | |
|---|---|---|
| 4.4 | Negative feedback in Op-amps. | 1 |
| 4.5 | Inverting and non- inverting amplifier circuits | 1 |
| 4.6 | Summing and difference amplifiers, Instrumentation amplifier. | 1 |
| **5** | | **8** |
| 5.1 | OP-AMP Circuits: Differentiator and Integrator circuits-practical circuits - Design | 1 |
| 5.2 | Comparators: Zero crossing and voltage level detectors, Schmitt trigger. Comparator IC: LM311. | 2 |
| 5.3 | Wave form generation using Op-Amps: Square, triangular and ramp generator circuits using Op-Amp- Effect of slew rate on waveform generation. | 2 |
| 5.4 | Timer 555IC: Internal diagram of 555IC–Astable and Monostable multi-vibrators using 555 IC. | 3 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEL308** | **CIRCUITS AND MEASUREMENTS LAB** | **PCC** | **0** | **0** | **3** | **2** |

**Preamble** : This laboratory course is designed to train the students to familiarize and practice various measuring instruments and different transducers for measurement of physical parameters. Students will also be introduced to a team working environment where they develop the necessary skills for planning, preparing and implementing basic instrumentation systems.

**Prerequisite** : Basic Electrical Engineering

**Course Outcomes** : After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Analyse voltage current relations of RLC circuits |
| **CO 2** | Verify DC network theorems by setting up various electric circuits |
| **CO 3** | Measure power in a single and three phase circuits by various methods |
| **CO 4** | Calibrate various meters used in electrical systems |
| **CO 5** | Determine magnetic characteristics of different electrical devices |
| **CO 6** | Analyse the characteristics of various types of transducer systems |
| **CO 7** | Determine electrical parameters using various bridges |
| **CO 8** | Analyse the performance of various electronic devices for an instrumentation systems and, to develop the team management and documentation capabilities. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | | | | | | 2 | | | 3 |
| **CO 2** | 3 | 3 | - | - | - | - | - | - | 2 | - | - | 3 |
| **CO 3** | 3 | 3 | - | - | - | - | - | - | 2 | - | - | 3 |
| **CO 4** | 3 | 3 | 2 | - | - | - | - | - | 2 | - | - | 3 |
| **CO 5** | 3 | 3 | - | - | - | - | - | - | 2 | - | - | 3 |
| **CO 6** | 3 | 3 | 2 | - | - | - | - | - | 2 | - | - | 3 |
| **CO 7** | 3 | 3 | - | - | - | - | - | - | 2 | - | - | 3 |
| **CO 8** | 3 | 3 | 3 | 3 | 2 | - | - | - | 3 | 3 | 3 | 3 |

## ASSESSMENT PATTERN:

**Mark distribution:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| **150** | 75 | 75 | 3 hours |

**Continuous Internal Evaluation (CIE) Pattern:**

| Attendance | Regular Lab work | Internal Test | Course Project | Total |
|---|---|---|---|---|
| 15 | 30 | 25 | 5 | **75** |

Internal Test Evaluation (Immediately before the second series test)

**End Semester Examination (ESE) Pattern:**

The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks

(b) Implementing the work/Conducting the experiment : 10 Marks

(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks

(d) Viva voce : 20 marks

(e) Record : 5 Marks

**General instructions :** Practical examination is to be conducted immediately after the second series test after conducting 12 experiments from the list of experiments given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

**LIST OF EXPERIMENTS:**

**(12 experiments are mandatory)**

**1.** Verification of Superposition theorem and Thevenin's theorem**.**

**2.** Determination of impedance, admittance and power factor in RLC series/ parallel circuits.

**3.** 3-phase power measurement using one wattmeter and two-wattmeter methods, and determination of reactive/apparent power drawn.

**4.** Resistance measurement using Kelvin's Double Bridge and Wheatstone's Bridge and extension of range of voltmeters and ammeters.

**5.** Extension of instrument range by using Instrument transformers(CT and PT)

**6.** Calibration of ammeter, voltmeter, wattmeter using Potentiometers

**7.** Calibration of 1-phase Energy meter at various power factors (minimum 4 conditions)

**8.** Calibration of 3-phase Energy meter using standard wattmeter

**9.** Determination of B-H curve, μ-H curve and μ-B curve of a magnetic specimen

**10.** Measurement of Self inductance, Mutual inductance and Coupling coefficient of a 1-phase transformer

**11.** a. Measurement of Capacitance using AC bridge

b. Setup an instrumentation amplifier using Opamps.

**12.** Determination of characteristics of LVDT, Strain gauge and Load-cell.

**13.** Determination of characteristics of Thermistor, Thermocouple and RTD

**14.** Verification of loading effect in ammeters and voltmeters with current measurement using Clamp on meter.

**15.** Demo Experiments/Simulation study:

a) Measurement of energy using TOD meter
b) Measurement of electrical variables using DSO
c) Harmonic analysers
d) Simulation of Circuits using software platform
e) Computer interfaced measurements of circuit parameters.

**Mandatory Group Project Work :** Students have to do a mandatory micro project (group size not more than 5 students) to realise a functional instrumentation system. A report also is to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

Example projects (Instrumentation system with sensors, alarm, display units etc)

1. Temperature Monitoring System.
2. Gas / Fire smoke Detection Systems.
3. Simulation using LabVIEW, PLC or Similar Softwares.

**Reference Books:**


1. K. Sawhney: A course in Electrical and Electronic Measurements & Instrumentation, Dhanpat Rai Publishers
2. J. B. Gupta: A course in Electrical & Electronic Measurement & Instrumentation., S. K. Kataria & Sons Publishers
3. Kalsi H. S.: Electronic Instrumentation, 3/e, Tata McGraw Hill, New Delhi.

| CODE 22EEL309 | ANALOG ELECTRONICSLAB | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 0 | 0 | 3 | 2 |

| | |
|---|---|
| **CO 1** | Use the various electronic instruments and for conducting experiments. |
| **CO 2** | Design and develop various electronic circuits using diodes and Zener diodes. |
| **CO 3** | Design and implement amplifier and oscillator circuits using BJT and JFET. |
| **CO 4** | Design and implement basic circuits using IC (OPAMP and 555 timers). |
| **CO 5** | Simulate electronic circuits using any circuit simulation software. |
| **CO 6** | Use PCB layout software for circuit design |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | | | | | | | 2 | | | |
| **CO 2** | 2 | 2 | 2 | | | | | | 2 | | | |
| **CO 3** | 2 | 2 | 2 | | | | | | 2 | | | |
| **CO 4** | 2 | 2 | 2 | | | | | | 2 | | | |
| **CO 5** | 1 | 1 | | | 3 | | | | 3 | | | |
| **CO 6** | 1 | | | | 3 | | | | 3 | | | |

## LIST OF EXPERIMENTS

1. Measurement of current, voltage, frequencyand phase shift of signal in a RC network using oscilloscope.
2. Clipping circuits usingdiodes.
3. Clamping circuits usingdiodes.
4. Design and testing ofsimple Zener voltage regulator.
5. RC coupled amplifier using BJT in CE configuration-Measurement of gain, BW and plotting of frequencyresponse.
6. JFETamplifier-Measurement of gain, BW and plotting of frequencyresponse.
7. Op-amp circuits – Design and set up of invertingand non-inverting amplifier, scale changer, adder, integrator, and differentiator.
8. Op-amps circuits – Scale changer, adder, integrator, and differentiator.
9. Precision rectifierusingOp-amps.
10. Phase shift oscillator usingOp-amps.
11. Wein’sBridgeoscillator using Op-amps.
12. Waveform generation– Square, triangular andsaw tooth waveformgeneration usingOPAMPs.
13. Basic comparator and Schmitt triggercircuits using Op-amp (Use comparator ICs such as

LM311).

14. Design and testing of series voltage regulator using Zenerdiode.
15. Astable and Monostable circuit using555IC.
16. RC phase shift oscillator using Op-amp.
17. Introductionto circuit simulation using any circuit simulation software.
18. Introductionto PCB layout software.

**Course Project :**

Students have to do a mandatory course project (group size not more than 4 students) using to realise a functional analog circuit on PCB. A maximum of 5 marks shall be awarded for this project (to be evaluated along with the final internal test). Report to be submitted.

Example projects:

1. Audio amplifier.
2. Electronic Pest Repellent Circuit.
3. Electronic Siren.

**Assessment Pattern :**

**Mark distribution :**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 75 | 75 | 2.5 hours |

**Continuous Internal Evaluation (CIE) Pattern:**

| Attendance | Regular Lab work | Internal Test | Course Project | Total |
|---|---|---|---|---|
| 15 | 30 | 25 | 5 | 75 |

**End Semester Examination Pattern:**

The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipment and troubleshooting) : 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

**General instructions :**

Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

# SEMESTER III
# MINOR

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEMR 310.1** | **ELECTRIC CIRCUITS** | **MINOR** | **3** | **1** | **0** | **4** |

**Preamble :** This course deals with circuit theorems applied to dc and ac electric circuits. Steady and transient state response of electric circuits is discussed. Network analysis is introduced with network parameters and transfer functions. This course serves as the most important prerequisite of all many advanced courses in electrical engineering.

**Prerequisite : Basics of Electrical Engineering / Introduction to Electrical Engineering**

**Course Outcomes :** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Apply circuit theorems to simplify and solve DC and AC electric networks. |
| **CO 2** | Analyse dynamic DC circuitsand develop the complete response. |
| **CO 3** | Analyse coupled circuits in S-domain |
| **CO 4** | Analyse three-phase networks in Y and Δ configurations. |
| **CO 5** | Develop the representation of two-port networks using Z and Y parameter. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | 2 |
| **CO 5** | 3 | 3 | | | | | | | | | | 2 |

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. State and explain network theorems (K1)
2. Problems on solving circuits using network theorems. (K2, K3)

**Course Outcome 2 (CO2):**

1. Distinguish between the natural response and forced response. (K2, K3)
2. Problems on steady state and transient analysis of RL, RC and RLC series circuits with DC excitation and initial conditions. (K2, K3)

**Course Outcome 3 (CO3):**

1. Problems on mesh analysis,analysis of transformed circuits in s-domain (K2, K3).
2. Problems on nodal analysis,analysis of transformed circuits in s-domain (K2, K3).

**Course Outcome 4 (CO4):**

1. Problems on analysis of balanced Y and Δ configurations. (K2, K3)
2. Problems on analysis of unbalanced Y and Δ configurations. (K2, K3)

**Course Outcome 5 (CO5):**

1. Problems on finding Z and Y parameters of simple two port networks. (K2).
2. Derive the expression for Z parameters in terms of Y parameters. (K1).

**Model Question paper**

QP CODE: PAGES: 3

Reg. No:_______________

Name:_________________

**TKM COLLEGE OF ENGINEERING**
**FIRST SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**
**Course Code: 22EEMR310.1**
**Course Name: ELECTRIC CIRCUITS**

**Max. Marks: 100 Duration: 3 Hours**

**PART A**
**Answer all Questions. Each question carries 3 Marks**

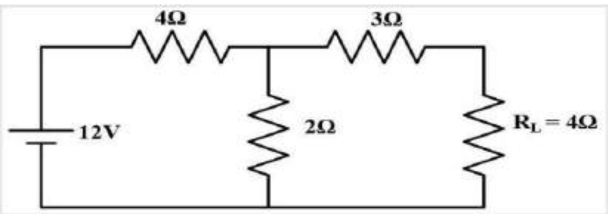
1. Compare the analogy between Nodal and Mesh analysis method.
2. State and explain superposition theorem with suitable examples.
3. Differentiate between transient and steady state analysis.
4. Explain Initial value and final value theorem.
5. Define Self-inductance, Mutual inductance and coupling coefficient.
6. Explain dot rule used in magnetically coupled circuits with the help of a neat figure.
7. Define the terms, real power, reactive power and apparent power.
8. Draw the circuit of a four-wire star connected three phase circuit and mark the lineand phase Voltage.
9. Differentiate driving point and transfer functions with respect to a two port network.
10. Draw the equivalent circuit representation in terms of Z-parameters. **(10 x 3=30)**

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

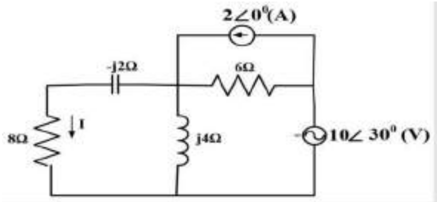
**Module-1**

11. (a) Draw the Thevenin’s equivalent circuit and hence find the power dissipated across $R_L$ **(8)**




(b)Compare the difference between dependent and independent sources. **(6)**

12. (a) Determine the power dissipated across 8Ω for the circuit shown by applying superpositiontheorem. **(10)**




(b) State and explain Thevenin'stheorem with suitable examples. **(4)**

**Module-2**

13. (a) The current through 5Ω resistor is **I(S) =(5S+3)/(S²+5S+6).** Find the power dissipated across 5Ω resistor. **(7)**

(b) Derive the equation for the transient current flow through series RL circuit with DCsource and zero initial condition. **(7)**

14. (a) Derive the equation for the transient current flow through series RC circuit with DC source and zero initial condition. **(7)**

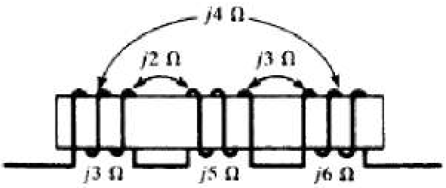
(b) Explain the term time constant with respect to series RL circuit with suitable figures. **(7)**

**Module-3**

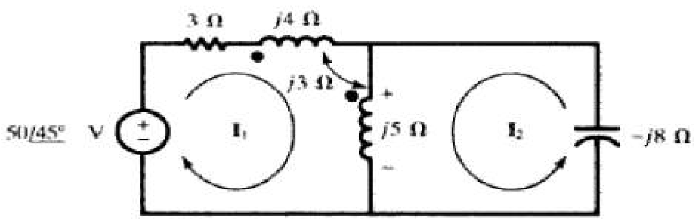
15. (a) In a series aiding connection, two coupled coils have an equivalent inductance LAand in a series opposing connection, the equivalent inductance is LB. Obtain an expression for M in terms of LA and LB. **(7)**

(b) Two coupled coils, L1 = 0.8 H and L2 = 0.2 H, have a coefficient of coupling k = 0:90. Find the mutual inductance M and the turns ratio N1/N2. **(7)**

16. (a) Obtain the dotted equivalent for the circuit shown and use the equivalent to find theequivalent inductive reactance. **(7)**




(b) In the circuit shown in figure, find the voltage across the 5 Ω reactance with the polarity shown. **(7)**



## Module-4

17. (a) Explain two watt-meter method to measure the three phase power with the help of suitable equations. **(7)**

(b) Derive the relationship between the line and phase voltage in a three phase starconnected circuit. **(7)**

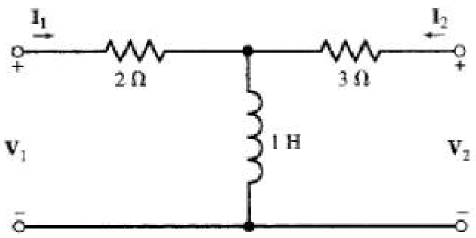
18. (a) A three-phase, three-wire, balanced, delta-connected load yields wattmeter readings of 154W and 557W. Obtain the load impedance, if the line voltage is 141.4 V. **(7)**

(b) Derive the relationship between the line and phase current of a three phase deltaconnected circuit. **(7)**

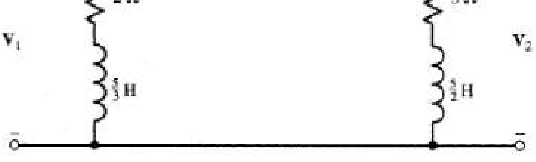
## Module-5

19. (a) Derive the relationship between Z and Y parameters. **(6)**

(b) Find the Z-parameters of the two-port circuit. **(8)**




20. (a) Find the Y-parameters of the circuit. **(10)**




(b) Explain the condition for symmetry and reciprocity with respect to Z-parameters. **(4)**

## Syllabus

**Module 1**

**Circuit theorems:**Review of Nodal and Mesh analysis method. DC and ACcircuits analysis with dependent and independent sources applying Network theorems – Superposition theorem, Thevenin's theorem.

**Module 2**

**Steady state and transient response**:Review of Laplace Transforms. DCresponseof RL, RC and RLC series circuitswith initial conditions and complete solution using Laplace Transforms- Time constant.

**Module 3**

**Transformed circuits and analysis** – Mutual inductance, coupling coefficient, dot rule. Analysis of coupled coils -– mesh analysis and node analysis of transformed circuits in S-domain.

**Module 4**

**Three phase networks:**Three phase power in sinusoidal steady state-complex power, apparent power and power triangle. Steady state analysis of three-phase three-wire and four-wire balanced and unbalanced Y circuits, Balanced and unbalanced Delta circuit. Three phase power measurement and two-wattmeter method.

**Module 5**

**Two port networks**: Driving point and transfer functions – Z and Y parameters.**-** Conditions for symmetry & reciprocity – Z and Y parameters. Relationshipbetween Z and Y parameters.

**Text Books**

1. Joseph A. Edminister and MahmoodNahvi, "Theory and Problems in Electric circuits", McGraw Hill, 5th Edition, 2010.
2. Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013

**References:**

21. Hayt and Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education, New Delhi, 8th Ed, 2013.

2. Van Valkenberg, "Network Analysis", Prentice Hall India Learning Pvt. Ltd., 3 edition, 1980.

3. K. S. Suresh Kumar, "Electric Circuit Analysis", Pearson Publications, 2013.

4. Chakrabarti, "Circuit Theory Analysis and Synthesis", DhanpatRai& Co., Seventh - Revised edition, 2018

5. R. Gupta, "Network Analysis and Synthesis", S. Chand & Company Ltd, 2010.

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Circuit theorems(12 hours)** | |
| 1.1 | Review of Nodal analysis method. | 2 |
| 1.2 | Review of Mesh analysis method. | 2 |
| 1.3 | Dependent and independent current and voltage sources | 2 |
| 1.4 | Superposition theorem - Application to the analysis of DCand AC circuits with dependent and independent sources. | 3 |
| 1.5 | Thevenin's theorem - Application to the analysis of DC and AC circuits with dependent and independent sources. | 3 |
| **2** | **Steady state and transient response. (9 hours)** | |
| 2.1 | Review of Laplace Transforms – Formulae of Laplace Transforms of common functions/signals, Initial value theorem and final value theorem, Inverse Laplace Transforms – partial fraction method. | 3 |
| 2.2 | DC response of RL series with initial conditions and complete solution using Laplace Transforms- Time constant | 2 |
| 2.3 | DC response of RC series with initial conditions and complete solution using Laplace Transforms- Time constant | 2 |
| 2.4 | DC response of RLC series with initial conditions and complete solution using Laplace Transforms- Time constant | 2 |
| **3** | **Transformed circuits and analysis (8 Hours)** | |
| 3.1 | Mutual inductance and Coupling Coefficient | 2 |
| 3.2 | Dot rule and polarity convention | 1 |
| 3.3 | Mesh analysis of transformed circuits in s-domain. | 3 |
| 3.5 | Nodalanalysis of transformed circuits in s-domain. | 2 |
| **4** | **Three phase networks. (9 Hours)** | |
| 4.1 | Three phase power in sinusoidal steady state-complex power, apparent power and power triangle. | 2 |
| 4.2 | Steady state analysis of three-phase three-wire and four-wire balanced and unbalanced Y circuits | 3 |
| 4.3 | Steady state analysis of three-phase three-wire and four-wire balanced and unbalanced Delta circuits. | 2 |
| 4.4 | Three phase power measurement and two-wattmeter method. | 2 |

| | | |
|---|---|---|
| **5** | **Two port networks (7 Hours)** | |
| 5.1 | Two port networks: Terminals and Ports, Driving point and transfer functions. | 2 |
| 5.2 | Z –parameters. Equivalent circuit representation. | 1 |
| 5.3 | Y parameters. Equivalent circuit representation. | 1 |
| 5.6 | Conditions for symmetry & reciprocity- Z and Y-parameters | 2 |
| 5.7 | Relationship between Z and Yparameters. | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEMR 310.2** | **INTRODUCTION TO POWER ENGINEERING** | **Minor** | **3** | **1** | **0** | **4** |

**Preamble :** This course introduces various conventional energy sources. This course also introduces the design of transmission system and distributions system. It also introduces the economics of power generation.

**Prerequisite :** EST 130Basics of Electrical & Electronics Engineering

**Course Outcomes :** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Illustrate various conventional sources of energy generation |
| **CO 2** | Analyse the economics of power generation |
| **CO 3** | Analyse the economics of power factor improvement |
| **CO 4** | Design mechanical parameters of a transmission system. |
| **CO 5** | Design electrical parameters of a transmission system. |
| **CO 6** | Classify different types of ac and dc distribution systems. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | 2 |
| **CO 5** | 3 | 3 | | | | | | | | | | 2 |
| **CO 6** | 3 | 3 | | | | | | | | | | 2 |

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. Schematic and equipment of Conventional Power generation schemes (K1)
2. Comparison of various turbines associated with conventional generation (K2, K3)

**Course Outcome 2 (CO2):**

1. Definition and Calculation of various terms associated with power generation (K1, K2)
2. Problems on economics of power generation. (K2, K3)

**Course Outcome 3 (CO3):**

1. Problems on calculation of size of capacitors for power factor improvement (K2, K3).
2. Problems on economics of power factor placement (K2, K3).

**Course Outcome 4 (CO4):**

1. Derivation of various mechanical parameters associated with transmission line (K2, K3)
2. Derivation and problems of corona and insulators. (K2, K3).

**Course Outcome 5 (CO5):**

1. Derivation of various electrical parameters associated with transmission line (K2, K3).
2. Definition on transposition of line and changes in electrical parameters (K1,K2)

**Course Outcome 6 (CO6):**

1. Problems on AC and DC distribution systems (K2,K3).
2. Architecture and technologies in smart grid (K2,K3)

**Model Question paper**

**QPCODE:** PAGES:3

Reg.No:______

Name :

**TKM COLLEGE OF ENGINEERING**

**FIRSTSEMESTERB.TECHDEGREEEXAMINATION, MONTH &YEAR**

**Course Code: 22EEMR 310.2**

**Course Name: Introduction to Power Engineering**

**Max.Marks:100** **Duration: 3Hours**

## PART A

**Answer all Questions. Each question carries 3 Marks**

1. What are the main differences between nuclear and thermal power plants?
2. How are turbines classified? How is a turbine selected for a site?
3. Explain the significance of Load factor and Load curve.
4. Discuss the disadvantages of low power factor in power system.
5. What is corona? Explain the factors have an influence on corona loss
6. High voltage is preferred for transmission. Discuss the merits and demerits of high voltage transmission.
7. Draw and explain the equivalent models of a medium transmission line.
8. What is transposition of lines? Comment on its necessity in the system.
9. Discuss the requirements of a distribution system.
10. Discuss the main features of an interconnected distribution system.

**(10x3=30)**

## PART B

**Answer any one full question from each module. Each question carries 14 Marks**

### Module 1

11. (a) Explain thegeneral arrangement of gas turbine power plant. **(8)**

(b) Discuss the importance of small hydro power generation along with their advantages and disadvantages. **(6)**

12. (a) Explain various elements of a elements of diesel power plant **(8)**

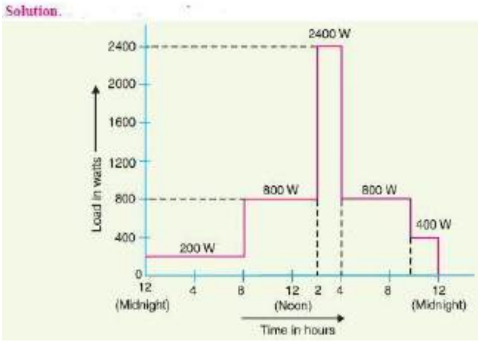
(b) Explain the general layout of a nuclear power plant. **(6)**

### Module 2

13. (a)A generating station has a maximum demand of 150000 kW. The annual load factor is 50% and plant capacity factor is 40%. Determine the reserve capacity of the plant. **(6)**

(b) The power factor in a three-phase plant with supply voltage of 400 V and absorbing an average power of 300 kW is 0.8. Determine the kVAr of the capacitor required to improve the power factor to 0.93. Determine the reduction in current drawn from the supply after installation of the capacitors. **(8)**

14. (a) Determine average demand and load factor of the load curve shown below **(7)**




(b) Explain any two methods of power factor improvement. **(7)**

**Module 3**

15. (a) Derive the equation for Sag in transmission lines, when the support is at equaland unequal heights. **(10)**

(b) Discuss the difference between disruptive critical corona and visual critical corona **(4)**

16. (a) In a 33 kV overhead line, there are three units in the string of insulators. If the capacitance between each insulator pin and earth is 11% of self-capacitance of each insulator, find (i) the distribution of voltage over 3 insulators and (ii) string efficiency. **(9)**

(b) Discuss various types of conductors used in power system. **(5)**

**Module 4**

17. (a) A 3 phase 70km long Transmission line has its conductors of 1 cm diameter spaced at the corners of the equilateral triangle of 100cm side. Find the inductance per phase of the system. **(6)**

(b) Derive loop inductance of a single phase two wire line. **(8)**

18. (a) The three conductors of a 3-phase line are arranged at the corners of a triangleof sides 2 m, 2·5 m and 4·5 m. Calculate the inductance per km of the line when the conductors areregularly transposed. The diameter of each conductor is 1·24 cm. **(6)**

(b)A single-phase transmission line has two parallel conductors 3 m apart,radius of each conductor being 1 cm. Calculate the capacitance of the line per km. **(8)**

**Module 5**

19. (a) Compare radial and ring main distribution system with the help of appropriate schematics. **(6)**

(b) A two conductor main, AB, 500m in length is fed from both ends at 250 V. Loads of 50A, 60A, 40A and 30A are tapped at distances of 100m, 250m, 350m and 400m from end A respectively. If the cross section of conductor is 1 $cm^2$ and specific resistance of the material is 1.7 μΩcm, determine the minimum consumer voltage. **(8)**

20. (a) A 2-wire dc distributor cable AB is 2 km long and supplies loads of 100A, 150A,200A and 50A situated 500 m, 1000 m, 1600 m and 2000 m from the feeding point A. Each conductor has a resistance of 0·01 Ω per 1000 m. Calculate the p.d. at each load point if a p.d. of 300 V is maintained at point A. **(7)**

(b) Explain the architecture of smart grid with the help of a schematic **(7)**

**(14x5=70)**

**Syllabus**

**Module 1**

**Generation of power**

Conventional sources**:** Hydroelectric Power Plants- Selection of site. General arrangement of hydel plant, Components of the plant, Classification of the hydel plants -Water turbines: Pelton wheel, Francis, Kaplan and propeller turbines, Small hydro generation.

Steam Power Plants: Working of steam plant, Power plant equipment and layout, Steam turbines

Diesel Power Plant: Elements of diesel power plant, applications

Gas Turbine Power Plant: Introduction Merits and demerits, selection site, fuels for gas turbines, General arrangement of simple gas turbine power plant, comparison of gas power plant with steam power plants

Nuclear Power Plants:Nuclear reaction, nuclear fission process, nuclear plant layout, Classification of reactors

**Module 2**

**Economics of power generation**

Types of loads, Load curve, terms and factors, peak load and base load

Cost of electrical energy – numerical problems

Power factor improvement – causes of low power factor, disadvantages - methods of power factor improvement, calculations of power factor correction, economics of power factor improvement

**Module 3**

**Transmission system**

Different types of transmission system - High voltage transmission - advantages

Mechanical design of overhead transmission line: Main components of overhead lines – types of conductors, line supports

Insulators–Types-String efficiency – methods of improving string efficiency

Corona – Critical disruptive voltage - Visual Critical Voltage – corona loss - Factors affecting corona, advantages and disadvantages, methods of reducing corona

Sag - calculation

**Module 4**

**Electrical design of transmission line**

Constants of transmission line – Resistance, inductance and capacitance

Inductance and capacitance of a single phase transmission line

Inductance and capacitance of a three phase transmission line with symmetrical and unsymmetrical spacing – transposition of lines

**Module 5**

**Distribution system**

Types of distribution systems

Types of DC distributors – calculations – distributor fed at one end and at both ends

Types of AC distributors – calculations

**Smart Grid** Smart Grid – Introduction - challenges and benefits — architecture of smart grid introduction to IEC 61850 and smart substation

**Text Books**

Text Books:

D P Kothari and I Nagrath, "Power System Engineering," 2/e Tata McGraw Hills, 2008.

1. Wadhwa, “Electrical Power system”, Wiley Eastern Ltd. 2005.

**References:**


1. A.Chakrabarti, ML.Soni, P.V.Gupta, V .S.Bhatnagar, “A text book of Power system Engineering” DhanpatRai, 2000.
2. Grainer J.J, Stevenson W.D, “Power system Analysis”, McGraw Hill.
3. I.J.Nagarath& D.P. Kothari, “Power System Engineering”, TMH Publication.
4. A Stuart Borlase, “Smart Grids, Infrastructure, Technology and Solutions”, CRC Press, 2013.


**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Conventional energy sources (9 hours)** | |
| 1.1 | Introduction and history ofpower generation | 1 |
| 1.2 | Hydel power plant- Schematic, components and turbines | 2 |
| 1.2 | Steam power plant – Schematic, components and turbines | 2 |
| 1.3 | Schematic and various turbines with diesel and GT power generation | 3 |
| 1.4 | Nuclear power generation | 1 |
| **2** | **Economics of power generation and power factor improvement (8 hours)** | |
| 2.1 | Important terms associated with power generation such as load factor, load curve, etc | 1 |
| 2.2 | Numerical problems on the economics of generation. | 2 |
| 2.3 | Significance of power factor in power system | 1 |
| 2.4 | Methods of power factor improvement | 2 |
| 2.5 | Numerical problems on capacitor value evaluation and economics of power factor improvement | 2 |
| **3** | **Transmission System (10 Hours)** | |
| 3.1 | Introduction to transmission systems | 1 |
| 3.2 | Mechanical design of transmission lines- line supports and conductors | 2 |

| | | |
|---|---|---|
| 3.3 | Types of insulators | 1 |
| 3.4 | String Efficiency, Methods of improving string efficiency, Numerical problems | 2 |
| 3.5 | Corona - Critical disruptive voltage : Visual Critical Voltage –corona loss | 1 |
| 3.6 | Factor affecting corona and corona loss, Numerical problems on corona | 2 |
| 3.7 | Sag in transmission lines | 1 |
| **4** | **Electrical parameters of a transmission line (9 Hours)** | |
| 4.1 | Introduction to constants of transmission line | 1 |
| 4.2 | Derivation of inductance and capacitance of a single phase transmission line | 2 |
| 4.3 | Derivation of Inductance and capacitance of a three phase transmission line with symmetrical and unsymmetrical spacing, transposition of lines | 3 |
| 4..4 | Numerical problems on inductance, capacitance of transmission lines | 3 |
| **5** | **Distribution systems (9 Hours)** | |
| 5.1 | Introduction to distribution system | 1 |
| 5.2 | DC distribution system – various types | 2 |
| 5.3 | Numerical Examples of DC distribution system | 1 |
| 5.4 | AC distribution system – various types | 2 |
| 5.5 | Numerical Examples of DC distribution system | 2 |
| 5.6 | Introduction to smart grid | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEMR310.3** | **DYNAMIC CIRCUITS AND SYSTEMS** | **Minor** | **3** | **1** | **0** | **4** |

**Preamble :** This course introduces the application of circuit analysis techniques to dc and ac electric circuits. Analysis of electric circuits both in steady state and dynamic conditions are discussed. Network analysis using network parameters and transfer functions is also included .

**Prerequisite : Basics of Electrical Engineering / Introduction to Electrical Engineering**

**Course Outcomes :** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Apply circuit theorems to simplify and solve complex DC and AC electric networks. |
| **CO 2** | Analyse dynamic DC and AC circuits and develop the complete response to excitations. |
| **CO 3** | Solve dynamic circuits by applying transformation to s-domain. |
| **CO 4** | Solve series /parallel resonant circuits. |
| **CO 5** | Develop the representation of two-port networks using network parameters and analyse the network. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | 2 |
| **CO 5** | 3 | 3 | | | | | | | | | | 2 |

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO 1):**

1. State and explain network theorems (K1)
2. Problems on solving circuits using network theorems. (K2, K3)

**Course Outcome 2 (CO 2):**

1. Distinguish between the natural response and forced response. (K2, K3)
2. Problems related to steady state and transient analysis of RL, RC and RLC series circuits with DC excitation and initial conditions. (K2, K3)
3. Problems related to steady state and transient analysis of RL, RC and RLC series circuits with sinusoidal excitation. (K2, K3)

**Course Outcome 3 (CO 3):**

1. Problems related to mesh analysis and node analysis of transformed circuits in s-domain (K2, K3).
2. Problems related to solution of transformed circuits including mutually coupled circuits in s-domain (K2, K3).

**Course Outcome 4 (CO 4):**

1. Define Bandwidth, and draw the frequency dependence of impedance of an RLC network. (K1).
2. Develop the impedance/admittance Vs frequency plot for the given RLC network. (K2).
3. Evalutate the parameters such as quality factor, bandwidth,

**Course Outcome 5 (CO 5):**

1. Problems to find Z, Y, h and T parameters of simple two port networks. (K2).
2. Derive the expression for Z parameters in terms of T parameters. (K1).
3. Show that the overall transmission parameter matrix for cascaded 2 port network is simply the matrix product of transmission parameters for each individual 2 port network in cascade. (K1).

**Model Question paper**

**QP CODE:**

PAGES:2

Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**THIRD SEMESTER B.TECH. DEGREE EXAMINATION**

**Course Code: 22EEMR310.3**
**Course Name: DYNAMIC CIRCUITS AND SYSTEMS**

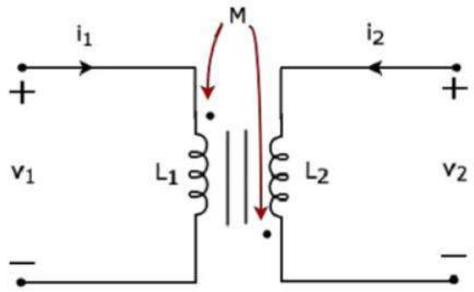
Max. Marks: 100

Duration: 3 Hours

**PART A**

***Answer all questions, each carries 3 marks.***

1. What is the condition for transferring maximum power to load in an ac network? How is it obtained?
2. State and explain the reciprocity theorem.
3. Derive an expression for calculating the steady state current when an ac is applied to a series RL circuit.
4. A voltage of $v(t) = 10\cos(1000t + 60^0)$ is applied to a series RLC circuit in which $R=10\Omega$, $L=0.02H$ and $C=10^{-4}F$. Find the steady current.
5. Apply KVL in both primary and secondary circuits and write the corresponding equations.




6. Give the transform representation in s-domain of an inductor with initial current and transform representation in s-domain of a capacitor with initial voltage.
7. Compare series and parallel resonance on the basis of resonant frequency, impedance and bandwidth.
8. How is selectivity measured in a parallel resonant circuit? How is selectivity increased?
9. What are the conditions for reciprocity of a two port network in terms of z parameters? What are the similar conditions in terms of y parameters?
10. How do we find equivalent T network of a two port network if z parameters are given?

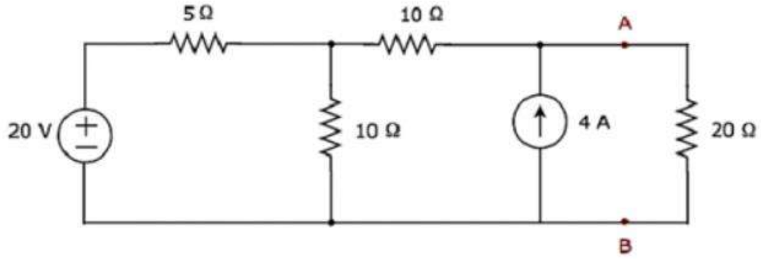
**(10 x 3 = 30)**

**PART B**

***Answer any one full question, each carries14 marks.***

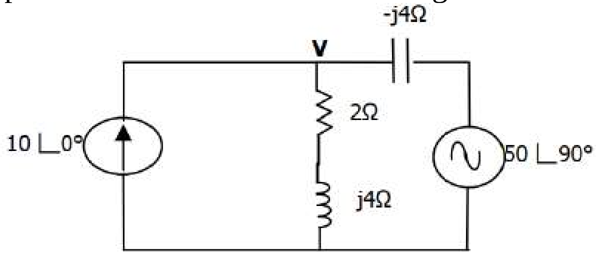
**MODULE1**

11. a) Find the current through the 20Ω resistor using Norton's theorem. **(6)**




b) State and prove maximum power transfer theorem. **(8)**

12. a) Use superposition theorem to find the voltage V shown in figure. **(8)**




b)State Thevenin's theorem. How is Thevenin equivalent circuit developed? **(6)**

## MODULE II

13. a)Write the dynamic equations for analyzing the behavior of step response of a series RLC circuit. **(7 )**

b) A sinusoidal voltage 25 sin 10t is applied at time t=0 to a series RL circuit comprising of R=5 Ω, L = 1 H. Using Laplace transformation, find an expression for instantaneous current in the circuit. **(7)**

14. a) A voltage 10 cos (1000t + $60^0$) is applied to a series RLC circuit comprising of R=10 Ω, L = 0.02 H, C = $10^{-4}$F. Find an expression for the steady state current in the circuit. **(7)**

b) A capacitor C having capacitance of 0.2 F is initially charged to 10 volts and it is connected to an RL series circuit comprising of R=4Ω and L = 1 H, by means of a switch at time t=0. Find the current through the circuit by means of Laplace transformation method. **(7)**

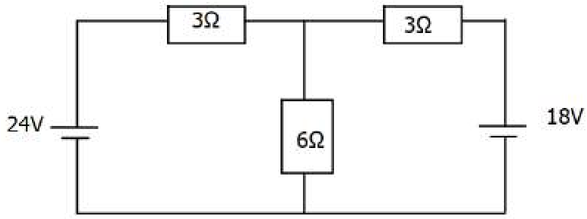
## MODULE III

15. a) An LC network comprises of series inductor branches L1 and L2 each of inductance 2 H and parallel capacitor branches C1 and C2 each with capacitance 1 F. Find the transform impedance Z(s). **(6)**

b) What are reciprocal networks? What are the conditions that should be satisfied by a network to be reciprocal? **(8)**

16. a) How is transfer function representation of a network function helpful in analyzing the behavior of the network? Mention the significance of poles and zeros in network functions? **(8)**

b)Using Laplace transformation, find the current in the 6 Ω resistor. **(6)**



## MODULE IV

17. a) In a series RLC circuit, for frequencies more than the resonant frequency, what nature of reactance is exhibited? Substantiate the reason for the answer. **(6)**

b) A series RLC circuit consists of R= 25 Ω, L = 0.01 H, C = 0.04 μF. Calculate the resonant frequency. If 10 V is applied to the circuit at resonant frequency, calculate the voltages across L and C. Find the frequencies at which these voltages are maximum. **(8)**

18. a) A coil of resistance 20 ohm and inductance of 200 mH is connected in parallel with a variable capacitor. This combination is connected in series with a resistance of 8000 ohm. Supply voltage is 200 V, 50Hz. Calculate the following

i) The value of C at resonance

ii) The Q of the coil

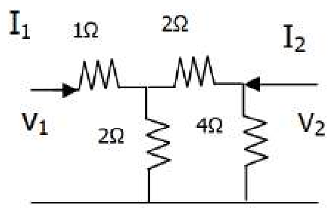
iii) Dynamic resistance of the circuit. **(7)**

b) Derive expressions for selectivity and bandwidth of a parallel tuned circuit. **(7)**

## MODULE V

**19.** a) A two port network has the following z parameters: $z_{11}$=10 **Ω**, $z_{12}$=$z_{21}$=5 **Ω**, $z_{22}$ = 12 **Ω**. Evaluate the y parameters for the network. **(8)**

b)Find the z parameters of the network given. **(6)**




20. a)For the given two-port network equations, draw an equivalent network. $I_1 = 5V_1 - V_2$ ; $I_2 = -V_2 + V_1$. **(7)**

b) A symmetrical T-network has the following open-circuit and short-circuit impedances:

$Z_{oc}$= 800Ω ( open circuit impedance)

$Z_{sc}$= 600Ω(short circuit impedance)

Calculate impedance values of the network. **(7)**

## Syllabus

### Module 1

**Circuit theorems:** DC and Sinusoidal steady state analysis of circuits with dependent and independent sources applying Superposition principle, Source transformation, Thevenin's, Norton's and Maximum Power Transfer theorems - Reciprocity theorem.

### Module 2

**Analysis of first and second order dynamic circuits:** Formulation of dynamic equations of RL, RC and RLC series and parallel networks with dc excitation and initial conditions and complete solution using Laplace Transforms - Time constant - Complete solution of RL, RC and RLC circuits with sinusoidal excitation using Laplace Transforms – Damping ratio – Over damped, under damped, critically damped and undamped RLC networks.

### Module 3

**Transformed circuits in s-domain:** Transform impedance/admittance of R, L and C - Mesh analysis and node analysis of transformed circuits in s-domain. Transfer Function representation – Poles and zeros.

**Analysis of Coupled Circuits:** – Dot polarity convention – Sinusoidal steady state analysis of coupled circuits - Linear Transformer as a coupled circuit - Analysis of coupled circuits in s-domain.

### Module 4

**Resonance in Series and Parallel Circuits:**

Resonance in Series and Parallel RLC circuits – Quality factor – Bandwidth – Impedance Vs Frequency, Admittance Vs Frequency, Phase angle Vs frequency for series resonant circuit.

### Module 5

**Two port networks**: Driving point and transfer functions – Z, Y, h and T parameters **-** Conditions for symmetry & reciprocity – relationship between parameter sets – interconnections of two port networks (series, parallel and cascade) — T-π transformation.

### Text Books

1. Joseph A. Edminister and MahmoodNahvi, "Theory and Problems in Electric circuits", McGraw Hill, 5th Edition, 2010.
2. Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013

### References:

1. Hayt and Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education, New Delhi, 8th Ed, 2013.
2. Van Valkenberg, "Network Analysis", Prentice Hall India Learning Pvt. Ltd., 3 edition, 1980.

3. K. S. Suresh Kumar, “Electric Circuit Analysis”, Pearson Publications, 2013.
4. Chakrabarti, "Circuit Theory Analysis and Synthesis", DhanpatRai& Co., Seventh - Revised edition, 2018
5. R. Gupta, "Network Analysis and Synthesis", S. Chand & Company Ltd, 2010.

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Network theorems - DC and AC steady state analysis (12 hours)** | |
| 1.1 | Linearity and Superposition principle - Application to the analysis of DC and AC (sinusoidal excitation) circuits. Application of source transformation in electric circuit analysis. | 2 |
| 1.2 | Thevenin’s theorem - Application to the analysis of DC and AC circuits with dependent and independent sources. | 3 |
| 1.3 | Norton’s theorem - Application to the analysis of DC and AC circuits with dependent and independent sources. | 3 |
| 1.4 | Maximum power transfer theorem - DC and AC steady state analysis with dependent and independent sources. | 2 |
| 1.5 | Reciprocity Theorem - Application to the analysis of DC and AC Circuits. | 2 |
| **2** | **First order and second order dynamic circuits. (9 hours)** | |
| 2.1 | Review of Laplace Transforms – Formulae of Laplace Transforms of common functions/signals, Initial value theorem and final value theorem, Inverse Laplace Transforms – partial fraction method. *(Questions to evaluate the Laplace/inverse transforms of any function / partial fractions method shall not be given in tests/final examination. Problems with application to circuits can be given).* | 2 |
| 2.2 | Formulation of dynamic equations of RL series and parallel networks and solution using Laplace Transforms – with DC excitation and initial conditions. Natural response and forced response. Time constant. | 1 |
| 2.3 | Formulation of dynamic equations of RC series networks and solution using Laplace Transforms – with DC excitation and initial conditions. Natural response and forced response. Time constant. | 1 |
| 2.4 | Formulation of dynamic equations of RLC series networks with DC excitation and initial conditions, and solution using Laplace Transforms – Natural response and forced response. Damping coefficient. Underdamped, Overdamped, critically damped and undamped cases. | 1 |
| 2.5 | Formulation of dynamic equations of RL, RC and RLC series networks and solution with sinusoidal excitation. Complete solution (Solution using Laplace transforms). | 2 |

| | | |
|---|---|---|
| 2.6 | Formulation of dynamic equations of RL, RC and RLC parallel networks and solution using Laplace Transforms – with DC and Sinusoidal excitations. Damping ratio. | 2 |
| **3** | **Transformed Circuits in s-domain and Coupled circuits (9 Hours)** | |
| 3.1 | Transformed circuits in s-domain: Transformation of elements (R, L, and C) with and without initial conditions. | 2 |
| 3.2 | Mesh analysis of transformed circuits in s-domain. | 1 |
| 3.3 | Node analysis of transformed circuits in s-domain. | 1 |
| 3.4 | Transfer Function representation – Poles and zeros. | 1 |
| 3.5 | Analysis of coupled circuits: mutual inductance – Coupling Coefficient- Dot polarity convention — Conductively coupled equivalent circuits. Linear Transformer as a coupled circuit. | 2 |
| 3.6 | Analysis of coupled circuits in s-domain. | 2 |
| **4** | **Resonance in Series and Parallel Circuits. (6 Hours)** | |
| 4.1 | Resonance in Series and Parallel RLC circuits –Related problems | 3 |
| 4.2 | Quality factor – Bandwidth – | 1 |
| 4.3 | Impedance Vs Frequency, Admittance Vs Frequency and Phase angle Vs frequency for series resonant circuit. | 2 |
| **5** | **Two port networks (9 Hours)** | |
| 5.1 | Two port networks: Terminals and Ports, Driving point and transfer functions. Voltage transfer ratio, Current transfer ratio, transfer impedance, transfer admittance, poles and zeros. | 2 |
| 5.2 | Z –parameters. Equivalent circuit representation. | 1 |
| 5.3 | Y parameters. Equivalent circuit representation. | 1 |
| 5.4 | h parameters. Equivalent circuit representation. | 1 |
| 5.5 | T parameters. | 1 |
| 5.6 | Conditions for symmetry & reciprocity, relationship between network parameter sets. | 1 |
| 5.7 | Interconnections of two port networks (series, parallel and cascade). | 1 |
| 5.8 | T-π Transformation. | 1 |

# SEMESTER IV

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EET 402 | DC MACHINES AND TRANSFORMERS | PCC | 2 | 2 | 0 | 4 |

**Preamble** : The purpose of the course is to provide the fundamentals of DC generators, DC motors and transformers and giving emphasis to applications in engineering field.

**Prerequisite** : Basics of Electrical Engineering

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Acquire knowledge about constructional details of DC machines |
| **CO 2** | Describe the performance characteristics of DC generators |
| **CO3** | Describe the principle of operation of DC motors and select appropriate motor types for different applications |
| **CO 4** | Acquire knowledge in testing of DC machines to assess its performance |
| **CO 5** | Describe the constructional details and modes of operation of single phase and three phase transformers |
| **CO6** | Analyse the performance of transformers under various conditions |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | | | 2 | | | | | | | 3 |
| **CO 2** | 3 | 2 | | | | 2 | | | | | | 3 |
| **CO 3** | 3 | 2 | 2 | | | 2 | | | | | | 3 |
| **CO4** | 3 | 3 | | | | 2 | | | | | | 3 |
| **CO5** | 3 | | | | | 2 | | | | | | 3 |
| **CO6** | 3 | | | | | 2 | | | | | | 3 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 10 | 10 | 30 |
| Apply | 10 | 10 | 30 |

| | | | |
|---|---|---|---|
| Analyse | 10 | 10 | 20 |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern**

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 5 marks for each question. Students should answer all questions. Part B contains five sections;each section shall have 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 10 marks.

**Part A:** 10 Questions x 5 marks=50 marks, **Part B:** 5 Questions x 10 marks =50 marks

**Course Level Assessment Questions**

**CO1:**

1. Describe the functions of individual parts of DC machines.
2. Develop simplex lap and wave windings for different pole and slot configurations.
3. Explain in detail why equaliser rings are required in lap windings.

**CO2:**

1. Describe different types of DC generators.
2. Derive the EMF equation of a DC machine.
3. Draw the open circuit and load characteristics of DC generators.
4. Explain the condition for voltage build up.
5. Explain armature reaction in DC machines and solutions to overcome its effects.
6. Analyse parallel operation of DC generators.

**CO3**:

1. Derive the torque equation of a DC motor.
2. Why starters are used in DC motors?
3. Explain types of speed control in DC motor.
4. Explain regenerative braking in DC motor.
5. What are the losses associated with DC motor?
6. Select suitable type of DC motor for specific applications.

**CO4**:

1. Describe the principle of Swinburn’s test for testing of DC motor and perform the calculations.
2. Describe the principle of Hopkinson’s test for testing of DC motor.
3. Describe the principle of retardation test for separation of losses in a DC motor.

**CO5**:

1. Derive the EMF equation of single-phase transformer.
2. Derive the condition for maximum efficiency in a transformer.
3. Explain the difference between power transformer and distribution transformer.
4. Explain the current rating and kVA rating of auto transformers.
5. Explain in detail no load and on load tap changing.
6. Draw the various three phase transformer connections.
7. Explain the stabilization by tertiary winding.

**CO6**:

1. Draw the equivalent circuit of single-phase transformer referred to primary side.
2. Explain no load and short circuit test on a single-phase transformer.
3. Explain Sumpner’s test on transformers.
4. What are the necessary condition for parallel operation of a single phase and three phase transformers?

**Model Question paper**

**QP CODE:**

PAGES: 2

Reg. No:______________
Name:________________

**TKM COLLEGE OF ENGINEERING**
**FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EET 402**

**Course Name: DC MACHINES AND TRANSFORMERS**

**Max. Marks: 100** **Duration: 3 Hrs**

**PART A**

**Answer all questions. Each Question Carries 3 marks**

1. Compare Lap and Wave Windings in DC machines.
2. Explain the need of Dummy Coils in DC machines.
3. What is armature reaction and mention two methods to eliminate it in DC machines.
4. What are the necessary conditions for voltage build up in a DC shunt generator.
5. Explain the significance of Back emf in a DC motor. Write down the voltage equation of a DC shunt motor.
6. Discuss the different types of armature speed control in DC shunt motor.
7. Derive the emf equation for a single phase Transformer.
8. How the rating of a transformer is specified? Justify.
9. Discuss the operation of open delta (V-V) configuration of transformers.
10. Discuss the need and working of on-load tap changers.

**PART B**

**Answer any one full question from each module. Each question carries 14 marks.**

**Module 1**

11. a) Discuss the need of Equalizer rings. **(5)**
    b) Obtain the front and back pitch of a progressive simplex double layer wave winding for a 4 pole dc generator with 30 armature conductors. **(9)**
12. Explain the construction of a DC machine with neat diagram. **(14)**

**Module 2**

13. Explain different types of DC generator with neat circuit diagram and necessary equations. **(14)**
14. Two DC shunt generators with induced emfs of 120V and 115V, armature resistance of 0.05Ω and 0.04Ω and field resistances of 20Ω and 25Ω respectively are in parallel supplying a total load of 25kW. Calculate the load shared by each generator? **(14)**

## Module 3

15. Draw the circuit diagram and explain the experimental procedure to conduct Hopkinson test on DC machine. **(14)**
16. A DC machine is rated at 5kW, 250V, 2000rpm and Ra=1Ω. Driven at 2000rpm, the no load power input to the armature is 1.2A at 250V with field winding (Rsh) = 250Ω, excited by Ish =1A. (i) Estimate efficiency as a generator delivering. (ii) Estimate the efficiency as a motor taking 5kW from supply. **(14)**

## Module 4

17. a) Derive the condition for maximum efficiency and the load current at which max. Efficiency occurs in a single phase transformer. **(8)**

    b) Discuss the significance of all day efficiency of transformers. **(6)**

18. A 20kVA, 250/2500V single phase transformer gave the following test results.

    OC Test (LV side): 200V, 1.4A, 105W

    SC Test (HV side): 120V, 8A, 320W

    Draw the equivalent circuit of single phase transformer referred to LV side. **(14)**

## Module 5

19. Explain Auto transformer with neat diagram and Derive an expression to justify thesaving of copper in auto transformer with respect to an ordinary two winding transformer with same rating. **(14)**
20. Explain Dy11 and Yd1 vector groupings of three phase transformers with phasor and winding connection diagrams. **(14)**

## Syllabus

### Module 1

Constructional details of dc machines - armature winding- single layer winding, double layer winding- lap and wave, equalizer rings, dummy coils, MMF of a winding, EMF developed, electromagnetic torque - numerical problems.

### Module 2

DC generator –principle of operation, EMF equation, excitation,armature reaction– demagnetising and cross magnetising ampere turn,compensating windings, interpoles, commutation,OCC, voltage build upand load characteristics, parallel operation. Power flow diagram– numerical problems.

### Module 3

DC motor –back emf, generation of torque,torque equation,performance characteristics – numerical problems.

Starting of dc motors- starters –3point and 4 point starters(principle only).

Speed control of dc motors - field control, armature control. Braking of dc motors. Power flow diagram – losses and efficiency.Testing of dc motors - Swinburne's test,Hopkinson's test, and retardation test.DC motor applications – numerical problems.

### Module 4

Single phase transformers –constructional details, principle of operation, EMF equation, ideal transformer,dot convention, magnetising current, transformation ratio, phasor diagram, operation on no load and on load, equivalent circuit, percentage and per unit impedance, voltage regulation. Transformer losses and efficiency, condition for maximum efficiency,kVA rating. Testing of transformers– polarity test, open circuit test, short circuit test, Sumpner's test – separation of losses, all day efficiency.Parallel operation of single-phase transformers– numerical problems

### Module 5

Autotransformer – saving of copper –ratingof autotransformers.

Three phase transformer – construction- difference between power transformer and distributiontransformer –Different connections of 3-phase transformers. Y-Y, Δ-Δ,Y-Δ, Δ-Y, V-V. Vector groupings – Yy0, Dd0, Yd1, Yd11, Dy1, Dy11.Parallel operation of three phase transformers.

Three winding transformer – stabilization by tertiary winding. Tap changing transformers - no load tap changing, on load tap changing, dry type transformers.

**Text Books**

1. Bimbra P. S., Electrical Machinery, 7/e, Khanna Publishers, 2011.
2. Nagrath J. and D. P. Kothari, Theory of AC Machines, Tata McGraw Hill, 2017.

**Reference Books**

1. Fitzgerald A. E., C. Kingsley and S. Umans, Electric Machinery, 6/e, McGraw Hill, 2003.
2. Langsdorf M. N., Theory of Alternating Current Machinery, Tata McGraw Hill, 2001.
3. Deshpande M. V., Electrical Machines, Prentice Hall India, New Delhi, 2011.
4. B. L. Theraja, Electrical Technology Vol II,S.Chand Publications.
5. A. E. Clayton & N. N. Hancock, The Performance and design of Direct Current Machines,CBS Publishers& Distributors, NewDelhi.

**Course Contents and Lecture Schedule**

| **Sl. No.** | **Topic** | **No. of Hours** |
|---|---|---|
| **1** | **Constructional details of dc machines** | **8** |
| 1.1 | Constructional details of DC machines | 2 |
| 1.2 | Armature winding- single layer | 1 |
| 1.3 | Armature winding- double layer-wave and lap, equaliser rings, dummy coils. | 3 |
| 1.4 | MMF of a winding, EMF developed, electromagnetic torque. | 2 |
| **2** | **DC Generator** | **9** |
| 2.1 | DC generators- principle of operation, EMF equation, methods of excitation –separately and self-excited – shunt, series, compound machines.Numerical problems | 3 |
| 2.2 | Armature reaction – effects of armature reaction, demagnetising and cross magnetising ampere-turns, compensating windings,interpoles. Numerical problems. | 3 |
| 2.3 | Load characteristics, losses and efficiency power flow diagram. Parallel operation – applications of dc generators. Numerical problems. | 3 |
| **3** | **DC Motor** | **10** |
| 3.1 | DC motor– principle of operation, back emf, classification– torque equation. Numerical problems. | 2 |
| 3.2 | Starting of DC motors – necessity of starters. Numerical problems. | 2 |

| | | |
|---|---|---|
| | Types of starters – 3 point and 4 point starters(principle only). | |
| 3.3 | Speed control – field control, armature control- Numerical problems.<br>Braking of dc motors (Description only) | 2 |
| 3.4 | Losses and efficiency – power flow diagram. Numerical problems | 1 |
| 3.5 | Swinburne's test - Numerical problems. | 1 |
| 3.6 | Hopkinson's test, separation of losses – retardation test.<br>Applications of dc motors. | 2 |
| **4** | **Single phase Transformer** | **10** |
| 4.1 | Transformers – principle of operation, construction, core type and shell type construction. | 1 |
| 4.2 | EMF equation, transformation ratio, ideal transformer,transformer with losses, phasor diagram - no load and on load operation. Numerical problems. | 2 |
| 4.3 | Equivalent circuit, percentage and per unit impedance, voltage regulation. Numerical problems. | 2 |
| 4.4 | Transformer losses and efficiency, Condition for maximum efficiency, all day efficiency – Numerical problems. | 2 |
| 4.5 | Dot convention – polarity test, OC & SC test, Sumpner's test,separation of losses. Numerical problems. | 2 |
| 4.6 | kVA rating of transformers,parallel operation of single phase transformers | 1 |
| **5** | **Autotransformer & Three phase transformer** | 8 |
| 5.1 | Autotransformer – ratings, saving of copper.Numerical problems. | 2 |
| 5.2 | Three phase transformer construction, three phase transformer connections, power transformer and distribution transformer. | 2 |
| 5.3 | Vector groupings Yy0, Dd0, Yd1, Yd11, Dy1, Dy11. | 1 |
| 5.4 | Three winding transformer – tertiary winding. Percentage and per unit impedance. Parallel operation. | 2 |
| 5.5 | On load and off load tap changers, dry type transformers. | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET 403** | **ELECTROMAGNETIC THEORY** | PCC | 3 | 1 | 0 | 4 |

**Preamble** : The purpose of the course is to familiarize the students with the fundamentals of electrostatics, magnetostatics, time-varying fields and electromagnetic waves.

**Prerequisite** : Engineering Mathematics,Engineering Physics

**Course Outcomes** :After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Apply vector analysis and coordinate systems to solve static electric and magneticfield problems. |
| **CO 2** | Apply Gauss Law, Coulomb's law and Poisson's equation to determine electrostatic field parameters |
| **CO 3** | Determine magnetic fields from current distributions by applying Biot-Savart's law and Amperes Circuital law. |
| **CO 4** | Apply Maxwell Equations for the solution of timevarying fields |
| **CO 5** | Analyse electromagnetic wave propagation in different media. |

**Mapping of course outcomes with programme outcomes:**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 3 | | | | | | | | | | |
| **CO 2** | 2 | 3 | | | | | | | | | | |
| **CO 3** | 2 | 3 | | | | | | | | | | |
| **CO 4** | 2 | 3 | | | | | | | | | | |
| **CO 5** | 2 | 3 | | | | | | | | | | |

**Assessment Pattern:**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand* | 20 | 20 | 50 |
| Apply* | 20 | 20 | 30 |
| Analyse | - | - | - |
| Evaluate | - | - | - |
| Create | - | - | - |
| | | | |

*Numerical problems to test the understanding and application of principles to be asked.

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions:**

**Course Outcome 1 (CO1):**

1. Transform the vector **B**= 5$\mathbf{a_x}$-7$\mathbf{a_y}$ to Cylindrical Co-ordinate System at the point P (r=4, Φ=120$^o$, z=2).
2. Drawing necessary sketches, obtain the rectangular co-ordinates x,y,z of the point P , in terms of its cylindrical co-ordinates r,Φ,z. Assume the same origin for both co-ordinate systems.
3. Distinguish between Divergence and Gradient. Explain the physical significance of Divergence.
4. State and prove Divergence Theorem.

**Course Outcome 2 (CO2):**

1. A 2μC positive charge is located in vacuum at $P_1$(3,-2,4) and 5μC negative charge is at $P_2$ (1,-4,-2). Determine: (i) the vector force on the negative charge. (ii) the magnitude of the force on the charge at $P_1$?
2. Apply Gauss's Law to obtain the electric field intensity due to an infinite sheet of charge.
3. Derive an expression for the capacitance of a co-axial cable.

**Course Outcome 3(CO3):**

1. Derive the magnetic field intensity at a point on a line through the centre and perpendicular to the plane of a circular loop of radius 'r' m carrying current 'I' A. The point is at a distance 'h' m from the centre of the loop.
2. State Ampere's Circuital law. Express it in integral and differential forms.
3. State Biot-Savart's Law and express it in vector form.

**Course Outcome 4 (CO4):**

1. Formulate the Maxwell's equation in differential form and integral form for time-varying fields.
2. Derive general wave equations from Maxwell's equations.
3. Explain how Ampere's circuital law can be modified for time-varying fields.

**Course Outcome 5 (CO5):**

1. Define a) intrinsic impedance b) characteristic impedance.
2. Derive wave equations for Uniform plane wave in free space.
3. A 9375 MHz uniform plane wave is propagating in free space. If the amplitude of the electric field intensity is 20 V/m and the material is assumed to be loss less find α, β, λ, intrinsic impedance, propagation constant and amplitude of magnetic field intensity**.**

**Model Question paper**

**PAGES: 2**

**QP CODE:**

**Reg. No:______________**

**Name :______________**

**TKM COLLEGE OF ENGINEERING**

**FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EET 403**

**Course Name: ELECTROMAGNETIC THEORY**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. State Strokes Theorem and explain.
2. What do you understand by Curl of a vector? Explain its physical significance?
3. Define electric dipole. What is the electric field intensity due to an electric dipole?
4. Explain the term electric field intensity.
5. State Biot-Savarts Law.
6. What is conduction current and displacement current?
7. Explain group velocity and phase velocity.
8. Which of Maxwell's equation states that the magnetic field is a non-conservational field in both static and dynamic conditions? Comment.
9. Explain electromagnetic interference.
10. What is SWR?

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. (a) Transform vector A= 5 a$\hat{r}$ + 2 sinϕa$\hat{\theta}$ +2 cosθ a$\hat{\phi}$ in spherical to Cartesian coordinate system. **(6)**

(b) Evaluate both sides of the Divergence theorem for the region r ≤ 1 and if A= 3r $sin^2$θ $cos^2\phi$ a$\hat{r}$. **(8)**

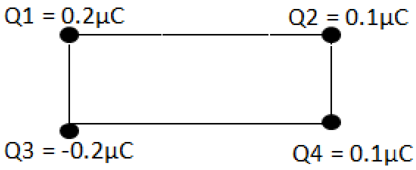
12. (a) Derive co-ordinate transformation between Cartesian and Spherical systems. **(10)**

(b) Explain the physical significance of divergence of a vector field. **(4)**

## Module 2

13. (a) State and Prove Gauss's Law. **(4)**

(b) Four point charges are located at the four corners of the rectangle as shown. Length and breadth of rectangle are 5cm and 2 cm respectively. Find the magnitude and direction of the resultant force on Q1. **(10)**




14. (a) Derive the expression of electric field intensity due to infinite line charge having line charge density ρ C/m. **(6)**

(b) Using Gauss's Law derive an expression for the capacitance per unit length between two infinitely long concentric conducting cylinders. The medium between two cylinders is completely filled with air. **(8)**

## Module 3

15. (a) State the boundary conditions at the boundary of two magnetic media of permeability μ1 and μ2. **(10)**

(b) Flux lines are received at an iron-air boundary at$88^0$. If the iron has a relative permeability of 350, determine the angle from the normal with which the flux emerges into air. **(4)**

16. (a) Find the incremental contribution ΔH to magnetic field intensity at the origin caused by a current element in free space, IdL equal to $3\pi\ a\hat{z}$nA, located at (3,-4,0). **(8)**

(b) Derive the magnetic field intensity on the axis of a circular loop carrying current. **(6)**

## Module 4

17. (a) A 10GHz plane wave travelling in free space has an amplitude 15V/m. Find velocity of propagation, wavelength, amplitude of H, characteristic impedance of media, propagation constant. **(10)**

(b) What is skin effect and skin depth? (4)

18. (a) Explain about Poynting Theorem. Show that the power flow along a concentric cable is the product of voltage and current using pointing Theorem. **(10)**

(b) What is uniform plane wave? What are its properties? **(4)**

## Module 5

19. (a) Explain in detail impedance matching of lines. **(10)**

(b) Explain the term propagation constant and phase velocity as applied to transmission lines. **(4)**

20. (a) Derive the basic transmission line equation. **(9)**

(b) What are the different parameters of transmission lines? **(5)**

## Syllabus

**Module 1:**

Introduction to Co-ordinate Systems – Rectangular, Cylindrical and Spherical Co- ordinate Systems – Co-ordinate transformation; Gradient of a Scalar field, Divergence of a Vector field and Curl of a Vector field- their physical interpretation; Divergence Theorem, Stokes' Theorem;

**Module 2:**

Coulomb's Law, Electric field intensity, Field due to a line charge, surface charge distribution. Electric Flux and Flux Density; Gauss's law and its application to determine the field due to an infinite line charge, infinite sheet charge; Electric Potential-Potential Gradient, conservative property of electric field, Equipotential surfaces; Electric Dipole; Capacitance - capacitance of co-axial cable, two wire line; Poisson's and Laplace's equations;

**Module 3:**

Biot-Savart's Law, Magnetic Field intensity due to a finite and infinite wire carrying current; Magnetic field intensity on the axis of a circular and rectangular loop carrying current; Magnetic flux Density; Magnetic Vector Potential; Ampere's circuital law and simple applications; Inductance and mutual inductance. Boundary conditions for electric fields and magnetic fields;

Conduction current and displacement current densities; Continuity equation for current; Maxwell's Equation in Differential and Integral form from Modified form of Ampere's circuital law, Faraday's Law and Gauss's Law.

**Module 4:**

Wave Equations from Maxwell's Equations; Uniform Plane Waves, Wave equations in Phasor form; Propagation of Uniform Plane waves in free space, loss-less and lossy dielectric medium, Uniform Plane waves in good conductor; Skin effect and skin depth, phase velocity and groupvelocity, Intrinsic Impedance, Attenuation constant and Propagation Constant in all medium;Poynting Vector and Poynting Theorem.

**Module 5:**

Transmission line: Waves in transmission line, Line parameters, Transmission line equation & solutions, Propagation constants, Characteristic impedance, Wavelength, Velocity of propagation. Standing Wave Ratio(SWR), impedance matching.Solution of problems. Electromagnetic interference.

**Text Books**

1. Matthew N.O. Sadiku, *Principles of Electromagnetics*, Oxford University Press, $6^{th}$ Edition.
2. Hayt W. H. and J. A. Buck, *Engineering Electromagnetics*, McGraw-Hill, $8^{th}$ Edition.

**Reference Books**

1. Joseph A. Edminister, *Electromagnetics, Schaum's Outline Series*, Tata McGraw-Hill, Revised $2^{nd}$ Edition.
2. John Kraus and Daniel Fleisch, *Electromagnetics with Applications*, McGraw-Hill, $5^{th}$edition
3. Cheng D K,*Fundamentals of Engineering Electromagnetics*, Addison-Wesley.
4. Guru B. S. and H. R.Hizroglu, *Electromagnetic Field Theory Fundamentals*,PWS Publication Company,Boston, 1998.
5. Gangadhar K. A. and P. M. Ramanathan, *Electromagnetic Field Theory*, Khanna Publishers, 2009

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Module 1:** | **9** |
| 1.1 | Introduction to coordinate systems – Rectangular, cylindrical and spherical coordinate Systems – Coordinate transformation. Numerical Problems. | 3 |
| 1.2 | Gradient of a scalar field, Divergence of a vector field and curl of a vector field- physical interpretation. Numerical Problems. | 3 |
| 1.3 | Divergence Theorem, Stokes' Theorem.Numerical Problems. | 3 |
| 2 | **Module 2:** | **9** |
| 2.1 | Coulomb's Law, Electric field intensity, Field due to a line charge, surface charge distribution. Numerical Problems. | 2 |
| 2.2 | Electric Flux and Flux Density; Gauss's law and its application to determine the field due to an infinite line charge, Infinite sheet charge. Numerical problems. | 3 |
| 2.3 | Electric Potential-Potential Gradient, conservative property of electric field, Equipotential surfaces. Numerical Problems. | 2 |
| 2.4 | Electric Dipole, Capacitance, Poisson's and Laplace's equations.Numerical Problems. | 2 |

| | | |
|---|---|---|
| 3 | **Module 3:** | **11** |
| 3.1 | Biot-Savart’s Law, Magnetic Field intensity due to a finite and infinite wire carrying current.Magnetic field intensity on the axis of a circular and rectangular loop carrying current.Numerical Problems. | 3 |
| 3.2 | Magnetic flux Density; Magnetic Vector Potential; Ampere’s circuital law and simple applications, Numerical Problems. | 3 |
| 3.3 | Boundary conditions for electric fields and magnetic fields. Conduction current and displacement current densities;<br><br>Continuity equation for current; Electrostatic Energy Density.; Numerical Problems. | 3 |
| 3.5 | Maxwell’s Equation in Differential and Integral form from Modified form of Ampere’s circuital law, Faraday's Law and Gauss’s Law; Numerical Problems. | 2 |
| 4 | **Module 4:** | 8 |
| 4.1 | Wave Equations from Maxwell's Equations; Uniform Plane Waves, Wave equations in Phasor form. Numerical Problems. | 3 |
| 4.2 | Propagation of Uniform Plane waves in free space, loss-less and lossy dielectric medium, Uniform Plane waves in good conductor-properties in different medium.Numerical Problems. | 3 |
| 4.3 | Skin effect and skin depth, Poynting Vector and Poynting Theorem.<br><br>Numerical Problems. | 2 |
| 5 | **Module 5:** | 8 |
| 5.1 | Transmission line: Waves in transmission line, Line parameters.Numerical Problems. | 3 |
| 5.2 | Transmission line equation &solutions, Physical significance of solutions,Propagation constants, Characteristic impedance, Wavelength, Velocity of propagation.Numerical Problems. | 3 |
| 5.3 | SWR, impedance matching .Solution of problems. Electromagnetic interference Solution of problems. | 2 |

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| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET404** | **DIGITAL ELECTRONICS** | PCC | 3 | 1 | 0 | 4 |

**Preamble : Nil**

**Prerequisite : Nil**

**Course Outcomes :**After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Perform arithmetic operations in decimal, binary, octal and hexadecimal number systems |
| **CO 2** | Design and implement combinational logiccircuits. |
| **CO 3** | Design and implement sequential logic circuits. |
| **CO 4** | Compare the operation of various analog to digital and digital to analog conversion circuits. |
| **CO 5** | Explain the basic concepts of programmable logic devices and VHDL. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | | | | | | | | | | |
| **CO 2** | 3 | 3 | 2 | | | | | | | | | |
| **CO 3** | 3 | 3 | 2 | | | | | | | | | |
| **CO 4** | 3 | 2 | 1 | | | | | | | | | |
| **CO 5** | 3 | 2 | 2 | | 2 | | | | | | | |

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Convert one number system to another form.-Binary, decimal, octal and hexadecimal
2. Arithmetic's using of a 2's complement method?
3. Binary and BCD arithmetic's.
4. Reduce the Boolean expression.
5. Develop logiccircuits using Universal gates.
6. Reduce the Boolean expression using Boolean laws.
7. Describe the logic levels used in TTL logic system.

**Course Outcome 2 (CO2):**

1. Convert an SOP form to a POS form and vice-versa?
1. Boolean expression simplification using K map.
2. Design full adder using NAND gates alone.
3. Draw and explain the circuit of carry look ahead adder circuit.
4. Discusshow the look ahead carry adder speed up the addition process?
5. Design of i)Half adder ii) Full adder iii) Full subtractor using gates
6. Differentiate priority encoder andordinaryencoder.
7. Explain the use of the enable input in a decoder?

8. Explain odd parity generator and even parity generator.
9. Differentiate between Multiplexers and De- Multiplexers.
10. Design an 8421 to 2421 BCD code converter and draw its logic diagram.

**Course Outcome 3(CO3):**

1. Explain different types of flip-flops and its application areas.
2. Design various counter circuits.
3. Describe a level triggered flipflopand compare it with an edge triggered flipflop?
4. Discuss master slave flipflop?
5. Design a mod-7 asynchronous counter using J-K flipflop.
6. Distinguish ring counter from Johnson counter.
7. Explain various types of shift register?
8. Differentiate between a counter and a shift register?

**Course Outcome 4 (CO4):**

1. Determine the number of output voltages that can be produced by an 8 bit ADC.
2. Write the advantage of the R-2R ladder DAC over the weighted resistor type DAC?
3. Which one is the fastest ADC and explain why?
4. Compare PLA and PAL?
5. Describe programmable logic array and differentiate it from ROM?

**Course Outcome 5 (CO5):**

1. Differentiate between Moore and Mealy machine?
2. Explain the function of mealy machine
3. Code implementation of simple circuits using VHDL
4. Explain FPGA and state its applications?

**Model Question Paper**

QP Code: Pages: 2

Reg No: ___________________

Name: ____________________

**TKM COLLEGE OF ENGINEERING**
**FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EET404**
**Course Name: DIGITAL ELECTRONICS**

Max. Marks: 100 Duration: 3 Hours

**PART A**
**Answer all Questions. Each question carries 3 Marks**

1. Translate the gray code 10110010101 to binary number.
2. Express the decimal number -31 as an 8 bit binary number in sign magnitude form, 1's complement form and 2's complement form.
3. Simplify the Boolean expression $AB + \overline{AC} + A\bar{B}C(AB + C)$ $AB + \overline{AC} + A\bar{B}C(AB + C)$.
4. Develop the standard Sum of Products(SOP) for the logic expression $F(A, B, C, D) = AB + \bar{A}B\bar{D} + B\bar{C}D$
5. Differentiate between Multiplexers and De- Multiplexers.
6. Realize a 2-bit comparator.
7. How does a J-K Flip Flop differ from an S-R Flip Flop in its operation?
8. What are PRESET and CLEAR inputs?
9. Draw the schematic of a successive approximation A/D converter.
10. Differentiate PLA and PAL circuits **(10 x 3 = 30)**

**PART B**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. (a) Why is two's - complement method of representing signed integer numbers preferred overones complement in digital circuits? What is range of numbers that can be represented using two's complement with four bits? **(10)**

(b) Represent the decimal number 3.248×$10^4 10^4$ in single precision IEEE binary format **(4)**

12. (a) Explain the working of a TTL NAND gate with the help of internal diagram. **(10)**

(b) Compare CMOS and TTL performance. **(4)**

**Module 2**

13. (a) Make use of a 4 variable K map and simplify $F(A,B,C,D) = \sum_m F(A,B,C,D) = \sum_m$ *(1,4,9,10,11,12,14) + d(0,8,13)*. Realize the function using NAND gates only. **(10)**

(b) Design a half adder circuit and realize using NAND gates only. **(4)**

14. (a) Realize a look-ahead-carry adder. **(8)**

(b) Construct the truth table for a full adder. Reduce it using K map. Implement it using logic gates. **(6)**

**Module 3**

15. (a) Explain the even parity method for error detection. **(8)**

(b) Use a 4 x 1 MUX to implement the logic function $F(A,B,C) = \sum_m(1,2,4,7)$. **(6)**

16. (a) What is the purpose of decoder? Explain the functioning of a BCD to Decimal Decoder circuit. **(8)**

(b) Explain the architecture of ALU with the help of a block diagram **(6)**

**Module 4**

17. (a) Realize an S-R flip flop using a D flipflop. **(10)**

(b) What is the race around condition of a J-K flip flop? How can it be avoided? **(4)**

18. (a) Design a Synchronous Mod-6 Counter using J-K FFs **(8)**

(b) Draw a parallel in -serial out (PISO) register and explain its working. **(6)**

**Module 5**

19. (a) Differentiate between Moore and Mealy machine? Compare them with the help of logic diagrams. **(10)**

(b) What is the advantage of the R-2R ladder DAC over the weighted resistor type DAC? **(4)**

20. (a) Explain FPGA and state its applications? **(8)**

(b) Design and implement a half adder using VHDL. **(6)**

(14 x 5 = 70)

## Syllabus

### Module 1

Number Systems and Codes: Binary, Octal and hexadecimal conversions- ASCII code, Excess -3 code, Gray code, BCD, Error detection codes-Parity method.

Signed numbers- representation, addition and subtraction,Fixed point and floating-point representation.

Logic gates, Universal gates, TTL and CMOS logic families-Internal diagram of TTL NAND gate and CMOS NOR gate. Comparison of CMOS and TTL performance.

### Module 2

Boolean Laws and theorems, Sum of Products method, Product of Sum method – K map representation and simplification(up to four variables) - Pairs, Quads, Octets, Don't care conditions.

Combinational circuits: Adders -Full adder and half adder, Subtractors- halfsubtractor and fullsubtractor, 4 bit parallel binary adder/subtractor, Carry Look ahead adders.

### Module 3

Comparators, Parity generators and checkers, Encoders, Decoders, , BCD to seven segment decoder, Code converters, Multiplexers, Demultiplexers, Architecture of Arithmetic Logic Units (Block schematic only).

### Module 4

Flip-Flops, SR, JK, D and T flip-flops, JK Master Slave Flip-flop, Preset and clear inputs, Conversion of flip-flops.

Registers -SISO, SIPO, PISO, PIPO.

Up/Down Counters: Asynchronous Counters – Modulus of a counter – Mod-N counters Ring counter, Johnson Counter

Synchronous counters,Design of Synchronous counters.

### Module 5

State Machines: State transition diagram, Moore and Mealy Machines

Digital to Analog converter –Specifications, Weighted resistor type, R-2R Ladder type -Analog to Digital Converter – Specifications, Flash type, Successive approximation type.

Programmable Logic Devices - PAL, PLA, FPGA (Introduction and basic concepts only) Introduction to VHDL, Implementation of AND, OR, half adder and full adder.
Note: Course assignments may be given in VHDL programming

**Text Books**

1. Floyd T.L, Digital Fundamentals, 10/e, Pearson Education, 2011.
2. C.H.Roth and L.L.Kimney Fundamentals of Logic Design, 7/e, Cengage Learning, 2013.
3. Mano M.M, Logic and Computer Design Fundamentals, 4/e, Pearson Education.
4. A Anand Kumar, Fundamental of Digital Electronics ,Prentice Hall
5. Roy Chaudari ,Linear Integrated Circuits, New Age International Publications
6. S. Salivahanan , Digital Circuits and Design, Oxford University Press

**Reference Books**

1. Donald P. Leach, Albert Paul Malvino and GoutamSaha, Digital Principles and Applications, 8/e, by McGraw Hill.
2. Tocci R.J. and N.S.Widmer, Digital Systems, Principles and Applications, 11/e, Pearson Education.
3. John F. Wakerly, Digital Design: Principles and Practices, 4/e, Pearson, 2005.
4. Taub& Schilling: Digital Integrated Electronics, McGraw Hill, 1997.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Number systems and Binary codes10** | |
| 1.1 | Introduction, Binary, Octal and hexadecimal conversions | 2 |
| 1.2 | ASCII code, Excess -3 code, Gray code, BCD. | 1 |
| 1.3 | Error detection codes –Parity Codes. | 1 |
| 1.4 | Signed numbersrepresentation, addition and subtraction | 1 |
| 1.5 | Fixed point and floating-point representation | 2 |
| 1.6 | Logic gates and universal gates | 1 |
| 1.7 | TTL and CMOS logic families-Internal diagram of TTL NAND gate and CMOS NOR gate. Comparison of CMOS and TTL performance. | 2 |
| **2** | **Boolean Algebra and Adders9** | |
| 2.1 | Boolean Laws and theorems. | 1 |
| 2.2 | Standard forms and canonical forms, Sum of Products method, Product of Sums method. | 2 |
| 2.3 | K-map representation and simplification (upto four variables) -Pairs, Quads, Octets, Don’t care conditions. Realisation using universal gates. | 2 |
| 2.4 | Adders - Full adder and half adder – Subtractors, half subtractor and full subtractor. | 2 |
| 2.5 | 4-bit parallel binary adder/subtractor. | 1 |
| 2.6 | Carry Look-ahead adders. | 1 |
| **3** | **Combinational Logic Circuits** | **9** |
| 3.1 | 2- and 4-bit magnitude comparator. | 2 |
| 3.2 | Parity generators and checkers. | 1 |
| 3.3 | Encoder, Decoder-BCD to decimal and BCD to seven segment decoders. | 2 |
| 3.4 | Realisation of Code converters. | 1 |

| | | |
|---|---|---|
| 3.5 | Multiplexers and implementation of functions, Demultiplexers | 2 |
| 3.6 | Architecture of Arithmetic Logic Units (Block schematic only) | 1 |
| **4** | **Sequential circuits10** | |
| 4.1 | Flip-Flops, SR, JK, D and T flip-flops, JK Master Slave Flip-flop, Preset and clear inputs | 2 |
| 4.2 | Conversion of flip-flops. | 2 |
| 4.3 | Registers -SISO, SIPO, PISO, PIPO. | 1 |
| 4.4 | Up/Down Counters: Asynchronous Counters – Modulus of a counter – Mod-N counters. | 2 |
| 4.5 | Ring counter, Johnson Counter. | 1 |
| 4.6 | Design of Synchronous counters | 2 |
| **5** | **State Machines, D/A and A/D converters and PLDs7** | |
| 5.1 | State Machines: State transition diagram, Moore and Mealy Machines | 1 |
| 5.2 | Digital to Analog converter – R-2R ladder, weighted resistors. | 1 |
| 5.3 | Analog to Digital Converter - Flash ADC, Successive approximation. | 1 |
| 5.4 | Programmable Logic Devices - PAL, PLA-function implementation - FPGA (Introduction and basic concepts only). | 2 |
| 5.5 | Introduction to VHDL, Implementation of AND, OR, half adder and full adder. | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEL 408** | **ELECTRICAL MACHINES LAB I** | **PCC** | **0** | **0** | **3** | **2** |

**Preamble** : The purpose of this lab is to provide practical experience in operation and testing of DC machines and transformers.

**Note** : A minimum of **TWELVE** experiments are mandatory out of the fifteen listed.

**Prerequisite** :

1. Fundamentals of Electrical Engineering
2. D.C Machines and Transformers (Theory)

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Analyse the performance of DC motors and DC generators by performing load test. |
| **CO 2** | Sketch the Open Circuit Characteristics of a self excited DC shunt generator and check conditions of voltage build up by performing suitable experiment. |
| **CO 3** | Develop equivalent circuit and predetermine their regulation and efficiency by performing OC & SC tests on transformer. |
| **CO 4** | Analyse the efficiency and regulation of the transformer by performing load test. |
| **CO 5** | Analyse the efficiency of a DC machine when working as motor and generator by conducting suitable test. |
| **CO 6** | Examine the efficiency by performing Sumpner's test on two similar transformers. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 2 | - | 3 |
| **CO 2** | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 2 | - | 3 |
| **CO 3** | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 2 | - | 3 |
| **CO 4** | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 2 | - | 3 |
| **CO 5** | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 2 | - | 3 |
| **CO 6** | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 2 | - | 3 |

**Assessment Pattern**

**Marks distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 75 | 75 | 2.5 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance: | 15 marks |
| Continuous Assessment: | 30 marks |
| Internal Test (Immediately before the second series test) : | 30 marks |

**End Semester Examination Pattern:** The following guidelines should be followed regarding award of marks

| | |
|---|---|
| (a) Preliminary work | 15 Marks |
| (b) Implementing the work/Conducting the experiment | 10 Marks |
| (c) Performance, result and inference (usage of equipment and troubleshooting) | 25 Marks |
| (d) Viva voce | 20 marks |
| (e) Record | 5 Marks |

**General instructions:** Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified Laboratory Record. The external examiner shall endorse the record.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1) Conduct a brake test on the given DC series motor and plot its electrical characteristics and speed versus armature current curve.
2) Plot the load characteristics of the given differentially compounded DC generator by conducting suitable experiments.
3) Plot the electrical and mechanical characteristics of the given DC shunt motor by conducting suitable experiments.

**Course Outcome 2 (CO2):**

1) Predetermine the OCC of the given D.C shunt generator when running at 80% rated speed and also find the critical resistance at rated speed.
2) Plot the OCC of the D.C shunt generator at its rated speed and obtain its critical resistance and critical speed. Also obtain the additional resistance required in the field circuit for generating rated voltage on no load.

**Course Outcome 3(CO3):**

1) Predetermine the per phase equivalent circuit of the 3 phase transformer referred to low voltage side by conduction suitable experiments. Also compute its KVA corresponding to maximum efficiency.
2) Predetermine the maximum efficiency of the given single phase transformer at upf by conducting suitable experiment. Also compute its full load regulation at upf.

**Course Outcome 4 (CO4):**

1) Plot the regulation and efficiency curves of the given 1-phase transformer by conducting a suitable experiment.
2) Plot the regulation and efficiency curves of the given 3-phase transformer by conducting a suitable experiment.

**Course Outcome 5 (CO5):**

1) Conduct a suitable test on the given DC shunt machine and predetermine the efficiency curve of the machine both as motor and as generator

**Course Outcome 6 (CO6):**

1) Conduct a suitable test on two similar 1-phase transformers and predetermine its efficiency at full load and 0.8 pf lagging.
2) Conduct a suitable test on two similar 1-phase transformers and predetermine its efficiency at half load and UPF.

## LIST OF EXPERIMENTS

### PART A- DC MACHINES

**1. Open Circuit Characteristics of a DC Shunt Generator**

*Objectives:*

a) Predetermine the OCC at different speeds
b) Determine the critical field resistance
c) Obtain maximum voltage built up with given shunt field
d) Obtain critical speed for a given shunt field resistance

**2. Load Test on a DC Shunt Generator**

*Objectives:*

a) Determine the external & internal characteristics of the given DC Shunt Generator

**3. Brake Test on a DC Shunt Motor**

*Objectives:*

Plot the following characteristics

a) Performance characteristics
b) Electrical characteristics
**c)** Mechanical characteristics

**4. Brake Test on a DC Series Motor**

*Objectives:*

Plot the following characteristics

a) Performance characteristics
b) Electrical characteristics
c) Mechanical characteristics.

**5. Load Test on a DC Shunt Generator**

*Objectives:*

a) Determine the external & internal characteristics of the given DC Shunt Generator

**6. Brake Test on a DC Shunt Motor**

*Objectives:*

Plot the following characteristics

d) Performance characteristics
e) Electrical characteristics

f) Mechanical characteristics.

**7. Brake Test on a DC Series Motor**

*Objectives:*

Plot the following characteristics

d) Performance characteristics
e) Electrical characteristics
f) Mechanical characteristics.

**8. Load Characteristics of a DC Compound Generator**

*Objectives:*

a) To plot the load characteristics of the given DC Compound generator when cumulatively compounded.
b) To plot the load characteristics of the given DC Compound generator when differentially compounded

**9. Swinburne's Test on a DC Shunt Machine**

*Objectives:*

a) To predetermine the efficiency of a D.C. shunt machine when the machine operates as a motor and as a generator for various load conditions
b) To plot the efficiency curves of the given DC machine.

**10. Hopkinson's test on a pair of DC machines**

*Objectives:*

Determination of the efficiency of the given dc shunt machine working as a motor and generator under various load conditions.

**11. Retardation test on a DC machine**

*Objectives:*

a) Separation of hysteresis, eddy current, friction &windage losses
b) Find the moment of inertia of the rotating system

**12. Separation of losses in a DC shunt motor**

*Objectives:*

a) Separation of hysteresis, eddy current, friction &windage losses
b) Plot the losses vs speed curves

**PART B - TRANSFORMERS**

**13. OC & SC Tests on a Single Phase Transformer**

*Objectives:*

a) To pre-determine the regulation and efficiency of the given single phase transformer at different loads and power factors
b) To obtain the equivalent circuit of the given transformer
c) To plot regulation vs power factor curves
d) To determine the power factors at which regulation is zero

**14. DirectLoad Test on a Single Phase Transformer**

*Objectives:*

a) To determine the efficiency of the given transformer at unity power factor at different loads
b) To determine the regulation of the given transformer at unity power factor at different loads
c) To plot the efficiency vs output and regulation vs output curves

**15. Separation of Constant losses of a Single Phase Transformer**

*Objectives:*

a) To separate hysteresis and eddy current losses of a single phase transformer, keeping V/f constant.
b) To plot losses vs. frequency curves, by separating the hysteresis and eddy current losses at normal voltage and different frequencies.

**16. Sumpner's Test**

*Objectives:*

a) To predetermine efficiency at different loads and power factors
b) To predetermine regulation at different loads and power factors
c) To determine the equivalent circuit

**17. Parallel Operation of two dissimilar Single Phase Transformers**

*Objectives:*

a) To determine the load sharing of each transformer by their equivalent impedances.
b) To verify the load sharing by actual measurement.

**18. OC & SC Tests on a Three Phase Transformer**

*Objectives:*

a) To predetermine the efficiency at different load conditions and power factors.
b) To predetermine the regulation at different power factors.
c) To develop the per phase equivalent circuit.

**Reference Books**

1. Bimbra P. S., Electrical Machinery, 7/e, Khanna Publishers, 2011.

2. Theraja B. L., A Textbook of Electrical Technology, S. Chand & Company, New Delhi,

| CODE 22EEL 409 | DIGITAL ELECTRONICS LAB | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PCC | 0 | 0 | 3 | 2 |

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO1** | Formulate digital functionsusing Boolean Algebra and verify experimentally. |
| **CO2** | Design and implement combinational logic circuits. |
| **CO3** | Design and implement sequential logic circuits. |
| **CO4** | Design and fabricate a digital circuit using the knowledge acquired from the laboratory. |

**Mapping of course outcomes with program outcomes**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 1 | 3 | 3 | | | 2 | 3 | 3 | | 1 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | | | 2 | 3 | 3 | | 1 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | | | 2 | 3 | 3 | | 1 |
| **CO4** | 3 | 2 | 1 | 3 | 2 | | | 2 | 3 | 3 | 2 | 3 |

## LIST OF EXPERIMENTS

**Pre-lab assignment** :Familiarisation of Logic Gates, Identification of typical logic ICs, Interpreting IC datasheets.

1. Verification & Realisation of De Morgan’s theorem.
2. Realisation of SOP & POS functions after K-map reduction.
3. Half adder & Full adder using gates.
4. 4-bit adder/subtractor & BCD adder using IC 7483.
5. Realisation of 2-bit comparator using gates and study of four-bit comparator IC 7485.
6. BCD to decimal decoder and BCD to 7-segment decoder & display.
7. Study of multiplexer IC and realization of combinational circuits using multiplexers.
8. Realization of RS, T, D & JK flip flops using gates.
9. Study of flip flop ICs (7474 & 7476).
10. Realisation of ripple up and down counters and modulo-N counter using flip-flops.
11. Study of counter ICs (7490, 7493).

12. Design of synchronous up, down & modulo-N counters.
13. a) Realization of 4-bit serial IN serial OUT registers using flip flops.
b) Study of shift register IC 7495, ring counter and Johnsons counter.

**Course Project** : Students have to do a mandatory course project (group size not more than 4 students) using digital ICs or Programmable Logic Devices (CPLD/FPGA) to realise a functional digital circuit. A maximum of 5 marks shall be awarded for this project (to be evaluated along with the final internal test).

**Example of course projects :**

1. Realisation of a real-time digital clock with display.
2. Digital Alarms
3. ALU (May be implemented in FPGA)
4. Digital Security Monitoring System
5. Traffic Control

**Assessment Pattern :**

**Mark distribution :**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 75 | 75 | 2.5 hours |

**Continuous Internal Evaluation (CIE) Pattern:**

| Attendance | Regular Lab work | InternalTest | CourseProject | Total |
|---|---|---|---|---|
| 15 | 30 | 25 | 5 | 75 |

**End Semester Examination Pattern:**

The following guidelines should be followed regarding award of marks:

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipment and troubleshooting) : 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

**General instructions :** Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

**Reference Books:**


1. Floyd T.L, Digital Fundamentals, 10/e, Pearson Education, 2011.
2. C.H.Roth and L.L.Kimney Fundamentals of Logic Design, 7/e, Cengage Learning, 2013.

# SEMESTER IV
# MINORS

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEMR 410.1** | **ELECTRICAL MACHINES** | **Minor** | **3** | **1** | **0** | **4** |

**Preamble :** This course gives exposure to the students about the concepts of electrical machines including constructional details, principle of operation and performance analysis.

**Prerequisite : Basics of Electrical Engineering**

**Course Outcomes :** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Identify the appropriate Electrical machines required for different applications, considering the parameters like input supply voltage, output torque and speed. |
| **CO 2** | Evaluate the performance of a single phase transformer based on appropriate test results. |
| **CO 3** | Analyse the performance of single phase and permanent magnet motors which can be used for household applications. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | | | | | | | | | | 2 |
| **CO 2** | 2 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 2 | | | | | | | | | | 2 |

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. Discuss the types of dc generators based on the method of excitation.(K2)
2. Discuss the applications of dc motors based on their characteristics.(K3)
3. Derive the expression for induced emf of alternator.(K1)
4. Problems on calculating induced emf of alternator. (K2, K3)
5. Why synchronous motor is not self starting? Discuss any two starting methods of synchronous motor? (K1)
6. What are V and Inverted V curves? (K1)
7. Explain the working principle of a three phase induction motor.(K1)
8. Why starting current of induction motor is high? Explain any two starting methods? (K2)

**Course Outcome 2 (CO2):**

1. Draw the phasor diagram of a single phase transformer. (K1)
2. Problems based on efficiency calculations, all day efficiency.(K2, K3)

**Course Outcome 3 (CO3):**

1. With the help of a neat diagram explain any two starting methods of single phase induction motor. (K1)
2. Discuss the advantages of permanent magnet rotor compared to the conventional construction. (K2)
3. Explain the principle of operation of a stepper motor.(K1)

**Model Question paper**

**QP CODE:**

PAGES:2

Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**THIRD SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEMR 410.1**
**Course Name: Electrical Machines**

**Max. Marks: 100 Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Derive an expression for emf generated in a dc machine.
2. Explain the principle of operation of a dc motor.
3. Draw the phasor diagram of a single phase transformer working under no load condition.
4. The emf per turn of a single phase 2200/220 V, 50 Hz transformer is approximately 12 V. Calculate (a) the primary and secondary turns (b) the net cross sectional area of the core if the maximum flux density is 1.5Wb/$m^2$.
5. How is voltage regulation of an alternator affected by the load connected to its terminals?
6. Why is synchronous motor not self starting?
7. Explain torque-slip characteristics of a three phase induction motor.
8. A three phase induction motor has 2 poles and is connected to 400 V, 50 Hz supply. Calculate the actual rotor speed and rotor frequency when slip is 4%.
9. Explain the working of a single phase induction motor.
10. List any three applications of PMBLDC motors.

**(10 x 3 = 30)**

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. (a) Briefly explain armature reaction of a dc machine. **(5)**
(b) Classify dc generators based on their method of excitation with the help of neat diagrams. **(9)**

12. (a) Explain the power stages of a dc motor. **(4)**
(b) A 75 kW, 250 V dc compound generator has the following data. $R_a$ = 0.04Ω, $R_{se}$=0.004Ω, $R_f$ = 100Ω, Brush contact drop = 1V/brush. Compare the generated emf when fully loaded for (i) short shunt compound (ii) long shunt compound. **(10)**

**Module 2**

13. (a) Draw the equivalent circuit of a single phase transformer and explain how the parameters are obtained from the test results. **(10)**
(b) In a 25 kVA, 2000/200 V transformer, the iron and copper losses are 300 W and 400 W respectively. Calculate the efficiency at unity pf at (i) full load (ii) half load. **(4)**

14. (a) What is all day efficiency? Explain its significance. **(4)**
(b) A transformer has its maximum efficiency of 0.98 at 20 kVA at unity pf. During the day it is loaded as follows: 12 hours - 2 kW at pf 0.6, 6 hours – 10 kW at pf 0.8, 6 hours – 20 kW at pf 0.9. Find the all day efficiency of the transformer. **(10)**

**Module 3**

15. (a) Explain the constructional details of a synchronous machine. **(9)**
(b) A 200 kVA, 3.3 kV, 50 Hz, three phase synchronous generator is star connected. The effective armature resistance is 5Ω/phase and synchronous reactance is 29.2Ω/phase. At full load calculate the voltage regulation for 0.8 lagging and 0.8 leading power factors. **(5)**

16. (a) (i) Explain V curves of a synchronous motor. **(3)**

(ii) What is a synchronous condenser? **(2)**

(b) What is voltage regulation? Explain the method of finding regulation by emf method. **(9)**

## Module 4

17. (a) Explain the working principle of a three phase induction motor. **(5)**

(b)Explain the methods of starting of a three phase induction motor. **(9)**

18. (a) The no load and blocked rotor test results conducted on a 30 hp, 835 rpm, 440V, 3 phase, 60 Hz, squirrel cage induction motor are as follows.

No load test: 440V, 14 A, 1470 W

Blocked rotor test: 163V, 60A, 7200W

Resistance measured between two terminals is 0.5Ω. Determine the equivalent circuit parameters. **(10)**

(b) What is a self-excited induction generator? **(4)**

## Module 5

**19.** (a) What are the applications of servomotors? **(4)**

(b) Explain the different types of stepper motors. **(10)**

20. (a) What are universal motors? Explain their working. **(9)**

(b) Write a short note on permanent magnet motors. **(5)**

**(14 x 5 = 70)**

## Syllabus

### Module 1

**DC Machines**-principle of operation of DC generator - emf equation - types of excitations -separately excited, shunt and series excited DC generators, compound generators. General idea of armature reaction, Open circuit and load characteristics-simple numerical problems. Principles of dc motors-torque and speed equations-torque speed characteristics- Characteristics and applications of dc shunt, series and compound motors. Methods of starting, losses and efficiency - simple numerical problems.

### Module 2

**Transformers** –principle of operation –emf equation - phasor diagram - losses and efficiency –OC and SC tests. Equivalent circuits-efficiency calculations - maximum efficiency –all day efficiency –simple numerical problems.

### Module 3

**Synchronous machines**–Parts of synchronous generator – principle of operation–types –emf equation of alternator – regulation of alternator under lagging and leading power factor – determination of regulation by emf method – numerical examples. Principle of operation of synchronous motors - methods of starting - V curves - synchronous condenser.

### Module 4

**Three phase induction motors**-slip ring and squirrel cage types-principle of operation–rotating magnetic field–equivalent circuit, torque slip characteristics-no load and blocked rotor tests. Methods of starting – direct online, star delta, rotor resistance and auto transformer starting.

Induction generator- principle of operation – self excited induction generators.

### Module 5

**Single phase motors -** principle of operation of single phase induction motor –split phase motor – capacitor start motor.

Stepper motor – principle of operation – types. Principle of operation and applications of universal motor and servomotor (dc and ac).

**Permanent magnet motors–** principle of operation of PMSM and PMBLDC motor, applications.

### Text Books

1. Bimbra P.S., "Electrical Machinery", 7/e, Khanna Publishers, 2011.
2. Nagrath J. and D.P. Kothari, "Theory of AC Machines", Tata McGraw Hill, 2006.

### Reference Books

1. Fitzgerald A.E., C. Kingsley and S. Umans, "Electric Machinery", 6/e, McGraw Hill, 2003.
2. Langsdorf M.N., "Theory of Alternating Current Machinery", Tata McGraw Hill, 2001.
3. Say M.G., "The performance and Design of AC Machines", CBS Publishers, New Delhi, 2002.

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **DC Machines(10 hours)** | |
| 1.1 | Principle of operation-emf equation-types of excitations -separately excited, shunt and series excited DC generators, compound generators. | 3 |
| 1.2 | Generalidea of armature reaction, OCCand load characteristics-simple numerical problems. | 2 |
| 1.3 | Principles of dc motors-torque and speed equations-torque speed characteristics | 2 |
| 1.4 | Characteristics and applications of dc shunt, series and compound motors. Principles of starting, losses and efficiency–simple numerical problems. | 3 |
| **2** | **Transformers (8 hours)** | |
| 2.1 | Principle of operation –emf equation - phasor diagram. | 2 |
| 2.2 | losses and efficiency –OC and SC tests. Equivalent circuit. | 3 |
| 2.3 | efficiency calculations-maximum efficiency –all day efficiency –simple numerical problems. | 3 |
| **3** | **Synchronous machines (9 hours)** | |
| 3.1 | Parts of synchronous generator – principle of operation – types | 2 |
| 3.2 | emf equation of alternator –regulation of alternator under lagging and leading power factor – simple numerical problems. | 2 |
| 3.3 | determination of regulation by emf method – numerical examples. | 2 |
| 3.4 | Principle of operation of synchronous motors-methods of starting.V-curves-synchronous condenser. | 3 |
| **4** | **Three phase induction motors (9 Hours)** | |
| 4.1 | Slip ring and squirrel cage types-principle of operation–rotating magnetic field. | 2 |
| 4.2 | Torque-slip characteristics-no load and blocked rotor tests, equivalent circuit - simple numerical problems. | 3 |
| 4.3 | Methods of starting –direct online, star-delta, rotor resistance and autotransformer starting. | 2 |
| 4.4 | Induction generator- principle of operation – self excited induction generators. | 1 |
| **5** | **Single phase motors (9 Hours)** | |
| 5.1 | Principle of operation of single phase induction motor –split phase motor – capacitor start motor- | 2 |
| 5.2 | Stepper motor – principle of operation - types | 2 |
| 5.3 | Universal motor, –servomotor – dc and ac servomotors – principle of operation, applications. | 3 |
| 5.4 | Permanent magnet motors – principle of operation of PMSM and PMBLDC motor, applications. | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEMR410.2** | **Energy Systems** | **Minor** | **3** | **1** | **0** | **4** |

**Preamble :** This course introduces various types of renewable energy sources. It discusses various means of generating and storing energy and the importance of renewable energy. Various energy standards and means to improve efficiency of systems are also introduced

**Prerequisites :** EST 130Basics of Electrical & Electronics Engineering

EET 253 Introduction to Power Engineering

**Course Outcomes :** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Illustrate Indian and global energy scenario |
| **CO 2** | Elaborate different conventional and non-conventional energy generation schemes and the economics of generation |
| **CO 3** | Analyse principle of operation and performance comparison of various energy storage schemes |
| **CO 4** | Identify major Global and Indian standards for Energy Management |
| **CO 5** | Perform a preliminary Energy Audit |
| **CO 6** | Appraise various aspects of energy economics |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | 2 |
| **CO 5** | 3 | 3 | | | | | | | | | | 2 |
| **CO 6** | 3 | 3 | | | | | | | | | | 2 |

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO 1):**

1. Discuss Indian and world energy scenario (K1)
2. Describe Indian energy sector reforms (K2)

3. Discuss energy and environment, energy security (K2)
4. Explain the features of Energy Conservation Act (K3)

**Course Outcome 2 (CO 2):**

1. Describe various sources of non conventional energy (K2)
2. Problems on calculating efficiency of Solar Photovoltaic Systems (K3)
3. Problems on energy availability from wind(K3)
4. Discuss the generation of energy from wave, tide, OTEC and Biomass (K2)

**Course Outcome 3 (CO 3):**

1. Describe various means of energy storage (K2,)
2. Explain the working of batteries (K2)
3. Calculate the efficiency of fuel cells (K3).

**Course Outcome 4 (CO 4):**

1. Identify ISO 50001 for Energy Management. (K2)
2. Describe the activities of BEE in India and star rating of equipment (K2).

**Course Outcome 5 (CO 5):**

1. Give the steps involved in Energy Audit (K1)
2. Calculate the payback period (K3).

**Course Outcome 6 (CO 6):**

1. Classify different types of tariff (K3)
2. Compare models for demand forecasting (K3)
3. Explain how economic analysis of energy investment is done (K2)

**Model Question paper**

**QPCODE:** PAGES: 2

Reg.No:______

Name:_

**TKM COLLEGE OF ENGINEERING**

**FOURTH SEMESTERB.TECHDEGREEEXAMINATION, MONTH &YEAR**

**Course Code: 22EEMR310.4**
**Course Name: Energy Systems**

**Max.Marks:100** **Duration: 3Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Enumerate the important features of Energy Conservation act.
2. Illustrate the concept of green buildings.
3. Find the maximum power and efficiency of a 100 x 100 mm sq. solar cell having an open circuit voltage is 0.611 V, Short circuit current of 3.5 A, Fill factor of 0.7 when input power is 10 W.
4. Draw and explain the block diagram of the ocean thermal energy system.
5. Derive the expression for the power output and efficiency of a fuel cell.
6. Give the relative advantages and disadvantages of battery storage.
7. Discuss the structure of a detailed energy audit report.
8. What is the significance of the energy audit?
9. What is the difference between long term and short forecasting? What is MAED?
10. Differentiate between cost of capital and discount rate.

**(10x3=30)**

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. (a) Compare Energy Scenario of India and the world. **(10)**

(b) The luminous efficiency of a lamp is 8.8 Lumens/Watt and its luminous intensity is 700 Cd. What is the power of the lamp? **(4)**

(a) Compare any four types of lamps. Give their approximate efficiencies as well. **(8)**

(b) Discuss the energy system reforms in India and illustrate their effect. **(6)**

**Module 2**

13. (a) Explain how energy can be extracted from the heat and light of sun. **(10)**

(b) Determine the power in the wind if the wind speed is 20 m/s and blade length is 50 m and air density = 1.23 $kg/m^3$. **(4)**

14. (a) Compare the schemes for extraction of energy from waves and tides. **(8)**

(b) Explain with the help of a schematic, extraction of energy from biomass. **(6)**

**Module 3**

15. (a) Differentiate between primary and secondary cells. **(4)**

(b) Explain the working of any one primary and secondary cell with the help of diagrams **(10)**

16. (a) Give the importance of energy storage. **(4)**

(b) Compare compressed air and fly wheel energy storage systems. **(10)**

**Module 4**

17. (a) Explain the important features of ISO 50001. **(6)**

(b) Discuss are the functions of Bureau of Energy efficiency. What is the significance of star ratings? **(8)**

18. (a) Explain the types of energy audit and their procedure. **(9)**

(b) Explain various instruments used for energy audit. **(5)**

**Module 5**

19. (a) Explain LEAP energy planning system with the help of block diagram. **(6)**

(b) A company is planning to install an energy-efficient motor requiring an initial investment of Rs 10.5 lakh. The motor is expected to save 2.5 lakh per year in net cash flows for 7 years. Calculate the payback period. **(8)**

20. (a) Explain one part, two part and three part tariff. **(9)**

(b) A machine can reduce annual cost by Rs 40,000. The cost of the machine is Rs 223,000 and the useful life is 15 years with zero residual value. Calculate the Internal Rate of Return. **(5)**

**(14x5=70)**

## Syllabus

### Module 1

**Energy Scenario:** Indian Energy Scenario, World Energy Scenario, Indian Energy Sector Reforms, Energy and Environment, Energy Security, Energy conservation act

**Energy Efficient Systems**: Reducing pollution and improving efficiency in buildings, Green Building Standards, Types of lamps and their efficiencies

### Module 2

**Renewable Energy Resources:** Solar Thermal System-Working Principle-Block diagram, Solar Photovoltaic System- Working Principle-Block diagram, Solar cell efficiency calculation, Wind Energy Systems- Working Principle-Block diagram, wind power equation, Energy from Waves and tides- Working Principle-Block diagram, Ocean Thermal Energy System- Working Principle-Block diagram, Energy from Biomass

### Module 3

**Energy Storage:** Importance of Energy Storage- Means of Storing Energy- Principle of operation and performance comparison. Compressed air storage, Fly wheel Energy Storage, Battery Storage-**Battery:** Specification, Charging/Discharging rate, Primary and secondary cells-Dry cell, lead acid, lithium ion, Lithium air, Nickel Cadmium, Nickel Metal Hydride

**Fuel Cell**: Working Principle, efficiency

### Module 4

**Energy Standards** – International Energy Standards-ISO50001, Bureau of Energy Efficiency, star rating

**Energy Management:**Significance and general principles of Energy Management, Energy audit-types and procedure, Energy audit report, Instruments for energy auditing

Study of various governmental agencies related to energy conservation and management.

### Module 5

**Energy Economics**: Traditional Types of Rates - Single-Part Rates - Two-Part Rates - Three-Part Rates – Numerical problems

Energy demand forecasting: Introduction –Forecasting using simple indicators- trend analysis- end use method - MAED Model - LEAP Model

Economic Analysis of Energy Investments - calculation of energy efficiency and payback period - Characteristics of Energy Projects - Identification of Costs and Benefits - Valuation of Costs and Benefits - Indicators of Cost-Benefit Comparison:Methods Without Time Value - Net Present Value Based Indicators - Role of Discount Rates - Internal Rate of Return – Numerical Problems

**References:**

1. K.C. Kothari, D.P.Ranjan, Rakeshsingal "Renewable Energy Sources and Emerging Technology"- PHI; 2nd Revised edition (1 December 2011)
2. M.V.R. Koteswara Rao, Energy Resources: Conventional & Non-Conventional BS Publications/BSP Books (2017)
3. Albert Thumann, Scott Dunning, "EFFICIENT LIGHTING APPLICATIONS & CASE STUDIES"; The Fairmont Press, Inc. (16 April 2013)
4. "Energy Efficiency in Electrical Utilities"-Guide book for National Certificate Examination for Energy Managers and Energy Auditors : Bureau of Energy Efficiency
5. Subhes C. Bhattacharyya, "Energy Economics-Concepts, Issues, Markets and Governance," Springer, 2011
6. ISO50001

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Energy Scenario (9hours)** | |
| 1.1 | Indian and world Energy Scenario | 2 |
| 1.2 | Indian Energy Sector reforms | 1 |
| 1.3 | Energy, Environment, Energy Security | 1 |
| 1.4 | Green Building Standards, Industries and electrical Power System | 2 |
| 1.5 | Energy Conservation Act 2001 features | 1 |
| 1.6 | Green Building Standards | 1 |
| 1.7 | Types of lamps and their efficiencies | 1 |
| **2** | **Non-Conventional Energy Sources. ( 9hours)** | |
| 2.1 | Solar Thermal System, Working Principle- Solar cell efficiency Calculation | 2 |
| 2.2 | Solar Photovoltaic System-Working Principle | 1 |
| 2.3 | Wind Energy Systems-Working Principle | 2 |
| 2.4 | Energy From waves and Tides-Block diagram | 2 |
| 2.5 | Energy from Biomass and Ocean Thermal Energy Systems | 2 |
| **3** | **Energy Storage (9 Hours)** | |
| 3.1 | Specification, Discharging time calculation | 1 |
| 3.2 | Compressed air storage, Fly wheel Energy Storage, Battery Storage-Advantages | 2 |
| 3.3 | Primary and secondary cells-Dry cell | 1 |
| 3.4 | lead acid, lithium ion, Lithium air, Nickel Cadmium, Nickel Metal Hydride | 3 |
| 3.5 | Fuel Cells, Working Principle, efficiency calculation | 2 |
| **4** | **Energy Management (9 Hours)** | |
| 4.1 | International Energy Standards-ISO50001 | 2 |
| 4.2 | Bureau of Energy Efficiency, star rating | 2 |
| 4.3 | Significance and general principles of Energy Management, Energy audit-types, procedure, instruments and reports | 4 |
| 4.4 | Study of various governmental agencies related to energy conservation and management. | 1 |
| **5** | **Energy Economics (9 Hours)** | |

| | | |
|---|---|---|
| 5.1 | Traditional Types of Rates - Single-Part Rates - Two-Part Rates - Three-Part Rates – Numerical problems | 3 |
| 5.2 | Energy demand forecasting: Introduction –Forecasting using simple indicators- trend analysis- end use method - MAED Model - LEAP Model | 2 |
| 5.3 | Economic Analysis of Energy Investments - Characteristics of Energy Projects - Identification of Costs and Benefits - Valuation of Costs and Benefits - Indicators of Cost-Benefit Comparison:Methods Without Time Value - Net Present Value Based Indicators - Role of Discount Rates | 3 |
| 5.4 | Internal Rate of Return – Numerical Problems | 1 |

| 22EEMR310.6 | PRINCIPLES OF INSTRUMENTATION | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | MINOR | 3 | 1 | 0 | 4 |

**Preamble:**This course introduces principle of operation and construction of basic instrumentation components, their selection and applications.Familiarization of modern basic digital systems are also included.

**Prerequisite:**Basics of Electronics and Circuits

**Course Outcomes:**After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Identify and analysethe factors affecting performance of instrumentation system |
| **CO 2** | Choose appropriate instrumentation system components for the measurement of different parameters |
| **CO 3** | Identify different amplifier circuits for instrumentation including selection of Op-amp for linear and Non-linear applications. |
| **CO 4** | Identification and selection of basic filters for instrumentation |
| **CO 5** | Outline the principles of operation of linear &Non-linear signal processing systems |
| **CO 6** | Understand the operating principles of basic building blocks of digital systems, recording and display units |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 1 | - | - | - | - | - | - | - | - | - | - |
| **CO 2** | 3 | 1 | - | - | - | - | - | - | - | - | - | - |
| **CO 3** | 3 | 1 | - | - | - | - | - | - | - | - | - | - |
| **CO 4** | 3 | - | - | - | - | - | - | - | - | - | - | - |
| **CO 5** | 3 | - | - | - | 1 | - | - | - | - | - | - | 2 |
| **CO 6** | 3 | - | - | - | 2 | - | - | - | - | - | - | 2 |

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO1)**

1. What is the loss angle of a capacitor?
2. Explain sensitivity.
3. What is the theoretical relationship between the current through a pn-diode and the voltage across it?

**Course Outcome 2 (CO2):**

1. What phenomenon is described by the early effect?
2. What is the loss angle of a capacitor?
3. What types of transducers are used for pressure measurements?

**Course Outcome 3(CO3):**

1. How to design a second order band pass filter using an OPAMP circuit?
2. Explain the working of Schmitt trigger using OPAMP circuit?
3. Show how Analog multipliers can be used for division and square rooting applications?

**Course Outcome 4 (CO4):**

1. Explain the different types of passive filters.
2. Differentiate between first and second order filters.

**Course Outcome 5 (CO5):**

1. What is an amplitude modulated signal with a suppressed carrier?
2. Explain phase locked loop (PLL).
3. How to calculate the maximum digital output error for 3-bit cascaded converter?
4. Explain why the pulse frequency is not of importance to the dual slope converter

**Course Outcome 6 (CO6):**

1. Block diagram of DMM, CRO, DSO
2. Explain the handshake procedure and indicate also what implications this has for data transmission speed?
3. Discuss the main aspects of “virtual instruments”.

**MODEL QUESTION PAPER**

QP CODE: PAGES:3

Reg No:______________

Name :______________

**TKM COLLEGE OF ENGINEERING**

**FOURTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEMR310.6**

Course Name: **PRINCIPLES OF INSTRUMENTATION**

Max. Marks: 100 Duration: 3 Hours

**PART A**

Answer all Questions. Each question carries 3 Marks

1. What is transducer?
2. What you mean by DC hall effect sensors?
3. How we can find the maximum operating signal frequency of OPAMP?
4. Determine the output voltage of an op-amp for input voltages of $V_{i1}$ = 150 µV, $V_{i2}$ = 140 µV. If it has a differential gain of $A_d$ = 4000 and the value of CMRR is 100
5. Explain voltage-controlled oscillator?
6. What is meant by multiplexing?
7. Draw the block diagram of Dual slope ADC.
8. Calculate the cut-off frequency of a first-order low-pass filter for $R_1$ =1.2 kΩ and $C_1$ =0.02 µF.
9. Explain Synchronization and triggering operation in CRO
10. What is use of spectrum and network analysers?

**(10x3=30)**

**PART B**

Answer any one full question from each module. Each question carries 14 Marks

**Module 1**

11. a)To obtain the value of the series resistance $\mathbf{r}_s$ of a diode the voltage is measuredin two different currents: 0.1 mA and 10 mA. The respective results are 600 mVand 735 mV. Find $\mathbf{r}_s$. **(4)**

b)With neat diagram explain the working of diode peak detector. **(5)**

c)Give the approximate value of the differential resistance of a pn-diode at 1 mA,at 0.5 mA and at 1 µA. Give also the conductance values. **(5)**

12. a)Explain with neat diagram explain the operation of diode Limiter/clipper. **(7)**

b) Explain about thermocouples and their practicaluse in instrumentation. **(7)**

**Module 2**

13. a)What phenomenon is described by the early effect? **(4)**

b.Explain the working of differential amplifier. **(5)**

c. State and explain Inverse square law and Lamberts cosine law. **(5)**

14. a) If the input signal has an rms value of 1 V, the op amp input impedance is 1 MΩ and the circuit's load resistance is 1 kΩ. What is the load current? Express the power gain in terms of the input resistance $R_i$ and the load resistance $R_L$, what is its value in decibels?

**(8)**

b) Derive the expression for noise factor in OPAMP amplifiers **(6)**

## Module 3

15. a)Explain the operation of Active voltage limiter and its advantages over diode voltage limiters. **(6)**

b) With neat diagram explain the operation of Schmitt trigger. Why positive feedback is provided always in the comparator circuit using an OPAMP? Also explain the hysteresis property of Schmitt trigger circuit. **(8)**

16. a)A voltage amplifier is specified as follows: input offset voltage at 20°C is < 0.5 mV, the temperature coefficient of the offset is < 5 µV/K. Calculate the maximum input offset that might occur within a temperature range of 0 to 80 °C. **(6)**

b) In the integrator circuit given below the component values are C = 1 mF and R = 10 kW. The specifications of the operational amplifier are: $|V_{off}|$ <0.1 mV and $|I_{bias}|$ < 10 nA. The input is supposed to be zero. At t = 0 the output voltage $v_o$ = 0. What is the value of $v_o$ after 10 seconds? **(8)**

## Module 4

17. a) Explain why the pulse frequency is not of importance to the dual slope converter. **(4)**

b) The integration period of an integrating AD-converter is 100 ms 1 µs.Determine the maximum conversion error caused by a 50 Hz interferencesignal withrms value of 1 V. **(6)**

c)Explain R-2R ladder digital to analog converter operation. **(4)**

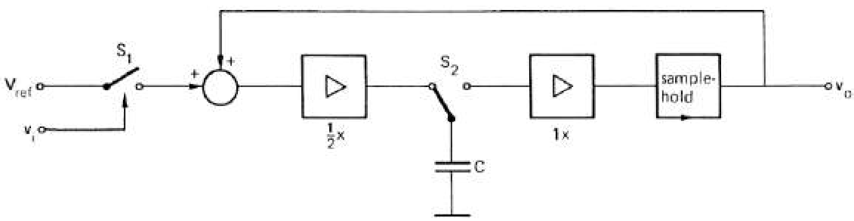
18. a)What is the differential non-linearity of a DA-converter? What is monotony? **(4)**

b) The clock frequency of a 10-bit successive approximation AD-converter is 200 kHz. Find the (approximated) conversion time for this converter. **(6)**

c) Explain the term "multiplying DAC" for a DA-converter with external reference. **(4)**

## Module 5

19. a) The input signal of the DAC in Figure below is the 3-bit word 101. Make a plot of the relevant output signal versus time. The capacitor is uncharged for t < 0.**(10)**




b)The reference voltage of a 10-bit DA-converter is 10 V. Calculate the outputvoltage when the input code is 1111100000 (MSB first). **(4)**

20. a) Explain the operation of Integrating AD-converters with neat diagram. **(6)**

b)Explain the operation of parallel AD-converters with neat diagram. **(8)**

# Syllabus

**Module 1**

Passive electronic components– Resistors- Capacitors- Inductors and transformers

Circuits with pn-diodes - Limiters - Peak detectors - Clamp circuits - DC voltages sources

Sensors– Sensor components - Resistive sensors - Inductive sensors - Capacitive sensors - Thermoelectric sensors - Piezoelectric sensors.

Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers-modes of operation-force transducer, Load cell, Strain gauge.

**Module 2**

Circuits with bipolar transistors & field effect transistors - Voltage-to-current converter - voltage amplifier stage with base-current bias - voltage amplifier stage with a base-voltage bias - emitter follower - source follower- differential amplifier

Operational amplifiers - Amplifier circuits with ideal operational amplifiers - Current-to-voltage converters - Inverting voltage amplifiers - Non-inverting voltage amplifiers - Differential amplifiers -Instrumentation amplifiers

Non-ideal operational amplifiers - Selection of operational amplifiers (Specifications)- Input offset voltage - Finite voltage gain

**Module 3**

Nonlinear signal processing with OPAMP - Voltage comparators - Schmitt-trigger - Voltage limiters - Rectifiers - Nonlinear arithmetic operations - Logarithmic converters - Exponential converters – Multipliers and other arithmetic operators

Electronic switching circuits - Electronic switches - Properties and Components as electronic switches - Circuits with electronic switches - Time multiplexers - Sample-hold circuits - Transient errors

Passive filters - First and second order RC-filters - Low-pass first-order RC-filter – High pass first-order RC-filter - Bandpass filters - Notch filters

**Module 4**

Modulation and Demodulation - Amplitude modulation and demodulation - Amplitude modulation methods - Demodulation methods. Systems based on synchronous detection - Phase-locked loop - Lock-in amplifiers - Chopper amplifiers

Digital-to-Analogue and Analogue-to-Digital conversion - Parallel converters - Binary signals and codes - Parallel DA-converters - Parallel AD-converters. Special converters - The serial DA-converter - The direct AD converter - Integrating AD-converters

**Module 5**

Measurement instruments - Stand-alone measurement instruments - Multimeters - Signal generators - Counters, frequency meters and time meters - Spectrum analyzers - Network analyzers - Impedance analyzers

Oscilloscopes- Principal of operation of general purpose CRO-basics of vertical and horizontal deflection system, sweep generator etc. DSO-Characteristics-Probes and Probing techniques.

Computer-based measurement instruments - Bus structures - Introduction to Virtual Instrumentation systems- Simulation softwares(description only)

**Text Books**

1. D. Patranabis, ‘Sensors and Transducers’, Prentice Hall of India, 2003
2. Helfrick& Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall of India,5th Edition,2002
3. Sawhney A.K., A course in Electrical and Electronic Measurements & instrumentation, DhanpatRai.
4. Kalsi H. S., Electronic Instrumentation, 3/e, Tata McGraw Hill, New Delhi, 2012
5. S Tumanski, Principles of electrical measurement, Taylor & Francis.
6. David A Bell, Electronic Instrumentation and Measurements,3/e, Oxford

**Reference Books**

1. Cooper W.D., Modern Electronics Instrumentation, Prentice Hall of India
2. Oliver & Cage, Electronic Measurements & Instrumentation, McGraw Hill
3. E.O Doebelin and D.N Manik, Doebelin’s Measurements Systems, sixth edition, McGraw Hill Education (India) Pvt. Ltd.
4. P.Purkait, B.Biswas, S.Das and C. Koley, Electrical and Electronics Measurements and Instrumentation, McGraw Hill Education (India) Pvt. Ltd.,2013

**Course Contents and Lecture Schedule**

| Module | Topic coverage | No. of Lectures |
|---|---|---|
| **1** | **Basic Instrumentation Circuit Components (8 hours)** | |
| 1.1 | Passive electronic components– Resistors- Capacitors- Inductors and transformers. Circuits with pn-diodes - Limiters - Peak detectors - Clamp circuits - DC voltages sources | 3 |
| 1.2 | Sensors– Sensor components - Resistive sensors - Inductive sensors - Capacitive sensors - Thermoelectric sensors - Piezoelectric sensors | 2 |
| 1.3 | Transducers - Definition and classification. LVDT, Electromagnetic and Ultrasonic flow meters, Piezoelectric transducers-modes of operation-force transducer, Load cell, Strain gauge. | 3 |
| **2** | **Transistor and amplifier circuits (9 hours)** | |
| 2.1 | Circuits with bipolar transistors - Voltage-to-current converter - voltage amplifier stage with base-current bias - voltage amplifier stage with a base-voltage bias - emitter follower - - differential amplifier. | 2 |
| 2.2 | Circuits with field-effect transistors - Voltage-to-current converter - voltage amplifier stage - source follower. | 2 |
| 2.3 | Operational amplifiers - Amplifier circuits with ideal operational amplifiers - Current-to-voltage converters - Inverting voltage amplifiers - Non-inverting voltage amplifiers - Differential amplifiers -Instrumentation amplifiers | 3 |
| 2.4 | Non-ideal operational amplifiers - Selection of operational amplifiers (Specifications)- Input offset voltage - Finite voltage gain | 2 |

| | | |
|---|---|---|
| **3** | **Nonlinear signal processing with OPAMP and Filters (9 hours)** | |
| 3.1 | Nonlinear transfer functions - Voltage comparators - Schmitt-trigger - Voltage limiters - Rectifiers - Nonlinear arithmetic operations - Logarithmic converters - Exponential converters – Multipliers and other arithmetic operators | 3 |
| 3.2 | Electronic switching circuits - Electronic switches - Properties and Components as electronic switches - Circuits with electronic switches - Time multiplexers - Sample-hold circuits - Transient errors. | 3 |
| 3.3 | Passive filters - First and second order RC-filters - Low-pass first-order RC-filter – High pass first-order RC-filter - Bandpass filters - Notch filters | 3 |
| **4** | **Magnetic ,Lumen and Temperature Measurements (8 hours)** | |
| 4.1 | Modulation - Amplitude modulation and demodulation - Amplitude modulation Demodulation- Demodulation methods.<br><br>Systems based on synchronous detection - The phase-locked loop - Lock-in amplifiers - Chopper amplifiers | 4 |
| 4.2 | Digital-to-Analogue and Analogue-to-Digital conversion - Parallel converters - Binary signals and codes - Parallel DA-converters - Parallel AD-converters | 2 |
| 4.3 | Special converters - The serial DA-converter - The direct AD converter - Integrating AD-converters | 2 |
| **5** | **Measuring instruments including modern recording and displaying instruments (7 hours)** | |
| 5.1 | Measurement instruments - Stand-alone measurement instruments - Multimeters - Signal generators - Counters, frequency meters and time meters - Spectrum analyzers - Network analyzers - Impedance analyzers. | 3 |
| 5.2 | Oscilloscopes- Principal of operation of general purpose CRO-basics of vertical and horizontal deflection system, sweep generator etc. DSO-Characteristics-Probes and Probing techniques. | 2 |
| 5.3 | Computer-based measurement instruments - Bus structures - Introduction to Virtual Instrumentation systems- Simulation software’s (description only) | 2 |

# SEMESTER IV
# HONOUR

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| 22EEHR411.1 | TWORK ANALYSISAND SYNTHESIS | Core (Honors) | 3 | 1 | 0 | 4 |

**:** This honors course is designed with the objective of expanding the student's knowledge in network analysis beyond the basic topics. It includes advanced topics in network analysis, basics of filter design and network synthesis concepts. This course would help students to explore more advanced concepts in the analysis of complexnetworks.

**Prerequisite : 22EET 302 Circuits and Networks**

**Course Outcomes :** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Apply network topology concepts in the formulation and solution of electric network problems. |
| **CO 2** | Apply two-port network analysis in the design and analysis of filter and attenuator networks. |
| **CO 3** | Identify the properties and characteristics of network functions, and verify the mathematical constraints for their physical realisation. |
| **CO 4** | Synthesize passive one-port networks using standard Foster and Cauer forms. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 15 | 15 | 20 |
| Understand (K2) | 20 | 20 | 50 |
| Apply (K3) | 15 | 15 | 30 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain

10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

[K1]: Questions on Network topology terminology, definitions.
[K2}: Questions on identification of graphs, paths, sub-paths, etc.,
Questions on incidence matrix.

[K2, K3] Understand level and application level numerical problems on application of Kirchoff's laws in matrix formulation, nodal analysis.
[K2, K3]. Numerical problems on graph theory based network analysis, cut-set, circuit matrices, nodal and loop analysis.

**Course Outcome 2 (CO2):**
[K1, K2] Questions on definitions and properties of filters.
[K2, K3]. Numerical problems on constant-k and m-derived filter design and analysis.

**Course Outcome 3 (CO3):**
[K1] Questions on the properties of network functions and realizability of passive impedance functions.
[K2, K3]. Numerical problems on the realizability of network functions, testing of positive real functions and Hurwitz polynomials.

**Course Outcome 4 (CO4):**
[K1]. Questions to describe Foster and Cauer forms and the properties of immittance functions.
[K2, K3]. Numerical problems to synthesise networks in Foster and Cauer forms.

Model Question Paper

Reg. No.:
Name: Pages: 4

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
**FOURTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEMR410.1**

**Course Name: Network Analysis and Synthesis**

Max. Marks: 100 Time: 3 hrs

**Part A**
**Answer *all* questions. Each question carries 3 marks.**

1. Define subgraph, path and a tree, with proper examples.
2. Describe the properties of the complete incidence matrix.
3. What are dual graphs? What is the condition for a network graph to have a dual? Illustrate with an example.
4. Describe a cut-set with an example.
5. Show that the image impedances of a two-port network are given by $Z_{im1} = \sqrt{\frac{AB}{CD}}$ and $Z_{im2} = \sqrt{\frac{BD}{AC}}$.
6. Draw the frequency response curves for ideal and non-ideal low pass filter, band pass filter, band reject filter, and high pass filter respectively.
7. For the pole-zero plot shown in Fig. 1 below, for a network function, identify the function and find its impulse response.
8. List the properties of positive real functions.
9. What are the properties of LC immittance functions.
10. Draw the Foster and Cauer forms of RC networks. (10 x 3 = 30)

**Part B**
**Answer any one full question from each module.**
**Each question carries 14 Marks.**
**Module 1**

11. (a) Draw the oriented graph of the given network shown in Fig. 2, and identify one tree and its co-tree. Obtain the incidence matrix. (6)
    (b) Find all voltages and branch currents in the network shown in Fig. 3 by node analysis, and applying network graph principles. (8)

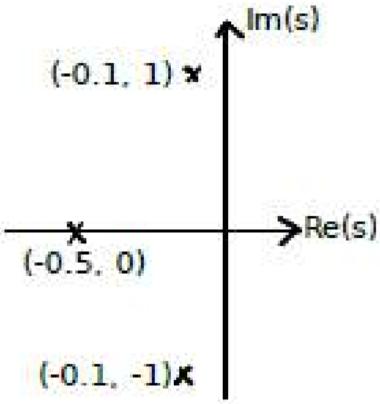



Figure 1: Pole Zero Plot

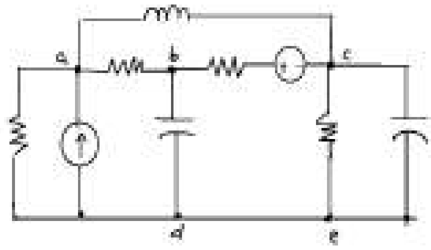



Figure 2: Figure for question 11 (a).

12. (a) The reduced incidence matrix A of an oriented graph is given below. (6)

$$A = \begin{bmatrix} -1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & -1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & -1 & 1 & 0 & -1 \\ 1 & 0 & 1 & 0 & 0 & 0 & -1 & 0 \end{bmatrix}$$

Draw the graph of an electrical network represented by this matrix. The branches constituting the outer loop of are independent current sources branches. All the current sources have their branch current variable at 1 A. Find the currents in all other branches.

(b) Find the total power dissipated in the circuit shown in Fig. 4 by node analysis (graph based). (8)

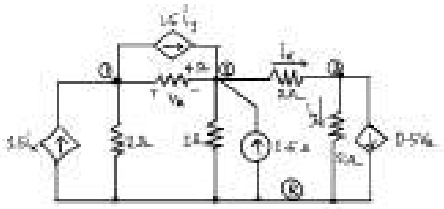


Figure 3: Figure for question 11 (b).

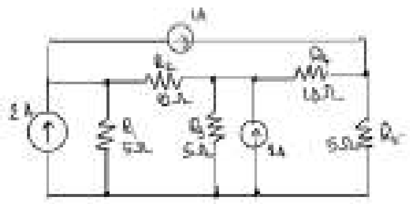


Figure 4: Figure for question 12 (b).

## Module 2

13. (a) Find the power delivered by the independent voltage sources in the network shown in Fig. 5 by loop analysis (use graph theory). Prepare the network graph using the reference directions marked in the figure. (8)

(b) A connected network has the fundamental circuit matrix given as, (6)

$$B_f = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & -1 & 0 & 0 & 1 & 0 \\ 1 & -1 & -1 & 0 & 0 & 1 \end{bmatrix}$$

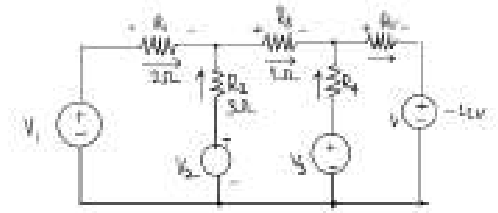


Figure 5: Figure for question 13 (a).

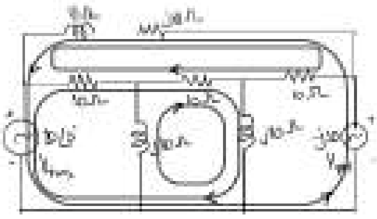


Figure 6: Figure for question 14 (a).

for some choice of tree. Obtain the f-cut-set matrix for the same tree.

14. (a) For the network shown in Fig. 6assign reference directions and draw the network graph. Obtain the connection matrix between branch currents and the loop currents in the three loops shown in the network diagram. Determine the loop impedance matrix of the network. (8)

(b) For the graph shown in Fig. 7, write the cut-set (KCL) equations for the following cut-sets: {1, 6}, {1,2,7,8}, {5, 6, 8, 9} and {2, 5, 7, 9}. Will this set of equations form an independent set of equations? If not why? (6)

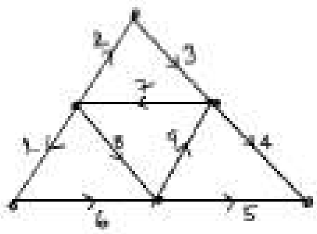


Figure 7: Figure for question 14 (b).

## Module 3

15. (a) Design a prototype T-section low-pass filter to cut-off at 100 Hz with a load resistance of 75Ω. Calculate the attenuation in Np and in dB at 200 Hz and 1 kHz. Also find the phase shift suffered by the output signal for 10 Hz and 50 Hz. (7)

(b) Design an m-derived high pass filter having a design impedance of 300 Ω, cut-off frequency of 2000 Hz and infinite attenuation at 1700 Hz. (7)

16. (a) The open-circuit voltage observed across a signal source varies between $\pm 100\ mV$. The voltage across a 60Ω resistance connected across this source is found to vary between $\pm 50\ mV$. Design a T-section attenuator such that the voltage across a 600 Ω load connected across the output of the attenuator varies between $\pm 5\ mV$. (7)

(b) Design the T-section and p-section of a constant K-type BPF that has a pass band from 1500 to 5500 Hz and characteristic resistance of 200 Ω. Further, find resonant frequency of series and shunt arms. (7)

## Module 4

17. (a) Test the following polynomials for the Hurwitz property: (6)
   (i). $s^3 + s^2 + 2s + 2$
   (ii). $s^7 + s^5 + s^3 + s$
   (iii). $s^7 + 2s^6 + 2s^5 + s^4 + 4s^3 + 8s^2 + 8s + 4$

   (b) Determine whether the following functions are positive real or not: (8)
   (i). $F(s) = \dfrac{2s^2 + 2s + 4}{(s+1)(s^2+2)}$
   (ii). $F(s) = \dfrac{5s^2 + s}{s^2 + 1}$

18. (a) Find the limits of K so that the polynomial $s^3 + 14s^2 + 56s + K$ may be Hurwitz. (6)

   (b) Find the driving point impedance Z(s) in the form $K\dfrac{N(s)}{D(s)}$ for the network shown in Fig. 8. Verify that Z(s) is positive real and that the polynomial D(s)+KN(s) is Hurwitz. (8)

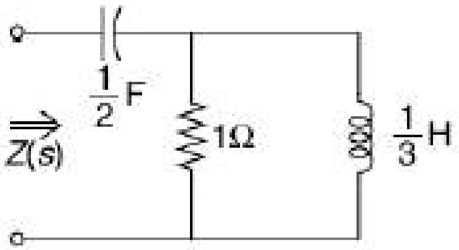



Figure 8: Figure for question 18 (b).

## Module 5

19. Realise the impedance $Z(s) = \dfrac{2(s^2+1)(s^2+0)}{s(s^2+4)}$ in three different ways. (14)

20. (a) For the network function $Y(s) = \dfrac{2(s+1)(s+3)}{(s+2)(s+4)}$, synthesise a Foster form and a Cauer form realisations. (10)

   (b) Check whether the driving point impedance $Z(s) = \dfrac{s^4 + s^2 + 1}{s^3 + 2s^2 - 2s + 10}$ represents a passive network or not. (4)

**Syllabus**

**Module 1**

Network Topology (8 hours)

Linear Oriented Graphs -incidence matrix of a linear oriented graph –Kirchoff's Laws in incidence matrix formulation –nodal analysis of networks (independent and dependent sources) – Circuit matrix of linear oriented graph –Kirchoff's laws in fundamental circuit matrix formulation.

**Module 2** (8 hours)

Loop analysis of electric networks (with independent and dependent sources) - Planar graphs – Mesh analysis- Duality –Cut set matrix -Fundamental cut set matrix –Relation between circuit, cut set and incidence matrices –Kirchoff's laws in fundamental cut-set formulation –Node-pair analysis – Analysis using generalized branch model (node, loop and node pair analysis) – Tellegen's theorem.

**Module 3:** (12 hours)

Modeling Two-port networks-application examples-amplifiers, transmission lines, passive filters.

Review of network parameter sets for two-port networks (z, y, h, g, T parameters,equivalent circuits and inter-relationship between parameters). (Review may be done using assignments/homeworks).

Image parameter description of a reciprocal two-port network -- Image impedance - Characteristic impedance - propagation constant—derivation of characteristic impedance and propagation constant for T and Pi networks under sinusoidal steady state -- Attenuation constant and phase constant.

Filter terminology: Low pass, high pass, band-pass and band-reject filters.

Constant k and m-derived filters -- low pass, high pass, band-pass and band-stop filters -- design--effect of cascading multiple sections. Resistive T, Pi and lattice attenuators.

**Module 4**

Network Functions (10 hours)

Review of Network functions for one port and two port networks: – pole zero location for driving point and transfer functions-Impulse response of Network functions from pole-zero plots- Sinusoidal steady-state frequency response from pole-zero plots.

Hurwitz polynomials –properties - Positive real functions –Properties of positive real functions – passivity-necessary and sufficient conditions for positive real functions-physical realizability.

**Module 5**

Synthesis of one port networks (8 hours)

Synthesis of reactive one-ports by Foster's and Cauer methods (forms I and II) -Synthesis of LC, RC and RL driving-point functions.

**Textbooks**

1. K. S. Suresh Kumar, ―Electric Circuit Analysis‖, Pearson Publications, 2013.
2. Ravish R. Singh, "Network Analysis and Synthesis", McGraw-Hill Education, 2013

**References**

1. Franklin Kuo, ―Network Analysis and Synthesis‖, 2nd Ed.,Wiley India.
2. Van Valkenburg M.E., ―Introduction to Modern Network Synthesis,‖ Wiley Eastern, 1960 (reprint 1986).
3. Van Valkenburg M.E, ―Network Analysis,‖ Prentice Hall India, 2014.
4. Charles A. Desoer and Ernest S. Kuh, ―Basic Circuit Theory,‖ Tata McGraw Hill Edition.
5. Chakrabarti, A., "Circuit Theory Analysis and Synthesis", DhanpatRai& Co., Seventh - Revised edition, 2018
6. S. K. Bhattacharya, ―Network Analysis and Synthesis,‖ Pearson Education India.

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Network Topology (8 hours)** | |
| 1.1 | Linear Oriented Graphs - Connected Graph, sub graphs, paths, The incidence matrix of a linear oriented graph – Path matrix, its relation to incidence matrix. | 2 |
| 1.2 | Kirchoff's Laws in incidence matrix formulation – nodal analysis of networks (independent and dependent sources) principle of v-shifting. | 2 |
| 1.3 | Circuit matrix of linear oriented graph – Fundamental Circuit matrix$B_f$. Relation between All incidence matrix and All Circuit matrix. | 2 |
| 1.4 | Kirchoff's laws in fundamental circuit matrix formulation - | 2 |
| **2** | **(8 hours)** | |
| 2.1 | Loop analysis of electric networks (with independent and dependent sources) -- Planar graphs –Mesh analysis- Duality. | 2 |
| 2.2 | Cut set matrix -Fundamental cut set matrix –Relation between circuit,cut set and incidence matrices – Orthogonality relation. | 2 |
| 2.3 | Kirchoff's laws in fundamental cut-set formulation –Node-pairanalysis. i-shifting. | 2 |

| | | |
|---|---|---|
| 2.4 | Analysis using generalized branch model (node, loop and node pair analysis) –Tellegen's theorem. | 2 |
| **3** | **(13 hours)** | |
| 3.1 | Modeling Two-port networks - application examples-amplifiers, transmission lines, passive filters.<br><br>Review of network parameter sets for two-port networks (z, y, h, g, T parameters, equivalent circuits and inter-relationship between parameters, Standard T- and pi networks. (Review may be done using assignments/homeworks). | 2 |
| 3.2 | Image parameter description of a reciprocal two-port network - Image impedance. | 1 |
| 3.3 | Characteristic impedance - propagation constant—derivation of characteristic impedance and propagation constant for T and Pi networks under sinusoidal steady state -- Attenuation constant and phase constant. | 2 |
| 3.4 | Filter terminology: Low pass, high pass, band-pass and band-reject filters. Gain characteristics.<br><br>Constant k-derived low pass filter -- Comparison with ideal low-passfilter -- Prototype Low pass filter design. | 2 |
| 3.5 | m-derived low pass filter sections, m-derived half-sections for filter termination. m-derived half-sections for input termination. Half-pi termination for pi section filters. | 2 |
| 3.6 | Constant k- and m-derived high pass filters --Design.<br><br>Constant k- band-pass filter -- Design of prototype bandpass filter -- Constant-k band-stop filter-effect of cascading multiple sections. | 2 |
| 3.7 | Resistive attenuators-Symmetric T and Pi section attenuators -- Lattice-section attenuator- Symmetrical bridged T-section attenuator - Asymmetrical T-Section and Pi-section attenuator. | 2 |
| **4** | **Network Functions (7 hours)** | |
| 4.1 | Review of Network functions for one port and two port networks: – calculation of network functions for ladder and general networks-poles and zeros for network functions-pole zero location for driving point and transfer functions. | 2 |
| | Impulse response of Network functions from pole-zero plots- Sinusoidal steady-state frequency response from pole-zero plots. | 2 |

| | | |
|---|---|---|
| | Hurwitz polynomials – properties - Positive real functions – Propertiesof positive real functions – passivity-necessary and sufficient conditions for positive real functions - physical realizability. | 3 |
| **5** | **Synthesis of one port networks (9 hours)** | |
| 5.1 | Synthesis of reactive one - ports by Foster's and Cauer methods (forms I and II):<br><br>Synthesis of R–C Network -- Properties of the R–C Impedance or R–L Admittance Function -- Foster Form-I of R–C Network -- Foster Form-II of R–C Network, Cauer Forms of R–C Network. | 3 |
| 5.2 | Synthesis of R–L Network -- Properties of R–L Function/R–C AdmittanceFunction -- Foster Form-I of R–L Network -- Foster Form-II of R–L Network -<br>- Cauer Form-I of R–L Network -- Cauer Form-II R–L Network. | 3 |
| 5.3 | Synthesis of L–C Networks -- Properties of L–C Immittance -- Foster Form-Iof L–C Network -- Foster Form-II of L–C Network -- Cauer Form-I of L–C Network -- Cauer Form-II of L–C Network. | 3 |

# SEMESTER V

| CODE | COURSE NAME | CATEGORY | | | | CREDIT |
|---|---|---|---|---|---|---|
| **22EET501** | **POWER SYSTEMS I** | **PCC** | | | | **4** |

**Preamble** : The basic objective of this course is to deliver fundamental concepts in power system components. The basic principle of generation, transmission and distribution of electrical power is comprehensively covered in this course ranging extensively from the conventional ones to the modern discoveries. Deregulated systems in the smart grid and micro-grid with details of grid connected energy storages are also introduced to the students through this course.

**Prerequisite** : **22EET 302 Circuits and Networks**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Identify the power generating system appropriate for a given area. |
| **CO 2** | Evaluate the electrical performance of any transmission line. |
| **CO 3** | Compute various physical characteristics of underground and overhead transmission sys |
| **CO 4** | Select appropriate switchgear for protection schemes. |
| **CO 5** | Design a simple electrical distribution system as per the standards. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | | | | | | | | | | |
| **CO 2** | 3 | | | | | | | | | | | |
| **CO 3** | 3 | | | | | | | | | | | |
| **CO 4** | 3 | | | | | | | | | | | |
| **CO 5** | 3 | | | | | | | | | | | |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Test** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 10 | 10 | 20 |
| Apply (K3) | 30 | 30 | 60 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. What are the methods employed for improving the efficiency of thermal power plant? (K1, K2)
2. How does diversity factor decide the capacity of a power station? (K2)
3. What are the limiting factors in tapping the wind and solar potential?(K2)
4. Problem to calculate the specification of ground mounted or rooftop solar plants. (K3)

**Course Outcome 2 (CO2):**

1. Explain the principle and causes of proximity effect and Ferranti effect using appropriate figures (K2)
2. What is transposition of lines? Comment on its necessity in the system. (K2)
3. Problems in Transmission line modelling and analysis.( K3)

**Course Outcome 3 (CO3):**

1. What are the critical voltages in the formation of Corona? What is the effect of Corona? (K1, K2).
2. With a neat cross sectional view show the constructional features of an EHT Cable. (K2).
3. Problems due to sag/ corona/insulators. (K3)

**Course Outcome 4 (CO4):**

1. What are the essential qualities required by any insulating medium used for arc quenching? What are the usual insulating media used? (K2)
2. What is current chopping? What is its effect on the system? (K1,K2).
3. What makes the differential protection very significant in the protection schemes of electrical machines and transformers?(K2)
4. Problems in Arc interruption (K3).

**Course Outcome 5 (CO5):**

1. Derive the equations for voltage drop and current loss in a two wire ring main distributor supplied by (i) DC and (ii) AC Voltages. (K3).
2. How does power factor affect an HT consumer's electricity bill? (K2).
3. Problems in power factor improvement (K3).

**Model Question paper**

**QP CODE:**

PAGES:4

Reg.No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EET501**

**Course Name: POWER SYSTEMS I**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Draw the block diagram of wind power generation and label each part clearly.
2. Discuss the difference between conventional electric power grid and smart grid
3. Draw the possible configurations for a three phase double circuit transposed line system.
4. Derive the deviation in sag due to ice in a winter climate.
5. What is meant by the term grading associated with insulators? Why is it very significant?
6. Discuss the classification of series and shunt FACTS devices.
7. Derive the peak value of current due to capacitive current chopping.
8. With the help of a schematic, explain the architecture of an IEC61850 enabled substation architecture
9. Write notes on energy markets.
10. Calculate the voltage drop and power loss for a radial load of 120A, 0.8 pf lag supplied by a 6.6kV three phase system with a branch impedance of 2 +j2 ohms.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a) A proposed station has the following load cycle:

Time in hours: 6-8 8-11 11-16 16-19 19-22 22-24 24-6

Load in MW: 20 40 50 35 70 40 20

Draw the load curve and select suitable generator units from 10,000, 20,000, 25,000, 30,000 kVA. Prepare the operation schedule for the selected machines and determine the load factor from the curve. **(5)**

b) State Skin Effect and Ferranti Effect and elucidate them with necessary diagrams. **(5)**

c) Enlighten upon the various components and their operation in a hydroelectric power plant for energy production**.** **(4)**

12. a)A generating station has the following maximum loads: 16000kW, 12000kW, 10000kW, 7000kW and 800kW. The annual load factor is 50%. Calculate the diversity factor and annual energy consumption if the maximum demand on the station is noted as 24000. **(5)**

b)With a neat sketch explain the principle of working of a Thermal Power Station. **(5)**

c)What are the limiting factors in tapping the wind and solar potential? **(4)**

**Module 2**

13. a)Derive the expression for capacitance in a single phase overhead line under the influence of earth effect. **(5)**

b)Classify transmission lines according to their length and enlist the line models. Derive the ABCD constants for medium lines using nominal π method. **(5)**

c) Following results are obtained by making experiments on three phase, three core metal sheathed cable. (i) Capacitance between all the three bunched conductors and sheath is 1.2 micro Farad. (ii) Capacitance between any one conductor and sheath and the other two being insulated is 0.8 micro Farad. (iii) Calculate the capacitance between any two conductors when the third conductor is connected to the sheath. **(4)**

14. a) An 80 km long transmission line has a series impedance of (0.15+j0.75) ohm per km and a shunt admittance of j5.1 x $10^{-6}$ ohm per km. Find the A, B, C, D parameters by Nominal π method. **(7)**

b) Derive the inductance of a single phase transmission line with three conductors arranged vertically in Side A and two conductors in Side B. The distance between adjacent conductors in each Side is 6m and that between the sides are 8m. Each conductor is of radius 0.3cm. **(7)**

**Module 3**

15. a)A transmission line conductor at a river crossing is supported from two towers at a height of 45m and 75m above the water level. The span length is 300m. Weight of the conductor is 0.85kg/mm. Determine the clearance between the conductor and water at a point midway between towers if the tension in the conductor is 2050kg. **(5)**

b) Illustrate the methods used for improving string efficiency of overhead line insulators using appropriate figures and equations. **(5)**

c) Surge impedance loading is a key parameter of any power system. Why? **(4)**

16. a) Explain the advantages and disadvantages of corona. **(4)**

b) (i) A single core, lead sheathed cable is graded by using three dielectrics of permittivity 6, 5 and 4 respectively. The conductor diameter is 2.5cm and overall diameter is 7cm. If the dielectrics are worked at the maximum stress of 38kV/cm, find the safe working voltage of the cable. **(5)**

(ii) What will be the value of safe working voltage for the same core and outside diameter assuming the same maximum stress? (ii) What should be the intersheath voltage, if the taps are provided at the same diameters as in Case (i) with a dielectric of permittivity 5, for the same maximum working stress? **(5)**

## Module 4

17. a) With a neat sketch explain the principle of operation of an Vacuum Circuit Breaker **(4)**

b)What are the primary causes of overvoltages? How are the equipments protected from over voltages? **(5)**

c)Explain the principle of operation of a static overcurrent relay. **(5)**

18. a)In a short circuit test on a 132kV three phase system, the breaker gave the following result: power factor of the fault =0.6, recovery voltage 0.97of full line value; the breaking current is symmetrical and the re-striking transient had a natural frequency of 16kHz. Determine the rate of rise of re-striking voltage. Assume that the fault is grounded. **(5)**

b)Explain the significant features of a Microprocessor based relay. **(5)**

c) What makes the differential protection very significant in the protection schemes of electrical machines and transformers? **(4)**

## Module 5

19. a) Derive the equations for voltage drop and current loss in a two wire ring main distributor supplied by (i) DC and (ii) AC Voltages. **(5)**

b)What are the modern practices in distribution system? **(4)**

c)How do you justify the connection of capacitors for the improvement of power factor economically? Explain with a real life example. **(5)**

20. a) State the main types of distribution systems and compare their applications. **(3)**

b) Derive most economical power factor for constant kW load & constant kVA type loads? **(7)**

c) A 3-phase, 5 kW induction motor has a power factor of 0.85 lagging. A bank of capacitor is connected in delta across the supply terminal and power factor raised to 0.95 lagging. Determine the kVAR rating of the capacitor in each phase? **(4)**

## Syllabus

**Module I (9 Hours)**

**Power System evolution**–Load curve -Load factor, diversity factor, Load curve (brief description only) - Numerical Problems.
**Generation**-conventional (block schematic details, special features, environmental and ethical factors, advantages, disadvantages) -hydro, thermal, nuclear –renewable energy(block schematic details, special features, environmental factors, regulations, advantages, disadvantages) –solar and wind – Design of a rooftop/ground mounted solar farm (concepts only) – Energy storage systems as alternative energy sources- grid storage systems- bulk power grids – smart grids – micro grids.

**Module II (10 hours)**

**Power Transmission System(Electrical Model)**-Line parameters -resistance- inductance and capacitance (Derivation of three phase double circuit) - Transmission line modelling-classifications -short line, medium line, long line- transmission line as two port network-parameters- derivation and calculations

**Module III (10 hours)**

**Power Transmission System** Calculation of Sag and tension-Insulators –string efficiency-grading–corona-Characteristics of transmission lines-Surge Impedance Loading- Series and shunt compensation.
Underground cables-ratings- classification- Capacitance –grading-testing
Introduction to EHVAC, HVDC and FACTS: Principle, classification and advantages/disadvantages

**Module IV (12 hours)**

**Switchgear:** Need for protection-circuit breakers - rating- SF6,VCB – Principle of GIS-protective relays – Demonstration of a typical electromechanical relay - Static, Microprocessor and Numeric types –Principles of overcurrent, directional, distance and differential- Types of protection schemes (Numeric relays) - causes of over voltages–Insulation co-ordination-Communication: PLCC - Fibre Optic- Introduction to IEC61850.

**Module V (7 hours)**

**Power Distribution Systems**– Distribution systems- Aerial Bunched Cables -Insulated conductors- Network standards-Earthing- transformer location – balancing of loads.
Methods of power factor improvement using capacitors- Tariff mechanisms– Introduction to energy markets (regulated and deregulated systems) -Distribution Automation systems

**Practical Exposure: Visit to a local Substation or a nearby power generating station, visit to a site of solar installation-Evaluation by a Viva**

**References:**


1. Cotton H. and H. Barber, *Transmission & Distribution of Electrical Energy*, 3/e, Hodder and Stoughton, 1978.
2. Gupta J.B., Transmission *& Distribution of Electrical Power*, S.K. Kataria& Sons, 2009.
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22. A. S. Pabla, *Electric Power Distribution*, 6/e, Tata McGraw Hill Publication, 2011 (or 5/e 2004).

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Power System evolution and Generation (9 hours)** | |
| 1.1 | Power System evolution- Load curve- Economic factors - Numerical Problems. | 2 |
| 1.2 | Hydroelectric -Thermal and Nuclear power plant- (Block schematic details, special features, environmental and ethical factors, advantages, disadvantages) | 2 |
| 1.3 | Nonconventional energy sources-Wind farm –(Block schematic details, special features, environmental factors, regulations, advantages, disadvantages). | 1 |
| 1.4 | Renewable energy sources – Solar–(Block schematic details, special features, environmental factors, regulations, advantages, disadvantages) - Design of a rooftop– Design of a ground mounted solar farm | 2 |
| 1.5 | Energy storage systems as alternate energy sources- Grid Storage systems - Bulk power grids - micro-grids | 2 |
| **2** | **Power Transmission System(Electrical Model)(10 hours)** | |
| 2.1 | Line parameters -resistance- inductance and capacitance (Derivation of single phase, three phase, single circuit and double circuit) - Numerical Problems. | 5 |
| 2.2 | Transmission line modelling- classifications -short line, medium line, long line-models- Transmission line as two port network-ABCD parameters-derivation and calculations- Numerical Problems. | 5 |
| **3** | **Power Transmission (Physical Aspects)(10 Hours)** | |
| 3.1 | Calculation of Sag and tension- Numerical Problems. | 2 |
| 3.2 | Insulators –string efficiency- grading- Numerical Problems. | 2 |
| 3.3 | Corona- Numerical Problems. | 1 |
| 3.4 | Surge Impedance Loading- Series and shunt compensation- Principle only. | 1 |
| 3.5 | Underground cables-ratings- classification- Capacitance –grading-testing-Numerical Problems. | 2 |
| 3.6 | Introduction to EHVAC, HVDC and FACTS: Principle, classification and advantages/disadvantages | 2 |

| | | |
|---|---|---|
| **4** | **Switchgear (12 Hours)** | |
| 4.1 | Need for protection-formation of arc-Arc quenching theory- Restriking Voltage-Recovery voltage, RRRV - Interruption of Capacitive currents and current chopping (Numerical Problems)<br>Circuit breakers-rating- SF6,VCB- (Diagram, construction, working, advantages, disadvantages) - Principle of GIS | 3 |
| 4.2 | Protective relays –Demonstration of a typical electromechanical relay - Static-Comparison and duality of Amplitude and Phase comparators-(Circuit Diagram, working, advantages, disadvantages)<br>Microprocessor -(Flow Chart, working, advantages, disadvantages) and Numeric-(Block Diagram, working, advantages, disadvantages)<br>Overcurrent, directional, distance and differential-(Principle, circuit diagram) Types of protection schemes (Using Numeric relays) | 6 |
| 4.3 | Causes of over voltages–Surge Protection | 1 |
| 4.4 | Transmission System -Communication- Fibre Optic - Abstract ideas only) | 1 |
| 4.5 | Introduction to IEC 61850 | 1 |
| **5** | **Power Distribution Systems(7 Hours)** | |
| 5.1 | Distribution systems- DC and AC distribution: Types of distributors- bus bar arrangement-Numerical problems. Aerial Bunched Cables -Insulated conductors-(Abstract ideas only) | 2 |
| 5.2 | Network-standards -Earthing- transformer location – balancing of loads-(Abstract ideas only) | 2 |
| 5.3 | Tariff – regulated and deregulated systems- Numerical Problems | 1 |
| 5.4 | Methods of power factor improvement using capacitors- Numerical Problems | 1 |
| 5.5 | Distribution Automation systems | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EET502 | MICROPROCESSORS AND MICROCONTROLLERS | PCC | 3 | 1 | 0 | 4 |

**Preamble:** This course helps the students to understand 8085 microprocessor and 8051 microcontroller architecture as well as to design hardware interfacing circuit. This also aids to thrive their programming skills to solve real world problems.

**Prerequisite:** **Fundamentals of Digital Electronics, C Programming**

**Course Outcomes:** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Describe the architecture and timing diagram of 8085 microprocessor. |
| **CO 2** | Develop assembly language programs in 8085 microprocessor. |
| **CO 3** | Identify the different ways of interfacing memory and I/O with 8085 microprocessor. |
| **CO 4** | Understand the architecture of 8051 microcontroller and embedded systems. |
| **CO 5** | Develop assembly level and embedded C programs in 8051 microcontroller. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | | | | | | | | | | |
| **CO 2** | 3 | 2 | 3 | 2 | 1 | | | | | | | |
| **CO 3** | 3 | 2 | 2 | 2 | 2 | | | | | | | |
| **CO 4** | 3 | 2 | | | | | | | | | | |
| **CO 5** | 3 | 2 | 3 | 2 | 1 | 1 | | | | | | 1 |

**Assessment Pattern:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 10 | 10 | 20 |
| Apply (K3) | 30 | 30 | 60 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

**Part B** contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Describe the register organization in 8085 microprocessor.
2. Explain the Stack and subroutine operations.
3. Explain the basic steps involved in accessing memory locations.
4. Draw the timing diagrams of different instructions of 8085 microprocessor.

**Course Outcome 2 (CO2):**

1. Describe the addressing modes of 8085 microprocessor.
2. Describe the various types of 8085 microprocessor instructions.
3. Explain in detail the instruction set of 8085 microprocessor.
4. Write an ALP for data transfer, arithmetic, logical and branching operations.

**Course Outcome 3(CO3):**

1. Explain how RAM and ROM memory are interfaced with 8085 microprocessor.
2. Describe address decoding used in I/O interfacing.
3. Explain the architecture of 8255 PPI.
4. Explain the modes of operation of 8255 PPI.

**Course Outcome 4 (CO4):**

1. Explain the special function registers in 8051 microcontroller.
2. Explain the operating modes of serial port of 8051 microcontroller.
3. Describe the addressing modes and modes of operation of timer of 8051 microcontroller.
4. Explain the embedded C Programming.

**Course Outcome 5 (CO5):**

1. Explain timer programming in assembly language and embedded C.
2. Explain serial port programming in assembly language and embedded C.
3. How to interface ADC, DAC and sensors with 8051 microcontroller.
4. Explain interrupt programming in assembly language and C.

**Model Question Paper**

QP Code: Pages: 2

Reg No: ____________________

Name: _____________________

**TKM COLLEGE OF ENGINEERING**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EET502**
**Course Name: MICROPROCESSORS AND MICROCONTROLLERS**

Max. Marks: 100 Duration: 3 Hours

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Explain the use of ALE signal in Intel 8085 microprocessor.
2. Describe the use of CLK OUT and RESET OUT signals.
3. With the help of an example explain the operation of XTHL instruction.
4. How can we check the status of flags in 8085 microprocessor?
5. Explain software and hardware interrupts.
6. Write the differences between microprocessor and microcontroller.
7. Draw the block diagram of 8051 microcontroller.
8. Explain the bit pattern of TMOD register of 8051 microcontroller.
9. How we can enable and disable interrupts in 8051 microcontroller.
10. Find the bits of TMOD registers to operate as timers in the following modes
    (i) Mode 1 Timer (ii) Mode 2 Timer 0.

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. (a) Explain the functional block diagram of 8085 microprocessor. **(10)**

    (b) Define machine cycle and T state. **(4)**

12. (a) Sketch and explain the timing diagram of LDA 2003H. **(10)**

    (b) Describe the addressing modes of 8085 microprocessor. **(4)**

**Module 2**

13. (a) Write an ALP to sort an array of 10 numbers stored from memory location 2001H onwards in ascending order. **(10)**

    (b) Explain stack related operations in 8085 microprocessor. **(4)**

14. (a) Write a delay program to introduce a delay of 1 second. **(8)**

(b) Explain the operation of DAA instruction in 8085 microprocessor. **(6)**

**Module 3**

15. (a) Explain the address decoding technique in memory interfacing. **(8)**

(b) Give the control word format for BSR and I/O Mode in 8255. **(6)**

16. (a) Explain the architecture of 8051 microcontroller. **(8)**

(b) Explain hard and soft real time systems. **(6)**

**Module 4**

17. (a) Explain the different methods to create a time delay in 8051 microcontroller. **(7)**

(b) Explain the different addressing modes of 8051 microcontroller? **(7)**

18. (a) Explain the various types of instructions in 8051 microcontroller? **(6)**

(b) Write a Program in 8051 for the generation of square wave having a duty ratio of 0.5 for a time period of 1ms. **(8)**

**Module 5**

19. (a) Explain how a DAC can be interfaced to 8051 microcontroller. **(10)**

(b) Explain the role of SBUF and SCON registers used in 8051 microcontroller. **(4)**

20. (a) Describe the generation of time delay using the timer of 8051 microcontroller. **(8)**

(b) Explain the various interrupts in 8051 microcontroller. **(6)**

(14 x 5 = 70)

## Syllabus

### Module 1

Internal architecture of 8085 microprocessor–Functional block diagram

Instruction set-Addressing modes - Classification of instructions - Status flags.

Machine cycles and T states – Fetch and execute cycles- Timing diagram for instruction and data flow.

### Module 2

Introduction to assembly language programming- Data transfer operations, arithmetic operations, logic operations, branching operations, I/O and machine control operations.

Assembly language programmes (ALP) in 8085 microprocessor- Data handling/Data transfer, Arithmetic operations, Code conversion- BCD to Binary - Binary to BCD, Sorting - Ascending and descending including bubble sorting.

Stack and subroutines – Conditional CALL and Return instructions

Time delay subroutines using 8 bit register, 16 bit register pair and Nested loop control.

### Module 3

Interrupt & interrupt handling - Hardware and Software interrupts.

I/O and memory interfacing – Address decoding– Interfacing I/O ports -Programmable Peripheral Interface PPI 8255 - Modes of operation- Interfacing of seven segment LED.

Introduction to embedded systems, Current trends and challenges, Applications of embedded systems- Hard and soft real time systems.

Introduction to microcontrollers- Microprocessor Vs Microcontroller- 8051 Microcontrollers – Hardware - Microcontroller architecture and programming model - I/O port structure - Register organization -General purpose RAM - Bit addressable RAM - Special Function Registers (SFRs).

### Module 4

Instruction set - Instruction types - Addressing modes of 8051 microcontrollers.

8051 microcontroller data types and directives - Time delay programmes and I/O port programming.

Introduction to embedded C Programming - time delay in C - I/O port programming in embedded C.

### Module 5

8051 Timer/counter programming - Serial port programming - Interrupt programming in assembly language and embedded C.

Interfacing –ADC - DAC and temperature sensor

**Text Books**

1. Ramesh Gaonkar, "Microprocessor Architecture Programming and Applications", Penram International Publishing; Sixth edition, 2014.
2. Mohamed Ali Mazidi, Janice Gillispie Mazidi, "The 8051 microcontroller and embedded systems using Assembly and C", second edition, Pearson/Prentice hall of India.
3. Kenneth J. Ayala, "The 8051 microcontroller", 3rd edition, Cengage Learning, 2010
4. Lyla B Das, "Embedded Systems - An Integrated Approach", Pearson Education India

**Reference Books**

1. B Ram, "Fundamentals of Microprocessors and Microcontrollers", 9e, Dhanpat Rai Publications, 2019.
2. Wadhwa, "Microprocessor 8085 microprocessor: Architecture, Programming and Interfacing", PHI 2010
3. Shibu K V, "Introduction to Embedded systems", TMH

**Course Contents and Lecture Schedule**

| No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Architecture and Instruction set of 8085 microprocessor (9 hours)** | |
| 1.1 | Internal architecture of 8085 microprocessor– functional block diagram | 2 |
| 1.2 | Instruction set- Addressing modes, Classification of instructions - Status flags. | 4 |
| 1.3 | Machine cycles and T states – Fetch and execute cycles - timing diagram for instruction and data flow. | 3 |
| **2** | **Assembly language programming (9 hours)** | |
| 2.1 | Introduction to assembly language programming- data transfer operations, arithmetic operations, logic operations, branching operations, I/O and machine control operations. | 2 |
| 2.2 | Assembly language programmes (ALP) in 8085 microprocessor-Data handling/Data transfer - Arithmetic operations - Code conversion - BCD to Binary - Binary to BCD, Sorting - Ascending and descending including bubble sorting. | 4 |
| 2.3 | Stack and subroutines – Conditional call and return instructions – Stack operations. | 2 |
| 2.4 | Time delay subroutines using 8bit register, 16 bit register pair and Nested loop control. | 1 |
| **3** | **Interfacing circuits for 8085 microprocessor and introduction to 8051 Microcontroller (10 hours)** | |
| 3.1 | Interrupt and interrupt handling - Hardware and Software interrupts. | 1 |
| 3.2 | I/O and memory interfacing – Address decoding – Interfacing I/O ports- Programmable peripheral interface PPI 8255 - Modes of operation - Interfacing of seven segment LED. | 4 |

| | | |
|---|---|---|
| 3.3 | Introduction to embedded systems - Current trends and challenges - Applications of embedded systems - Hard and Soft real time systems. | 1 |
| 3.4 | Introduction to microcontrollers - Microprocessor Vs Microcontroller - 8051- Microcontrollers - Hardware | 1 |
| 3.5 | Microcontroller Architecture and programming model: I/O Port structure - Register organization - General purpose RAM -Bit Addressable RAM - Special Function Registers (SFRs). | 3 |
| **4** | **Programming of 8051 Microcontroller (9 hours)** | |
| 4.1 | Instruction Set - Instruction Types - Addressing modes | 3 |
| 4.2 | 8051- Data types and directives -Time delay programmes and I/O port programming. | 3 |
| 4.3 | Introduction to embedded C Programming - Time delay in C - I/O port programming in embedded C. | 3 |
| **5** | **Interfacing circuits of 8051 Microcontroller (9 hours)** | |
| 5.1 | Timer/counter programming in assembly language and embedded C | 3 |
| 5.2 | Serial port programming in assembly language and embedded C | 2 |
| 5.3 | Interrupt programming in assembly language and embedded C | 2 |
| 5.4 | Interfacing –ADC - DAC and temperature sensor | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET503** | **SIGNALS AND SYSTEMS** | PCC | **3** | **1** | **0** | **4** |

**Preamble** : This course introduces the concept of signals and systems. The time domain and frequency domain representation, operations and analysis of both the continuous time and discrete time systems are discussed. The application of Fourier analysis, Laplace Transform and Z- Transforms are included. Stability analysis of continuous time systems and discrete time systems are also introduced.

**Prerequisite** : **Basics of Circuits and Networks**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Explain the basic operations on signals and systems. |
| **CO 2** | Apply Fourier Series and Fourier Transform concepts for continuous time signals. |
| **CO 3** | Analyse the continuous time systems with Laplace Transform. |
| **CO 4** | Analyse the discrete time system using Z Transform. |
| **CO 5** | Apply Fourier Series and Fourier Transform concepts for Discrete time domain. |
| **CO 6** | Describe the concept of stability of continuous time systems and sampled data systems. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | - | - | 2 | - | - | - | - | - | - | 1 |
| **CO 2** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 1 |
| **CO 3** | 3 | 3 | 3 | - | 2 | - | - | - | - | - | - | 2 |
| **CO 4** | 3 | 3 | 3 | - | 2 | - | - | - | - | - | - | 2 |
| **CO 5** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 2 |
| **CO 6** | 3 | 3 | - | - | 2 | - | - | - | - | - | - | 1 |

**Assessment Pattern:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 10 | 10 | 20 |
| Apply (K3) | 30 | 30 | 60 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

**Part B** contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

**Course Level Assessment Questions :**

**Course Outcome 1 (CO1)**

1. What are the standard test signals?
2. Problems related to various operations of signals.
3. Problems related to representation of systems in differential equation form.
4. Explain any three differences between linear and nonlinear systems.

**Course Outcome 2 (CO2):**

1. Problems related to Fourier series of continuous signals.
2. Problems related to Fourier transform of continuous systems.
3. Obtain the frequency response of the given system.

**Course Outcome 3(CO3):**

1. Derivations of transfer function of a given electrical system to comment on the system behaviour.
2. Problems related to analogous systems.
3. Problems related to block diagram reduction.

**Course Outcome 4 (CO4):**

1. Problems related ZIT.
2. Problems related to ZTF from difference equation form.
3. Problems related to block diagram development of ZTF of the given sampled system.

**Course Outcome 5 (CO5):**

1. Problems related to Discrete Fourier series of DT signals.
2. Problems related to Discrete time Fourier transform of DT signals
3. Obtain the frequency response of the given DT system.

**Course Outcome 6 (CO6):**

1. Problems related to the stability analysis of given continuous time systems using Routh criterion.
2. Problems related to stability analysis of DT systems.
3. Differentiate between asymptotic stability and BIBO stability?

**Model Question Paper** PAGES: 3

**QPCODE:**

Reg. No:___________

Name:_____________

**TKM COLLEGE OF ENGINEERING**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

Course Code**: 22EET503**

Course Name: **SIGNALS AND SYSTEMS**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1.Define unit ramp signal r(t). Sketch the signal r(-t+2).

Explain any two peculiar characteristics of nonlinear systems.

What are the conditions for the existence of Fourier transform?

Why do you use analogous systems? Explain with a suitable example.

Determine the unit impulse response for the system with $T(s) = \frac{2}{(s^2 + s - 12)}$

Explain the concept of positive real functions.

Explain the significance of ZOH circuit in signal reconstruction.

Write three properties of discrete convolution.

State and prove time reversal property of discrete time Fourier series.

Find the Fourier transform of x(n)= n u(n).

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

Check whether the following system is static, causal, linear and time invariant: $y(t) = |x(t)|$ **(8)**

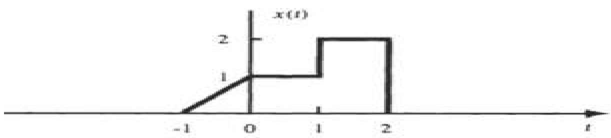
Find the convolution of $x_1(t)$ and $x_2(t)$ for the following signals: $x_1(t) = e^{-at}u(t); x_2(t) = e^{-bt}u(t)$ **(6)**

With suitable examples differentiate between:

i. Odd and even signals,

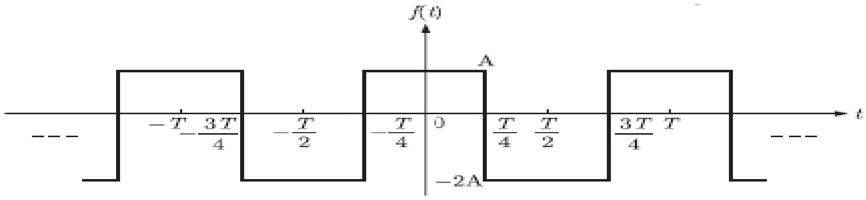
ii. Causal and non causal systems. **(7)**

The signal x(t) is given below. Plot x(t-1)+ x(-t+2) **(7)**




**Module 2**

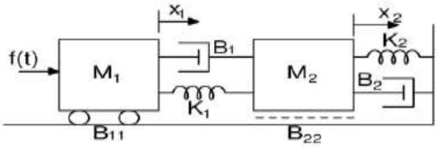
Find the trigonometric Fourier series for the periodic signal f(t).




**(9)**

State and prove time shifting property of Fourier transform. **(5)**

Derive the transfer function $X_2(s)/F(s)$ for the mechanical




**(7)**

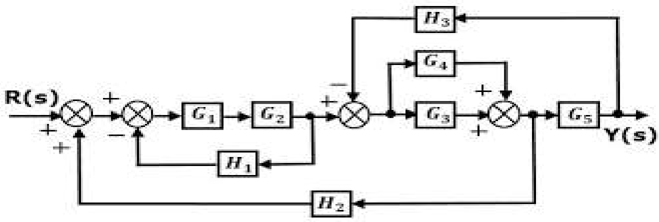
A system is described by the following differential equation:

$$\frac{d^2y(t)}{dt^2}+7\frac{dy(t)}{dt}+12y(t)=x(t);\, y(0^-)=-2, \frac{dy}{dt}(0^-)=0$$

Determine the response of the system to a unit step applied at t=0. **(7)**

**Module 3**

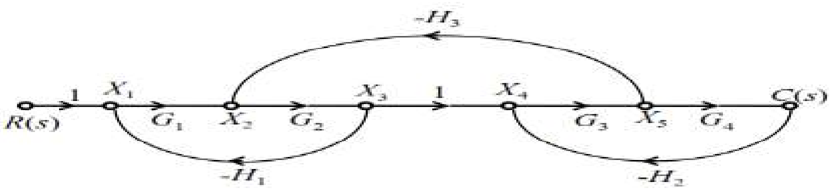
Determine the overall transfer function Y(s)/R(s) using block diagram reduction.




**(8)**

Check stability of the system represented by the following characteristic equation, using Routh stability criterion: $3s^4+10s^3+5s^2+5s+2=0$ **(6)**

Determine the transfer function of the system represented by the signal flow graph using Mason's gain formula.




**(9)**

How frequency response can be obtained from poles and zeros? **(5)**

**Module 4**

Determine the convolution sum of two sequences x(n)={1,4,3,2} and h(n)={1,3,2,1} using graphical method. **(8)**

Determine the z-transform of $x(n)=(1/2)^n u(-n)$. **(6)**

Explain the aliasing effect in sampled data systems. **(5)**

Determine the inverse z-transform of the following functions: $i) X(z) = \frac{2z^{-1}}{(1-\frac{1}{4}z^{-1})^2}; ROC: |z| > \frac{1}{4}, and, ii) F(z) = \frac{3z^{-1}}{(1-z^{-1})(1-2z^{-1})}; ROC: |z| > 2$ **(9)**

**Module 5**

Determine the complete solution of the difference equation: y (n) + 2y(n-1) + y(n-2) = x (n) + x(n-1) for the input x(n) = ($0.5^n$) u(n), initial conditions y(-1) = y(-2) = 1? **(9)**

Find the Fourier series coefficients for x(n)=cos(πn/4) **(5)**

i) Obtain the direct form-I realization for the system described by the difference equation: $y(n) - \frac{5}{6}y(n-1) + \frac{1}{6}y(n-2) = 2x(n)$

ii) Also determine the impulse response h(n) for the above system. **( 4+5 )**

Check stability of the system described by the following characteristic equation, using Jury's test: $z^3$-0.2$z^2$-0.25z+0.05=0 **(5)**

## Syllabus

**Module 1**

**Introduction to Signals and Systems (9 hours):**

Classification of signals: Elementary signals- Basic operations on continuous time and discrete time signals

Concept of system: Classification of systems- Properties of systems- Time invariance- Linearity -Causality – Memory- Stability-Convolution Integral- Impulse response

Representation of LTI systems: Differential equation representations of LTI systems

Basics of Non linear systems- types and properties

Introduction to random signals and processes (concepts only)

**Module 2**

**Fourier Analysis and Laplace Transform Analysis (10 hours):**

Fourier analysis of continuous time signals: Fourier Series- Harmonic analysis of common signals

Fourier transform: Existence- Properties of Continuous time Fourier transform- Energy spectral density and power spectral density

Concept of Frequency response

Laplace transform analysis of system transfer function: Relation between the transfer function and differential equation- Transfer function of LTI systems- Electrical, translational and rotational mechanical systems- Force voltage, Force current and Torque Voltage analogy

**Module 3**

**System Models and Response (8 hours):**

Block diagram representation - block diagram reduction

Signal flow graph - Mason's gain formula

Type and Order of the systems- Characteristic equation

Determining the time domain and frequency response from poles and zeros

Concepts of Positive real functions and Hurwitz polynomial- Routh stability criterion.

Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for mathematical and signal operations (Demo/Assignment only)

**Module 4**

**Sampled Data Systems and Z-Transform (9 hours):**

Sampling process-Impulse train sampling-sampling theorem- Aliasing effect

Zero order and First order hold circuits- Signal reconstruction

Discrete convolution and its properties

Z Transform**:** Region of convergence- Properties of Z Transform

Inverse ZT: Methods

**Module 5**

**Analysis of Sampled Data Systems (9 hours):**

Difference equation representations of LTI systems - Analysis of difference equation of LTI systems- Z Transfer function- Delay operator and block diagram representation- Direct form, cascade and parallel representations of $2^{nd}$ order systems

Stability of sampled data system: Basic idea on stability- Jury's test- Use of bilinear transformation

Discrete Fourier series**:** Fourier representation of discrete time signals - Discrete Fourier series– properties.

Discrete Time Fourier Transform: Properties- Frequency response of simple DT systems

**Text Books**


1. Oppenheim A.V., Willsky A.S. & Nawab S.H., Signals and Systems, 2/e, Prentice Hall
2. Nagrarth I. J, Saran S. N and Ranjan R, Signals and Systems, 2/e, Tata McGraw Hill
3. Haykin S. & Veen B.V., Signals & Systems, 2/e, John Wiley
4. Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern
5. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers


**Reference Books**


1. Bracewell R.N., Fourier Transform & Its Applications, McGraw Hill
2. Farooq Husain, Signals and Systems, Umesh publications.
3. Papoulis A., Fourier Integral & Its Applications, McGraw Hill
4. Taylor F.J., Principles of Signals & Systems, McGraw Hill


**Course Contents and Lecture Schedule:**

| Module | Topic coverage | No. of Lectures |
|---|---|---|
| **1** | **Introduction to Signals and Systems (9 hours)** | |
| 1.1 | Classification of signals - Elementary signals- Basic operations on continuous time and discrete time signals | 2 |
| 1.2 | Concept of systems - Classification of systems- Properties of systems - Time invariance- Linearity -Causality – Memory- Stability. | 2 |
| 1.3 | Convolution Integral- Impulse response- | 1 |
| 1.4 | Representation of LTI systems - Differential equation representations of LTI systems | 2 |
| 1.5 | Basics of Non linear systems- types and properties<br>Introduction to random signals and processes (concepts only) | 2 |
| **2** | **Fourier Analysis and Laplace Transform Analysis (10 hours)** | |
| 2.1 | Fourier Analysis of continuous time signals: Fourier Series- Harmonic analysis of common signals | 2 |

| | | |
|---|---|---|
| 2.2 | Fourier transform: Existence- Properties of Continuous time Fourier transform- Energy spectral density and power spectral density | 2 |
| 2.3 | Concept of Frequency response- Frequency response of simple LTI systems. | 2 |
| 2.4 | Laplace transform analysis of system transfer function: Relation between the transfer function and differential equation | 1 |
| 2.5 | Transfer function of LTI systems: Electrical, Translational and rotational Mechanical systems | 2 |
| 2.6 | Force Voltage, Force Current and Torque Voltage analogy | 1 |
| **3** | **System Models and Response (8 hours)** | |
| 3.1 | Block diagram representation - block diagram reduction | 2 |
| 3.2 | Signal flow graph - Mason's gain formula | 1 |
| 3.3 | Type and Order of the systems- Characteristic equation. | 1 |
| 3.4 | Determining the time domain and frequency response from poles and zeros. | 2 |
| 3.5 | Concepts of Positive real functions and Hurwitz polynomial- Basic idea on Stability- Routh stability criterion | 2 |
| 3.6 | *Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent simulation software and tool boxes for various mathematical operations (Demo/Assignment only)* | |
| **4** | **Sampled Data Systems and Z-Transform (9 hours)** | |
| 4.1 | Sampling process-Impulse train sampling-sampling theorem- Aliasing effect | 2 |
| 4.2 | Zero order and First order hold circuits- Signal reconstruction- | 2 |
| 4.3 | Discrete convolution and its properties | 1 |
| 4.4 | Z Transform**:** Region of convergence- Properties of Z Transform | 2 |
| 4.5 | Inverse ZT: Methods | 2 |
| **5** | **Analysis of Sampled Data Systems (9 hours)** | |
| 5.1 | Difference equation representations of LTI systems - Analysis of difference equation of LTI systems- Z Transfer function | 2 |
| 5.2 | Delay operator and block diagram representation- Direct form, cascade and parallel representations of $2^{nd}$ order systems. | 2 |
| 5.3 | Stability of sampled data system: Basic idea on Stability- Jury's test- Use of bilinear transformation. | 2 |
| 5.4 | Discrete Fourier Series**:** Fourier representation of discrete time signals - Discrete Fourier series– properties | 2 |
| 5.5 | Discrete Time Fourier Transform: properties- Frequency response of simple DT systems | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET504** | **SYNCHRONOUS AND INDUCTION MACHINES** | **PCC** | **3** | **1** | **0** | **4** |

**Preamble: Nil**

**Prerequisite: DC Machines and Transformers**

**Course Outcomes:** After the completion of the course, the student will be able to:

| | |
|---|---|
| **CO 1** | Analyse the performance of different types of alternators. |
| **CO 2** | Analyse the performance of a synchronous motor. |
| **CO 3** | Analyse the performance of different types of induction motors. |
| **CO 4** | Describe operating principle of induction machine as generator. |
| **CO 5** | Explain the types of single phase induction motors and their working principle. |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 2 | - | - | - | 2 | - | - | - | - | - | 2 |
| **CO 2** | 3 | 3 | 2 | - | - | 2 | - | - | - | - | - | 2 |
| **CO 3** | 3 | 3 | 2 | - | - | 2 | - | - | - | - | - | 2 |
| **CO 4** | 3 | 3 | 2 | - | - | 2 | - | - | - | - | - | 2 |
| **CO 5** | 2 | 2 | - | - | - | 2 | - | - | - | - | - | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand | 15 | 15 | 30 |
| Apply | 25 | 25 | 50 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

**Part A:** 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the principle of operation of alternators.
2. List the advantages of stationary armature type alternators over rotating armature types.
3. Derive emf equation of an alternator.
4. Define coil pitch factor and distribution factor of an alternator.
5. Problems based on emf equation of alternators.
6. Draw the phasor diagram of an alternator operating under lagging/leading/unity power factor and hence derive an expression for the no load induced emf/phase.

**Course Outcome 2 (CO2):**

1. Why synchronous motors are not self starting?
2. Develop the equivalent circuit and phasor diagram of synchronous motor.
3. Explain the V and Inverted V curves of synchronous motor
4. Explain the power flow diagram of synchronous motor.

**Course Outcome 3(CO3):**

1. Explain the principle of operation of a three phase induction motor.
2. List the constructional differences between slip ring and squirrel cage induction motors.
3. Problems based on analysing the performance of three phase induction motors using circle diagrams.
4. Problems based on developing the equivalent circuit of a three phase induction motor.
5. Explain the various speed control methods of three phase induction motors.
6. Explain the working of DOL/Star-Delta starter for three phase induction motors.

**Course Outcome 4 (CO4):**

1. Explain the principle of operation of induction generator.
2. Explain the difference between Grid connected and self excited induction generators
3. Differentiate between induction generator and synchronous generator.
4. Enumerate application of induction generator.

**Course Outcome 5 (CO5):**

1. Why single phase induction motor is not self starting.
2. Explain double field revolving theory.
3. Draw the torque slip characteristics of single phase induction motor.
4. Develop the equivalent circuit of single phase induction motor.

**Model Question paper**

**QP CODE:**

PAGES: 3

Reg.No:______________
Name:________________

**TKM COLLEGE OF ENGINEERING**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH& YEAR**

**Course Code: 22EET504**

**Course Name: SYNCHRONOUS & INDUCTION MACHINES**

**Max. Marks: 100** **Duration: 3 Hrs**

## PART A

**Answer all questions. Each Question Carries 3 marks**

1. List the advantages of stationary armature type alternators over rotating armature types.
2. Define coil pitch factor and distribution factor of an alternator.
3. State and explain Blondel's Two Reaction Theory.
4. What is meant by synchronisation? Lit the conditions to be met while synchronising an alternator to the common bus bars.
5. With the help of neat figures, explain why a synchronous motor is not self-starting.
6. Differentiate between slip ring and squirrel cage induction motors.
7. Explain the phenomenon of crawling and cogging in induction motors.
8. Explain any two braking techniques of induction motors.
9. Differentiate between synchronous and induction generators.
10. What is double field revolving theory?

## PART B

**Answer any one full question from each module. Each question carries 14 marks.**

**Module 1**

11. a) List the causes of harmonics in alternators and suggest ways to mitigate them. **(5)**

b) A 3-Φ, 10 pole alternator has 2 slots/ pole/ phase on its stator with 10 conductors per slot. The air gap flux is sinusoidally distributed and equals 0.05 Wb. The stator has a double layer winding with a coil span of 1500. If the alternator is running at 600 rpm, calculate the emf generated /phase at no load. **(9)**

12. With the help of neat diagrams, explain the effects of armature reaction in alternators under lagging, leading and unity power factors. **(14)**

**Module 2**

13. A 220V, 6 pole, 50 Hz, star connected alternator gave the following test results: -

| If (A) | 0.2 | 0.4 | 0.6 | 0.8 | 1 | 1.2 | 1.4 | 1.8 | 2.2 | 2.6 | 3 | 3.4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Voc (line) (V) | 29 | 58 | 87 | 116 | 146 | 172 | 194 | 232 | 261 | 284 | 300 | 310 |
| Vzpf (line) | - | - | - | - | - | 0 | 29 | 88 | 140 | 177 | 208 | 230 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (V) | | | | | | | | | | | | |
| Isc (A) | 6.6 | 13.2 | 20 | 26.5 | 32.4 | 40 | 46.3 | 59 | - | - | - | - |

Find % voltage regulation at full load current of 40A at power factor 0.8 lag by (i) m.m.f method (ii) ZPF method. Ra=0.06 Ω /phase. **(14)**

14. a) Two 3Φ, 6.6 kV star connected alternators supply a load of 3000kW at 0.8 pf lag. The synchronous impedance/phase of machine A is 0.5 + j 10 Ω and that of machine B is 0.4+j12 Ω. The excitation of machine A is adjusted so that it delivers 150 A at a lagging power factor and the governors are so set that the load is equally shared between the machines. Determine the current, power factor and induced emf of each machine. **(10)**

b) With the help of a neat circuit diagram, explain how an alternator is synchronised to the bus bars by bright lamp method. **(4)**

**Module 3**

15. a) With the help of a neat circuit diagram, explain how V and inverted V curves are obtained. **(6)**

b) A 2000V, 3-phase, 4 pole star connected synchronous motor runs at 1500 rpm. The excitation is constant and corresponds to an open circuit voltage of 2000V.The resistance is negligible compared to synchronous reactance of 3Ω per phase. Determine power input, power factor, torque developed for an armature current of 200A. **(8)**

16. a) In rice/flour mills driven by squirrel cage induction motors, the hopper is loaded with the grains only after starting the motor. Similarly, the delivery valve of centrifugal pumps driven by squirrel cage induction motor is opened only after starting the motor. What is the reason behind this? Justify your answer with a relevant performance curve of squirrel cage induction motor. **(4)**

b) A 6-pole, 50 Hz,3-Φ induction motor running on full load develops a useful torque of 150 Nm at a rotor frequency of 1.5 Hz. Calculate the shaft power output. If the mechanical torque lost in friction is 10 Nm, determine a) rotor copper loss b) input to the motor c) the efficiency. The total stator loss is 700W. **(10)**

**Module 4**

17. For the following test data, calculate (i) line current (ii) power factor (iii) rotor copper loss (iv) slip (v) efficiency (vi) maximum output power (vi) maximum torque and (vii) starting torque:

Induction Motor Details: 3.73kW, 200V, 50Hz, 4pole, 3$\phi$ star connected

No Load Test: 200V, 350W, 5A

Blocked Rotor Test: 100V, 26A, 1700W

Rotor Copper Loss at standstill is 60% of the total copper loss. **(14)**

18. Explain the methods of speed control in three phase induction motors. **(14)**

**Module 5**

19. a)Explain the working principle and modes of operation of an Induction Generator. **(8)**

b) With the help of a neat figure, explain the torque-slip characteristics of an induction machine. **(6)**

20. Explain the working of split phase and capacitor start single phase induction motors with the help of neat circuit diagrams and phasor diagrams. Also mention the applications of each. **(14)**

## Syllabus

### Module 1

Principle of Operation of three phase alternators, Constructional features, Types of Armature Windings (detailed winding diagram not required), EMF equation, Numerical Problems.

Harmonics-causes, suppression, Rating of alternators, Parameters of armature winding, Armature reaction, Equivalent Circuit, Phasor Diagram, Load characteristics, Power Flow Equations.

### Module 2

Voltage regulation of three phase Alternators-Direct loading, EMF Method, MMF Method, Potier Method, ASA Method -Numerical Problems.

Blondel's two reaction theory, Phasor Diagram under lagging power factor, Determination of $X_d$ and $X_q$ by slip test, Power developed by a Salient pole machine, Numerical Problems.

Parallel Operation of Alternators- Necessary Conditions, Synchronisation- Synchronising current, Power and Torque, Effect of reactance, Numerical Problems, Methods of Synchronisation.

### Module 3

Principle of Synchronous Motor, Equivalent circuit, Phasor diagrams, Power flow diagram and equations, Losses and efficiency -Numerical Problems, Power-angle Characteristics, V Curve and Inverted V Curves.

Three phase Induction motor – Constructional features, Expressions for Power and Torque-Torque- Slip characteristics, Phasor diagram, Equivalent Circuit of Induction motor- Tests on Induction motors for determination of equivalent circuit-Numerical Problems.

### Module 4

Performance of three phase Induction motors using Circle diagram, Numerical Problems. Cogging and Crawling in cage motors, Double cage Induction motor-Torque-Slip Characteristics.

Starting of Induction motors – Types of Starters – DOL starter, Autotransformer Starter, Star-Delta starter, Rotor Resistance Starter-Numerical Problems.

Braking of Induction motors – Plugging, Dynamic braking, Regenerative braking, Speed control – Stator Voltage control, V/f control, Rotor Resistance Control.

### Module 5

Induction generator – Principle of operation, Grid Connected and Self Excited Operation of Induction Generators,Torque-Slip Characteristics of an Induction machine.

Single phase Induction motors-Double field revolving theory, Equivalent Circuit, Torque-Slip Characteristics, Types of Single Phase Induction motor, Applications.

Selection of AC motors for different applications.

### Text Books

1. Bimbra P S, Electric Machines, Khanna Publishers, 2nd edition, 2017.

2. KothariD. P., NagrathI. J., Electric Machines, Tata McGraw Hill, 5th edition.2017.
3. Say M G, The Performance and Design of AC Machines, CBS Publishers, New Delhi, 3rd edition, 2002.
4. Alexander SLangsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill,2nd revised edition, 2001.

**Reference Books**

1. Deshpande M. V., Electrical Machines, Prentice Hall India, New Delhi, Eastern Economy Edition, 2011.
2. Gupta B R, Vandana Singhal, "Fundamentals of Electric Machines", New Age International,.2010.
3. Ashfaq Husain, Haroon Ashfaq, Electric Machines, Dhanpat Rai and Co., 3rd edition,2002.
4. Gupta J B, "Theory and Performance of Electrical Machines", S K Kataria& Sons, 14th edition, 2013.

**Course Contents and Lecture Schedule**

| Sl. No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Basics of Alternators (10 hours)** | |
| 1.1 | Principle of operation and classification of alternators, Synchronous speed. | 2 |
| 1.2 | Construction of synchronous machines. Salient and Cylindrical types, Turbo generators. Stationary and Rotating armature types. | 1 |
| 1.3 | Armature windings-Types.: Single layer, Double layer, Full pitched winding, Short pitched winding, Concentrated and Distributed winding | 1 |
| 1.4 | EMF Equation, Pitch factor and Distribution factor, Numerical problems | 3 |
| 1.5 | Harmonics in Alternators: Space and slot harmonics, Suppression, Effect of pitch factor on harmonics. | 1 |
| 1.6 | Armature Reaction, Equivalent Circuit and Phasor Diagrams, Power Flow Equations | 2 |
| **2** | **Voltage Regulation and Synchronisation of Alternators (10 hours)** | |
| 2.1 | Voltage Regulation of Alternators: EMF, MMF, Potier and ASA Method. | 4 |
| 2.2 | Blondel's Two Reaction Theory, Phasor Diagram under lagging power factor based on two reaction theory, Slip Test | 3 |
| 2.3 | Parallel Operation of Alternators, Necessity of Parallel Operation. Advantages. | 1 |
| 2.4 | Synchronisation of Alternators: Dark Lamp and Bright Lamp Method. | 2 |
| **3** | **Three Phase Synchronous and Induction Motors (10 hours)** | |
| 3.1 | Synchronous Motors-Principle, Equivalent Circuit, Phasor Diagrams, Power Flow Diagram, Power and Torque Equations, Numerical Problems | 3 |
| 3.2 | Effects of excitation on armature current and power factor- V and Inverted V Curves, advantages, disadvantages and applications of Synchronous motors. | 1 |

| | | |
|---|---|---|
| 3.3 | Three phase Induction Motors-Principle, Constructional details, Slip ring and Cage types. | 1 |
| 3.4 | Slip,frequency and rotor current, Expression for torque and Power-Starting torque, Full load and Pull out torque, Torque- Slip characteristics, Phasor diagram. | 3 |
| 3.5 | Tests on Induction motors for determination of Equivalent circuit, Equivalent Circuit of Induction motor-Numerical Problems. | 2 |
| **4** | **Three Phase Induction Motors Contd. (8 hours)** | |
| 4.1 | Circle Diagram, Numerical Problems. | 3 |
| 4.2 | Cogging, Crawling-–remedial measures, Double Cage Induction Motor-Principle. | 1 |
| 4.3 | Starters for three phase Induction Motors: DOL, Autotransformer, Star Delta and Rotor Resistance Starters. | 2 |
| 4.4 | Speed Control in Induction Motors | 1 |
| 4.5 | Braking in Induction Motors | 1 |
| **5** | **Induction Generators and Single Phase Induction Motors (7 hours)** | |
| 5.1 | Induction Generators: Grid Connected and Self Excited types. | 1 |
| 5.2 | Single phase induction motors-principle, Double field revolving theory, Torque-Slip characteristics, Applications | 2 |
| 5.3 | Types-Split phase, Capacitor Start, Capacitor Start and Run types, Shaded pole motor, Shaded Pole Motor-Principle of operation and applications. | 3 |
| 5.4 | Selection of AC motors for different Applications. | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEL508** | **MICROPROCESSORS AND MICROCONTROLLERS LAB** | **PCC** | **0** | **0** | **3** | **2** |

**Preamble** : This laboratory course is designed to train the students to familiarize and program microprocessors and microcontrollers. Students will also be introduced to a team working environment where they develop the necessary skills for planning, preparing and implementing embedded systems.

**Prerequisite** : Fundamentals of Digital Electronics and C programming

**Course Outcomes** : After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Develop and execute assembly language programs for solving arithmetic and logical problems using microprocessor/microcontroller. |
| **CO 2** | Design and Implement systems with interfacing circuits for various applications. |
| **CO 3** | Execute projects as a team using microprocessor/microcontroller for real life applications. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | 2 | 3 | - | - | 2 | 2 | 3 | - | 2 |
| **CO 2** | 3 | 3 | 2 | 2 | 3 | - | - | 2 | 2 | 3 | - | 2 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 |

**<u>ASSESSMENT PATTERN:</u>**

**Mark distribution:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| **150** | 75 | 75 | 3 hours |

**Continuous Internal Evaluation (CIE) Pattern:**

| Attendance | Regular Lab work | Internal Test | Course Project | Total |
|---|---|---|---|---|
| 15 | 30 | 25 | 5 | **75** |

Internal Test Evaluation (Immediately before the second series test)

**End Semester Examination (ESE) Pattern:**

The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks

(b) Implementing the work/Conducting the experiment : 10 Marks

(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks

(d) Viva voce : 20 marks

(e) Record : 5 Marks

**General instructions :** Practical examination is to be conducted immediately after the second series test after conducting 12 experiments from the list of experiments given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

**LIST OF EXPERIMENTS:**

**8085 Microprocessor Programming**

**1.** Data transfer using different addressing modes and block transfer.

**2.** (a) Arithmetic operations in binary and BCD: addition, subtraction, multiplication and division

(b) Logical instructions- sorting of arrays in ascending and descending order.

(c) Binary to BCD conversion and vice versa.

**8051 Microcontroller Programming**

**3.** ALP programming for

(a) Data transfer: Block data movement, exchanging data, sorting, finding largest element in an array.

(b) Arithmetic operations: Addition, subtraction, multiplication and division. Computation of square and cube of 16-bit numbers.

**4.** ALP programming for the implementation of counters: HEX up and down counters, BCD up/down counters

**5.** (a) ALP programming for implementing Boolean and logical instructions: bit manipulation.

(b) ALP programming for implementing conditional call and return instructions: Toggle the bits of port 1 by sending the values 55H and AAH continuously, Factorial of a number

**6.** ALP programming for

(a) Generation of delay

(b) Transmitting characters to a PC HyperTerminal using the serial port and displaying on the serial window

**7.** C Programs for stepper motor control.

**8.** C Programs for DC motor direction and speed control using PWM.

**9.** C Programs for Alphanumerical LCD panel/ keyboard interface.

**10.** C Programs for ADC interfacing.

**11.** Demo Experiments using 8085 Microprocessor Programming

(a) Digital I/O using PPI: square wave generation.

(b) Interfacing D/A converter- generation of simple waveforms-triangular, ramp etc.

(c) Interfacing A/D converter.

**12.** Demo Experiments using 8051 Microcontroller Programming

ALP programming for implementing code conversion– BCD to ASCII, ASCII to BCD, ASCII to decimal, Decimal to ASCII, Hexadecimal to Decimal and Decimal to Hexadecimal.

**13.** a) Familiarization of Arduino IDE

b) LED blinking with different ON/OFF delay timings with i) inbuilt LED ii) Externally

interfaced LED

**14.** Arduino based voltage measurement of 12V solar PV module/ 12V battery and displaying the measured value using I2C LCD display.

**15.** Arduino based DC current measurement using Hall-effect current sensor like LEM LA-55P sensor and displaying the value using I2C LCD module.

**16.** DC motor speed control using MOSFET driven by PWM signal from Arduino module.

**17.** Write a program on Arduino/Raspberry Pi to upload temperature and humidity data to thingspeak cloud.

**18.** Write a program on Arduino/Raspberry Pi to retrieve temperature and humidity data from thingspeak cloud.

**Mandatory Group Project Work :** Students have to do a mandatory micro project (group size not more than 3 students) to realise an embedded system for Industrial Control/ day-to-day life applications. A report also is to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

Example projects (Microcontroller based projects)

1. Temperature Monitoring and control System.
2. Home automation system
3. Remote health monitoring and emergency notification system
4. IoT based power monitoring
5. IoT based switching of power devices

**Reference Books:**


1. Ramesh Gaonkar, Microprocessor Architecture Programming and Applications, Penram International Publishing; Sixth edition, 2014.
2. Mohamed Ali Mazidi, Janice Gillispie Mazidi,” The 8051 microcontroller and embedded systems using Assembly and C”, second edition, Pearson/Prentice hall of India.
3. Kenneth. J. Ayala, The 8051 microcontroller, 3rd edition, Cengage Learning, 2010
4. Donald P. Leach, Albert Paul Malvino and Goutam Saha, Digital Principles and Applications, 8/e, by McGraw Hill.

**5.** A. P. Mathur, Introduction to Microprocessors, Tata McGraw Hill Publishing Company Limited, New Delhi.

**6.** Jeeva Jose, Internet of Things, Khanna Publishing House, Delhi

**7.** Raj Kamal, Internet of Things: Architecture and Design, McGraw Hill

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEL509** | **ELECTRICAL MACHINES LAB II** | **PCC** | **0** | **0** | **3** | **2** |

**Preamble**

The purpose of this lab is to provide practical experience in the operation and testing of synchronous and induction machines.

**Prerequisite :** Fundamentals of Electrical Engineering

**Course Outcomes:** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Analyse the performance of single phase and three phase induction motors by conducting suitable tests. |
| **CO 2** | Analyse the performance of three phase synchronous machine from V and inverted V curves. |
| **CO 3** | Analyse the performance of a three phase alternator by conducting suitable tests. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 2 | - | 3 |
| **CO 2** | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 2 | - | 3 |
| **CO 3** | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 2 | - | 3 |

**Assessment Pattern**

**Marks distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 75 | 75 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance: | 15 marks |
| Continuous Assessment: | 30 marks |
| Internal Test (Immediately before the second series test) : | 30 marks |

**End Semester Examination Pattern:** The following guidelines should be followed regarding award of marks

| | |
|---|---|
| (a) Preliminary work | 15 Marks |
| (b) Implementing the work/Conducting the experiment | 10 Marks |
| ) Performance, result and inference (usage of equipment and trouble-shooting) | 25 Marks |
| (d) Viva voce | 20 marks |
| (e) Record | 5 Marks |

**General instructions:** Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified Laboratory Record. The external examiner shall endorse the record.

## LIST OF EXPERIMENTS

(A minimum of **TWELVE** experiments are mandatory out of the fifteen listed.)

**1. Load test on a three phase Slip Ring Induction Motor**

*Objectives:*

Start the motor using auto transformer or rotor resistance starter

Plot the performance characteristics

**2. No load and block rotor tests on a three phase Squirrel Cage Induction Motor**

*tives:*

Predetermination of performance parameters from circle diagram

Determination of equivalent circuit

**3. Starting of a three phase Squirrel Cage Induction Motor using Y- ∆ Starter**

*Objectives:*

Start the motor using Y- ∆ Starter and perform load test

Plot the performance characteristics

**4. Performance characteristics of a Pole Changing Induction Motor**

*Objectives:*

Run the motor in two different pole configurations (example 4 pole and 8 pole)

Analyse the performance in the two cases by constructing circle diagrams and compare the results

**. No Load and Blocked Rotor Tests on a single phase Induction Motor**

*Objectives:*

a) Conduct no load and blocked rotor tests on the motor

b) Predetermine the equivalent circuit

**6. Load Test on a single phaseInduction Motor**

*Objectives:*

Perform load test on the motor

Plot the performance characteristics of the motor

**7. Variation of starting torque with rotor resistance in Slip-Ring Induction Motors**

*Objectives:*

Plot the variation of starting torque against rotor resistance in a three phase slip ring induction motor

Find the external rotor resistance for which maximum starting torque is obtained.

**8. V and inverted V curves of a Synchronous Motor**

*Objectives:*

Plot the V and inverted V curves of the Synchronous Motor at no load and full load.

**9. Regulation of a three phase Alternator by direct loading**

:ives:

Determine the regulation of three phase alternator

Plot the regulation versus load curve

**10. Regulation of a three phase Alternator by emf and mmf methods**

*:ives:*

Predetermine the regulation of alternator by emf and mmf methods at 0.8pf lag, upf and 0.8pf lead.

**11. Regulation of a three phase alternator by Potier method**

*Objectives:*

Synchronize the alternator by dark lamp method

Plot ZPF characteristics and determine armature reactance mmf and potier reactance

Predetermine the regulation by ZPF method

**12. Reactive power control in grid connected Alternators**

*ves:*

Synchronize the alternator by bright lamp method

Control the reactive power and plot the V and inverted V curves for generator operation

**13. Slip Test on a three phase Salient Pole Alternator**

*Objectives:*

Determine the direct and quadrature axis synchronous reactances

Predetermine the regulation at 0.8 lagging power factor

**14. V/f control of three phase Squirrel Cage Induction Motor**

*Objectives:*

Perform speed control of the given three phase induction motor by V/f control

**15. Performance characteristics of a three phase Induction Generator**

*Objectives:*

Plot the performance characteristics of the generator.

**Reference Books**

1) Bimbra P S, *Electric Machines*, Khanna Publishers, 2nd edition, 2017.

2). KothariD. P., Nagrath I. J., *Electric Machines*, Tata McGraw Hill, 5th edition, 2017.

3) Say M.G, *The Performance and Design of AC Machines*, CBS Publishers, New Delhi, 3rd edition, 2002.

4) Alexander S Langsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill, 2nd revised edition, 2001.

# SEMESTER V
# (MINOR)

| CODE 22EEMR510.1 | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | SOLID STATE POWER CONVERSION | MINOR | 3 | 1 | 0 | 4 |

**Preamble** **:**To impart knowledge about the power semiconductor devices, operation and performance of different power converters and its applications.

**Prerequisite** **:** Basic knowledge of electric circuits, and basic electronics.

**Course Outcomes** **:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the operation of various power semiconductor devices and its characteristics |
| **CO 2** | Select appropriate triggering circuit for thyristor |
| **CO 3** | Analyse the working of various power converters |
| **CO 4** | Describe the principle of operation and voltage control of inverters |
| **CO 5** | Compare the features and performance of different dc-dc Converters. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | - | 1 | - | - | - | - | - | - | - | - |
| **CO 2** | 3 | 2 | 1 | 2 | 1 | - | - | - | - | - | - | - |
| **CO 3** | 3 | 3 | - | 1 | - | - | - | - | - | - | - | - |
| **CO 4** | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| **CO 5** | 3 | 2 | 1 | 2 | - | - | - | - | - | - | - | - |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 20 | 20 | 40 |
| Apply | 20 | 20 | 40 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern** **:** There will be two parts; Part A and Part B. **Part A** contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. **Part B** contains 2 questions from each module of which student should answer anyone. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the Working of SCR, power diode, MOSFET, IGBT, TRIAC.
2. Draw the VI characteristics of different power devices

3. Draw and explain the switching characteristics of SCR.
4. Discuss the protection circuits for SCR.
5. Understand the requirements in series & Parallel operation of SCR

**Course Outcome 2 (CO2)**

1. With waveforms explain R and RC triggering circuits.
2. Explain the need and methods of electrical isolation in triggering circuits for Power Electronics

**Course Outcome 3 (CO3):**

1. Explain the working of halfwave controlled rectifier.
2. Explain the principle of operation, characteristics and performance of fully controlled and half controlled bridge converters.
3. Problems in finding the average output voltage of rectifier
4. Describe the operation of AC voltage controllers

**Course Outcome 4 (CO4):**

1. Explain the working of various inverter circuits.
2. Problems in finding the output voltage of inverter.
3. How the output voltage of an inverter can be varied
4. Explain single PWM & multiple PWM technique
5. Explain sinusoidal PWM technique.

**Course Outcome 5 (CO5):**

1. Explain the working of step down and step up choppers
2. Differentiate between first quadrant, two quadrant and four quadrant operation of choppers.
3. Describe pulse width modulation & current limit control in dc-dc converters
4. Design the value of filter inductor & capacitance in regulators

**Model Question paper**

Pages: 2

Reg. No:______________
Name:________________

**TKM COLLEGE OF ENGINEERING**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEMR510.1**

Course Name: **SOLID STATE POWER CONVERSION**

Max. Marks: 100 Duration: 3 Hrs

**PART A**

**Answer all questions. Each question carries 3 marks.**

1. Draw the circuit for two transistor analogy of silicon controlled rectifier and briefly describe the working.
2. Define holding current and latching current of SCR. Show these currents on the static VI characteristics of SCR.
3. Draw the circuit of an R-Triggering circuit for controlling the thyristor in a half wave-controlled rectifier.
4. Derive the expression for the output voltage of a single phase fully controlled bridge converter with RL load.
5. A three phase half wave converter is operated from 3–phase, 230 V, 50Hz supply with load resistance R= 10Ω. An average output voltage of 50% of the maximum possible output voltage is required. Determine the firing angle.
6. What are the two types of voltage control adopted in ac voltage controllers?
7. With the help of circuit diagram explain the working of current source inverter.
8. What is pulse width modulation? List the various PWM techniques.
9. Draw the circuit of step up chopper and explain its working.
10. A type A chopper has input voltage of 200 V. The current through a load of R=10Ω in series with L=80 mH, varies between 12 A and 16 A. Find the form factor of the output voltage waveform

**PART B**

**Answer any one full question from each module. Each question carries 14 marks.**

**Module 1**

11. a) Discuss the condition which must be satisfied for turning on the SCR with agate signal. **(7)**

    b) Explain the significance of dv/dt protection in thyristors and describe the method employed for improving the same. **(7)**

12. a) What are the steps to be employed to prevent the difficulties of parallel operation of thyristors? **(6)**

    b) Drew the structure of TRIAC and explain its principle of operation. **(8)**

## Module 2

13. a) Design an R-triggering circuit for a half wave controlled rectifier circuit for 24 V ac supply. The SCR to be used has the following data.

$I_{gmin}$ = 0.1 mA, $I_{gmax}$ = 12 mA, $V_{gmin}$ = 0.6V, $V_{gmax}$ = 1.5 V **(7)**

b) With the help of circuit diagram explain the operation of single phase semi converter with RL load. Draw the waveform of input voltage, output voltage, load current and voltage across the thyristor. **(7)**

14. a) Draw RC triggering circuit for SCR and explain with relevant wave forms. **(7)**

b) With the help of circuit diagram explain the working of single phase fully controlled converter with RL load. Draw the waveform of output voltage and output current. **(7)**

## Module 3

15. a) Sketch the waveform of input voltage, output voltage and output current of a three phase half wave controlled rectifier with R load operating at α = 30 °. **(7)**

b) A three phase half wave converter is operated from 3–phase, 400 V, 50Hz supply with load resistance R = 50 Ω. An average output voltage of 50% of the maximum possible output voltage is required. Determine the firing angle. **(7)**

16. a) Explain the basic working of a single phase dual converter. **(6)**

b) Draw the circuit of a three phase fully controlled bridge converter and draw the waveforms of input voltage, output voltage, output current and input current in any one phase. Assume resistive load and firing angle is 30 degrees. **(8)**

## Module 4

17. a) Describe the working of a three phase voltage source inverter with an appropriate circuit diagram. **(7)**

b) Explain with suitable diagram, the principle of voltage control in inverters with single pulse width modulation. **(7)**

18. Explain the 120 degree conduction mode of a three-phase bridge inverter with output voltage waveforms (phase and line), indicating the devices conducting in each state. **(14)**

## Module 5

19. a) With the help of circuit diagram and waveform explain the operation of buck converter and derive the equation of output voltage. **(7)**

b) Differentiate between PWM control and current limit control in choppers. **(7)**

20. a) Explain the working of two quadrant (class C) chopper, with relevant waveform. **(8)**

b) A step-up chopper is used to generate 220 V from 100 V dc source. The OFF period of switch is 80μs. Compute the required pulse width. **(6)**

## Syllabus

**Module 1**

Power semiconductor devices, their symbols and static characteristics, specifications of switches, steady state characteristics of Power MOSFET and IGBT.

SCR – Operation, V-I characteristics, steady state and switching characteristics, two transistor model, methods of turn-on, power diodes, operation of TRIAC, series and parallel connection of SCRs.

**Module 2**

Gate triggering circuits – R and RC triggering circuits – isolation circuits using opto-isolators and pulse transformers.

Controlled rectifiers – half-wave controlled rectifier with R load – single phase fully controlled bridge rectifier with R, RL and RLE loads (continuous conduction) – output voltage equation – single phase half controlled bridge rectifier with R, RL and RLE loads.

**Module 3**

Three phase half-wave-controlled rectifier with R load – three phase fully controlled & half-controlled converter with RLE load (continuous conduction) – output voltage equation-waveforms for various triggering angles (analysis not required) – single phase and three phase dual converter.

AC voltage controllers (ACVC) – 1-phase full-wave ACVC with R, & RL loads – waveforms – RMS output voltage, sequence control (two stage) with R load.

**Module 4**

Inverters – voltage source inverters – single phase half-bridge & full bridge inverter with R & RL loads – 3-phase bridge inverter with R load – 120° & 180° conduction mode, current source inverters.

Voltage control in inverters – Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM – modulation index & frequency modulation ratio.

**Module 5**

DC-DC converters – step down and step up choppers – single-quadrant, two-quadrant & four quadrant chopper – pulse width modulation & current limit control in dc-dc converters. Switching regulators – buck, boost & buck-boost – operation in continuous conduction mode – steady state waveforms – selection of components.

**Text Books**

Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education

2. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi

**Reference Books**

1. Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters, Applications & Design, Wiley-India
2. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998
3. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India

4. Alok Jain, Power Electronics and its Applications, Penram International Publishing (I) Ltd, 2016
5. Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Power semiconductor devices (9 hours)** | |
| 1.1 | Symbols, static characteristics and specifications of semiconductor switches. | 2 |
| 1.2 | Power diodes, power MOSFET and IGBT | 3 |
| 1.3 | SCR - VI Characteristics, Turn on methods | 1 |
| 1.4 | Structure and principle of operation of TRIAC | 1 |
| 1.5 | Series and parallel operation of SCRs | 2 |
| **2** | **Gate triggering circuits & single-phase controlled converters (9 hours)** | |
| 2.1 | R and RC triggering circuits | 3 |
| 2.2 | Isolation circuits using opto-isolators and pulse transformers | 1 |
| 2.3 | Half-wave controlled rectifier with R load | 1 |
| 2.4 | Single phase fully controlled bridge rectifier with R, RL and RLE loads | 2 |
| 2.5 | Single phase half controlled bridge rectifier with R, RL and RLE loads | 2 |
| **3** | **Three phase controlled converters & AC voltage regulator (9 hours)** | |
| 3.1 | Three phase half-wave-controlled rectifier with R load | 1 |
| 3.2 | Three phase fully controlled & half-controlled converter with RLE load | 4 |
| 3.3 | Single phase and three phase dual converter | 2 |
| 3.4 | AC voltage controllers (ACVC) | 1 |
| 3.5 | Sequence control (two stage) with R load | 1 |
| **4** | **Inverters (9 hours)** | |
| 4.1 | Single phase half-bridge & full bridge inverter with R & RL loads | 3 |
| 4.2 | Three phase bridge inverter with R load – 120° & 180° conduction mode | 2 |
| 4.3 | Current source inverters. | 1 |
| 4.4 | Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM | 3 |
| **5** | **DC-DC Converters (9 hours)** | |
| 5.1 | Principle of step down and step up choppers | 2 |
| 5.2 | Description of single-quadrant, two-quadrant & four quadrant choppers | 1 |
| 5.3 | Pulse width modulation & current limit control in dc-dc converters | 3 |
| 5.4 | Switching regulators – buck, boost & buck-boost - continuous conduction mode only | 2 |
| 5.5 | Design of filter inductance & capacitance | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEMR510.2** | **SOLAR AND WIND ENERGY CONVERSION SYSTEMS** | **MINOR** | **3** | **1** | **0** | **4** |

**Preamble** : This course introduces about solar and wind energy conversion systems. Design of wind and solar power systems are also discussed.

**Prerequisite** : **Introduction to Power Engineering/ Energy Systems**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Explain the basics of solar energy conversion systems. |
| **CO 2** | Design a standalone PV system. |
| **CO 3** | Describe different wind energy conversion systems. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | 1 | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain what do you mean by solar constant (K1)
2. Discuss about the different instruments used for measuring solar radiation and sun shine (K2)

**Course Outcome 2 (CO2):**

1. Design a standalone PV system. (K3)
2. Design a grid connected PV system. (K3)

**Course Outcome 3 (CO3):**

1. Compare the performance of different types of wind turbines. (K3).
2. Compare the performance of different types of generators used in wind turbines. (K3).

**Model Question paper**

**QP CODE:**

PAGES:2

Reg. No:_______________
Name:_______________

**TKM COLLEGE OF ENGINEERING**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEMR510.2**

**Course Name: SOLAR AND WIND ENERGY CONVERSION SYSTEMS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain briefly what do you mean by solar azimuth angle and zenith angle.
2. Differentiate between extraterrestrial and terrestrial solar radiation.
3. Write notes on the working of a solar cooker.
4. Discuss what do you mean by a solar green house.
5. Write notes on the different materials used for making solar cells.
6. Discuss the characteristics of a solar cell.
7. Differentiate between lift and drag forces.
8. Explain what do you mean by pitch control of wind turbines.
9. Write notes on the environmental impacts of wind power generation.
10. Discuss about the wind energy program in India

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a. With the help of a neat diagram, explain the working of a pyrheliometer. **(7)**
b. Explain how monthly average solar radiation on inclined surfaces can be calculated. **(7)**

12. a. State the reasons for variation in the amount of solar energy reaching earth surface. **(4)**
b. With the help of a neat diagram, explain the working of a sunshine recorder. **(6)**
c. Explain the difference in the working of pyrheliometer and pyranometer. **(4)**

**Module 2**

13. a. Explain the different types of solar collectors based on the way they collect solar radiation. **(7)**
b. Explain in detail, the working of a solar air conditioning system **(7)**

14. a. With the help of a diagram, explain the function of different components of a flat plate solar collector. **(7)**

b. Design a solar water heater for domestic application. **(7)**

**Module 3**

15. a. Write notes on the efficiency of a solar cell. **(3)**
b. Discuss the effect of shadowing on the performance of solar cells. **(3)**
c. Explain how maximum power point tracking can be done using buck-boostconverter. **(8)**

16. a. Compare the performance of single junction and multijunction PV modules. **(4)**

b. Write notes on packing factor of a PV module. **(3)**

c. Explain with a neat sketch, the working principle of a grid connected solar system. **(7)**

**Module 4**

17. a. Discuss the application of Weibull distribution in wind power generation **(3)**
b. Explain the characteristics of a wind turbine. **(4)**
c. Explain the different modes of wind power generation. **(7)**

18. a. Compare the performance of different types of wind turbines **(6)**

b. Derive an expression for wind turbine power. **(4)**

c. What do you mean by Betz's Law? Why wind turbines are not 100% efficient? **(4)**

**Module 5**

19. a. With the help of a diagram, explain the working of a wind energy conversion system. **(7)**
b. Compare the performance of different types of generators used in wind mills. **(7)**

20. a. With the help of a diagram, explain the working of a variable speed constant frequency wind energy conversion system. **(7)**
b. Discuss about the different types of converter used in renewable energy systems. **(7)**

## Syllabus

### Module 1

Introduction - Basic Concept of Energy -Source of Solar Energy -Formation of the Atmosphere - Solar Spectrum. Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer –Pyranometer -Sunshine Recorder -Solar Radiation on a Horizontal Surface - Extraterrestrial Region.-Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors -Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces .

### Module 2

Solar Thermal system-Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) –performance evaluation. Applications -Solar heating system, Air conditioning and Refrigeration system, Pumping system, solar cooker, Solar Furnace, Solar Greenhouse -Design of solar water heater

### Module 3

Solar PV Systems-Introduction -Fundamentals of Semiconductor and Solar Cells -Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials-.Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III-V Single Junction and Multijunction PV Modules-Emerging and New PV Systems -Packing Factor of the PV Module - Efficiency of the PV Module -Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules.- Effect of shadowing-Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected -Design steps for a Stand-Alone system –Storage batteries and Ultra capacitors.

### Module 4

Wind Turbines - Introduction -Origin of Winds- Nature of Winds – Classification of Wind Turbines -Wind Turbine Aerodynamics - Basic principles of wind energy extraction – Extraction of wind turbine power(Numerical problems)- Weibull distribution-Wind power generation curve-Betz’s Law-Modes of wind power generation.

### Module 5

Wind Energy Conversion Systems-Introduction-Components of WECS - Fixed speed drive scheme- Variable speed drive scheme - Wind–Diesel Hybrid System –Induction generators-Doubly Fed Induction Generator(DFIG)-Squirrel Cage Induction Generator(SCIG)-Power converters in renewable energy system-AC-DC Converters, DC-DC Converters, DC-AC Converters(Block Diagram Only)-Effects of Wind Speed and Grid Condition (System Integration) -Environmental Aspects -Wind Energy Program in India

### References:


1. A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977
2. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
3. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978
4. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers,2002

5. J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994.
6. Siraj Ahmed, *Wind Energy- Theory and Practice*, Prentice Hall of India, New Delhi,2010
7. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd Renewable energy systems, Pearson 2017
8. D. P. Kothari, S. Umashankar, Wind Energy Systems and Applications, Narosa publishers,2017
9. G. N. Tiwari,ArvindTiwari,Shyam, Handbook of Solar Energy: Theory, Analysis and Applications, springer,2016.
10. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
11. D.P.Kothari, K.C.Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009.
12. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999.
13. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
14. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
15. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001.
16. Boyle G. (ed.), Renewable Energy -Power for Sustainable Future, Oxford University Press, 1996.
17. Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy –Sources for Fuel and Electricity, Earth scan Publications, London, 1993.

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Solar energy (8 hours)** | |
| 1.1 | Introduction - Basic Concept of Energy -Source of Solar Energy - Formation of the Atmosphere - Solar Spectrum. | 2 |
| 1.2 | Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer –Pyranometer - Sunshine Recorder | 2 |
| 1.3 | Solar Radiation on a Horizontal Surface –Extraterrestrial Region.-Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors | 2 |
| 1.4 | Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces. | 2 |
| **2** | **Solar Thermal Systems (8 hours)** | |
| 2.1 | Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics | 1 |
| 2.2 | Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) –performance evaluation. | 2 |
| 2.3 | Applications -Solar heating system, Air conditioning and Refrigeration system | 1 |
| 2.4 | Pumping system, solar cooker, Solar Furnace, Solar Greenhouse | 2 |

| | | |
|---|---|---|
| 2.5 | Design of solar water heater | 2 |
| **3** | **Solar PV systems (8 Hours)** | |
| 3.1 | Introduction -Fundamentals of Semiconductor and Solar Cells - Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials | 2 |
| 3.2 | Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III-V Single Junction and Multijunction PV Modules -Emerging and New PV Systems | 1 |
| 3.3 | Packing Factor of the PV Module - Efficiency of the PV Module -Energy Balance Equations for PV Modules | 1 |
| 3.4 | Series and Parallel Combination of PV Modules.- Effect of shadowing-Maximum Power Point Tracker (MPPT) using buck-boost converter. | 2 |
| 3.5 | Solar PV Systems –stand-alone and grid connected -Design steps for a Stand-Alone system –Storage batteries and Ultra capacitors. | 2 |
| **4** | **Wind energy (9 Hours)** | |
| 4.1 | Wind Turbines - Introduction -Origin of Winds- Nature of Winds | 1 |
| 4.2 | Classification of Wind Turbines -Wind Turbine Aerodynamics - Basic principles of wind energy extraction | 2 |
| 4.3 | Extraction of wind turbine power(Numerical problems) | 2 |
| 4.4 | Weibull distribution-Wind power generation curve - Betz’s Law | 2 |
| 4.5 | Modes of wind power generation. | 2 |
| **5** | **Wind energy conversion systems (9)** | |
| 5.1 | Introduction-Components of WECS - Fixed speed drive scheme- Variable speed drive scheme | 2 |
| 5.2 | Wind–Diesel Hybrid System –Induction generators-Doubly Fed Induction Generator(DFIG)-Squirrel Cage Induction Generator(SCIG) | 3 |
| 5.3 | Power converters in renewable energy system-AC-DC Converters, DC-DC Converters, DC-AC Converters(Block Diagram Only) | 2 |
| 5.4 | Effects of Wind Speed and Grid Condition (System Integration) - Environmental Aspects -Wind Energy Program in India | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEMR510.3 | CONTROL SYSTEMS | MINOR | 3 | 1 | 0 | 4 |

**Preamble** : This course deals with the fundamental concepts of control systems theory. Modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach are discussed. The state space concept is also introduced.

**Prerequisite** : **Basics of Dynamic Circuits and Systems**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Describe the role of various control blocks and components in feedback systems |
| **CO 2** | Analyse the time domain responses of the linear systems |
| **CO 3** | Apply Root locus technique to assess the performance of linear systems |
| **CO 4** | Analyse the stability of the given LTI systems. |
| **CO 5** | Apply state variable concepts to assess the performance of linear systems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | - | - | - | - | - | - | - | - | - | 3 |
| **CO 2** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 3 |
| **CO 3** | 3 | 3 | 3 | - | 2 | - | - | - | - | - | - | 3 |
| **CO 4** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | 3 |

**Assessment Pattern:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 10 | 10 | 20 |
| Apply (K3) | 30 | 30 | 60 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

**Part B** contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

**Course Level Assessment Questions:**

**Course Outcome 1 (CO1)**

1. Derive and explain the transfer function of field controlled dc servo motor.
2. With the help of suitable example explain the need for analogous systems.
3. Explain how does the feedback element affect the performance of the closed loop system?

**Course Outcome 2 (CO2):**

4. Obtain the different time domain specification for a given second order system with impulse input and assess the system dynamics.
5. Determine the value of the natural frequency of oscillation $\omega_n$ for the unity feedback system with forward transfer function $G_p(s) = \frac{K}{s(s+10)}$, which results in a critically damped response.
6. Problems related to static error constant and steady state error for a given input.

**Course Outcome 3 (CO3):**

1. Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s\,(s+1)\,(s+4)}$ is oscillatory, using Root locus.
2. Construct the Root locus for the closed loop system with $G(s)H(s) = \frac{K}{s\,(s^2+3s+2)}$. Determine the value of K to achieve a damping factor of 0.5?
3. Problem on root locus for systems with positive feedback.

**Course Outcome 4 (CO4):**

4. Problems related to application of Routh's stability criterion for analysing the stability of given system.
5. Determine the value of K such that the gain margin for the system with $G(s)H(s) = \frac{K}{s\,(s+2)\,(s+5)}$ equals to 10 dB.
6. Problem related to the analysis of given system using Polar plot.

**Course Outcome 5 (CO5):**

1. Determine the transfer function of the system given by:

system with state model:

$$\dot{X} = \begin{bmatrix} -2 & 1 \\ -1 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u; \quad y = \begin{bmatrix} 0 & 1 \end{bmatrix} x \cdot$$

2. Obtain the time response y(t) of the homogeneous system represented by:

$$\begin{bmatrix} \dot{X} \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad [y] = [1 \quad 0][X] \text{ with } x(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$$

3. Derive and analyse the state model for a field controlled dc servo motor.

**Model Question Paper** PAGES: 3

**QP CODE:**

Reg. No:____________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

Course Code**: 22EEMR510.3**

Course Name: **CONTROL SYSTEMS**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

Give a comparison between open loop and closed loop control systems with suitable examples.

. With relevant characteristics explain the operation of a tacho generator as a control device.

. For a closed loop system with $G(s) = \frac{3}{s\,(s+2)}$; and H(s) = 0.1, calculate the steady state error constants.

. Check the stability of the system given by the characteristic equation, $G(s) = s^5 + 2s^4 + 4s^3 + 8s^2 + 16s + 32$; using Routh criterion.

. With suitable sketches explain how addition of zeroes to the open-loop transfer function affects the root locus plots.

. Explain Ziegler – Nichol's PID tuning rules.

. Explain the features of Non-minimum phase systems with a suitable example.

. How do you determine the gain margin of a system, with the help of Bode plot?

. A system is represented by $\frac{Y(s)}{U(s)} = \frac{3}{(s+1)(s+2)}$. Derive the Canonical diagonal form of representation in state space.

0. Discuss the advantages of state space analysis.

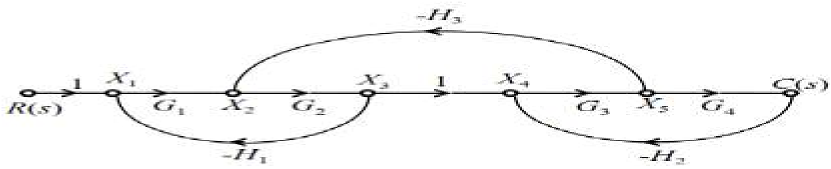
**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

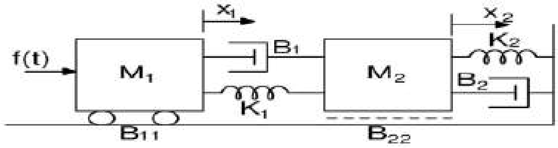
Derive the transfer function of an Armature controlled dc servo motor. Assess the effect of time constants on the system performance. **(8)**

Determine the transfer function of the system represented by the signal flow graph using Mason's gain formula.




**(6)**

Derive the transfer function $X_2(s)/\ F(s)$ for the mechanical system.




**(9)**

Compare the effect of H(s) on the pole-zero plot of the closed loop system with $G(s) = \frac{s+1}{(s^2 + 5s + 6)}$ with: i) derivative feed back H(s)= s; ii) integral feedback H(s)=1/s. **(5)**

**Module 2**

Derive an expression for the step response of a critically damped second order system? Explain the dependency of maximum overshoot on damping factor. **(9)**

Determine the value of gain K and the natural frequency of oscillation $\omega_n$ for the unity feedback system with forward transfer function $G(s) = \frac{K}{s(s+6)}$, which results in a critically damped response when subjected to a unit impulse input.

Also determine the steady state error for unit velocity input. **(5)**

A unity feedback system is characterized by an open loop transfer function $G(s) = \frac{4}{(s^2 + s + 5)}$. Determine the transient response when subjected to a unit step input and sketch the response. Evaluate the rise time and peak time of the system. . **(9)**

Using Routh criterion determine the value of K for which the unity feedback closed loop system with $G(s) = \frac{K}{s(s^2 + 3s + 1)}$ is stable. . **(5)**

**Module 3**

Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s\ (s+2)\ (s+5)}$ is oscillatory, using Root locus.
Also determine the value of K to achieve a damping factor of 0.866. **(10)**

Compare between PI and PD controllers. **(4)**

Sketch the root locus for a system with $G(s)H(s) = \frac{K(s-1)}{s(s+4)}$. Hence determine the range of K for the system stability. **(9)**

With help of suitable sketches, explain how does Angle and Magnitude criteria of Root locus method help in control system design. **(5)**

**Module 4**

The open-loop transfer function of a unity feedback system is G(s)=$\frac{K}{s(0.5s+1)(0.04s+1)}$.Use asymptotic approach to plot the Bode diagram and determine the value of K for a gain margin of 10 dB. **(10)**

Derive and explain the dependence of resonant peak on damping factor**.** **(4)**

Draw the polar plot for the system with $G(s)H(s) = \frac{K}{s(s+0.5)(s+2)}$ and determine the value of K such that phase margin equals to $40^o$. **(9)**

Explain the detrimental effects of transportation lag using Bode plot. **(5)**

## Module 5

Obtain the time response y(t) of the homogeneous system represented by:

$$\begin{bmatrix} \dot{X} \end{bmatrix} = \begin{bmatrix} -1 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad [y] = [1 \quad 0][X] \text{ with } x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$ **(6)**

Derive and analyse the state model for a field controlled dc servo motor **(8)**

A system is represented by $\frac{Y(s)}{U(s)} = \frac{4(s+0.5)}{(s+1)(s+2)}$. Derive the phase variable representation in state space. **(5)**

Derive the transfer function for the system with

$$\begin{bmatrix} \dot{X} \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 2 \\ -12 & -7 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} u; \quad [y] = [1 \quad 0 \quad 0][X]$$ **(9)**

## Syllabus

**Module 1**

**System Modeling (8 hours)**

Open loop and closed loop control systems

Transfer function of LTI systems- Electrical, translational and rotational systems – Force voltage and force current analogy

Block diagram representation - block diagram reduction

Signal flow graph - Mason's gain formula

Control system components: Transfer functions of DC and AC servo motors– Control applications of Tacho generator and Stepper motor.

**Module 2**

**Performance Analysis of Control Systems (12 hours)**

Characteristic equation of Closed loop systems- Effect of feedback-.

Time domain analysis of control systems: Time domain specifications of transient and steady state responses- Impulse and Step responses of first order and second order systems.

Error analysis: Steady state error analysis - static error coefficients of type 0,1,2 systems.

Stability Analysis: Concept of stability- BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems - Routh's stability criterion- analysis - relative stability

**Module 3**

**Root Locus Analysis and Compensators (8 hours)**

Root locus technique: General rules for constructing Root loci – stability from root loci -

Effect of addition of poles and zeros on Root Locus- Effect of positive feedback systems on Root Locus

Need for controllers: Types- Feedback, cascade and feed forward controllers

PID controllers (basic functions only)- Zieglar Nichols PID tuning methods

*Introduction to MATLAB functions and Toolbox for Root locus based analysis (Demo/Assignment only)*)

**Module 4**

**Frequency Domain Analysis (9 hours)**

Frequency domain specifications- correlation between time domain and frequency domain responses

Polar plot: Concepts of gain margin and phase margin- stability analysis

Bode Plot: Construction of Bode plots- Analysis based on Bode plot

Effect of Transportation lag and Non-minimum phase systems

*Introduction to MATLAB functions and Toolbox for various frequency domain plots and analysis (Demo/Assignment only)*.

**Module 5**

**State Space Analysis of Systems (10 hours)**

Introduction to state space and state model concepts- state equation of linear continuous time systems, matrix representation- features -Examples of simple electrical circuits, and dc servomotor.

Phase variable forms of state representation- controllable and observable forms- Diagonal Canonical forms - Jordan canonical form

Derivation of transfer function from state equations.

State transition matrix: Properties of state transition matrix- Computation of state transition matrix using Laplace transform- Solution of homogeneous systems

**Textbooks**

5. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
6. Ogata K, Modern Control Engineering, 5/e, Prentice Hall of India.
7. Nise N. S, Control Systems Engineering, 6/e, Wiley Eastern
8. Dorf R. C. and Bishop R. H, Modern Control Systems, 12/e, Pearson Education
9. K R Varmah, Control Systems, Tata McGrawHill, 2010

**Reference Books**

1. Kuo B. C, Automatic Control Systems, 7/e, Prentice Hall of India
2. Desai M. D., Control System Components, Prentice Hall of India, 2008
3. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill.
4. Imthias Ahamed T. P, Control Systems, Phasor Books, 2016
5. Gopal M., Modern Control System Theory, 2/e, New Age Publishers

**Course Contents and Lecture Schedule:**

| Module | Topic coverage | No. of Lectures |
|---|---|---|
| **1** | **System Model (8 hours)** | |
| 1.1 | Open loop and closed loop control systems | 1 |
| 1.2 | Transfer function of LTI systems- Electrical, translational and rotational systems – Force voltage and force current analogy | 2 |
| 1.3 | Block diagram representation - block diagram reduction | 2 |
| 1.4 | Signal flow graph - Mason's gain formula | 1 |
| 1.5 | Control system components: Transfer functions of DC and AC servo motors –Control applications of Tacho generator and Stepper motor. | 2 |
| **2** | **Performance Analysis of control systems (10 hours)** | |
| 2.1 | Characteristic equation of CL systems- Effect of feedback | 1 |
| 2.2 | Time domain analysis of control systems:<br>Time domain specifications of transient and steady state responses,<br>Impulse and Step responses of first order systems,<br>Impulse and Step responses of second order systems. | 3 |
| 2.3 | Error analysis:<br>Steady state error analysis - static error coefficients of type 0, 1, 2 systems. | 2 |
| 2.4 | Stability Analysis:<br>Concept of stability- BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems | 2 |
| 2.5 | Routh criterion:<br>Routh's stability criterion- analysis - relative stability | 2 |
| **3** | **Root locus Analysis and Compensators (8 hours)** | |
| 3.1 | Root locus technique:<br>General rules for constructing Root loci - stability from root loci - | 3 |
| 3.2 | Effect of addition of poles and zeros on Root Locus. | 1 |
| 3.3 | Effect of positive feedback on Root Locus | 1 |
| 3.4 | Need for controllers:<br>Types- Feedback, cascade and feed forward controllers | 1 |
| 3.5 | PID controllers**:**<br>PID controllers (basic functions only)- Zieglar Nichols tuning methods | 2 |

| | | |
|---|---|---|
| 3.6 | *Introduction to MATLAB functions and Toolbox for Root locus based analysis (Demo/Assignment only)* | |
| **4** | **Frequency domain analysis (9 hours)** | |
| 4.1 | Frequency domain specifications- correlation between time domain and frequency domain responses | 2 |
| 4.2 | Polar plot: Concepts of gain margin and phase margin- stability analysis | 2 |
| 4.3 | Bode Plot: Construction of Bode plots- Analysis based on Bode plot | 4 |
| 4.4 | Effect of Transportation lag and Non-minimum phase systems | 1 |
| 4.5 | *Introduction to MATLAB functions and Toolbox for various frequency domain plots and analysis (Demo/Assignment only)* | |
| **5** | **State space Analysis of systems (10 hours)** | |
| 5.1 | Introduction to state space and state model concepts- state equation of linear continuous time systems, matrix representation- features -Examples of simple electrical circuits, and dc servomotor. | 3 |
| 5.2 | Phase variable forms of state representation-controllable and observable forms | 2 |
| 5.3 | Diagonal Canonical forms of state representation- diagonal & Jordan canonical forms | 2 |
| 5.4 | Derivation of transfer function from state equation. | 1 |
| 5.5 | State transition matrix:<br>Properties of state transition matrix- Computation of state transition matrix using Laplace transform- Solution of homogeneous systems | 2 |

# SEMESTER V
# (HONOUR)

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEHR511.1** | **DIGITAL SIMULATION** | **HONOURS** | **3** | **1** | **0** | **4** |

**Preamble** : Numerical simulation using digital computers is an indispensable tool for electrical engineers. This honors course is designed with the objective of providing a foundation to the theory behind Numerical Simulation of electrical engineering systems and to give an overview of different styles of simulation tools and methodologies. This course would help students to explore and effectively use simulation tools with a clear understanding of their inner engines. This course also prepares students to explore and use the industry-standard tools like MATLAB and SPICE.

**Prerequisites** : **1. EET201 Circuits and Networks**

**2. EET 205: Analog Electronics**

**3. MAT 204: Probability, Random Processes and Numerical Methods**

**Course Outcomes** : After the successful completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Formulate circuit analysis matrices for computer solution. |
| **CO 2** | Apply numerical methods for transient simulation. |
| **CO 3** | Develop circuit files for SPICE simulation of circuits. |
| **CO 4** | Develop MATLAB/Simulink programs for simulation of simple dynamic systems. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | 2 | 3 | | | | | | | 2 |
| **CO 2** | 3 | 3 | | 2 | 3 | | | | | | | 2 |
| **CO 3** | 3 | 3 | | 2 | 3 | | | | | | | 2 |
| **CO 4** | 3 | 3 | | 2 | 3 | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 15 | 15 | 20 |
| Understand (K2) | 20 | 20 | 50 |
| Apply (K3) | 15 | 15 | 30 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

Problems on Circuit Analysis Matrix Formulation for Computer Solution (MNA and Sparse Tableau Approach) - K1 and K2 Level questions to be asked.

Writing code snippets in pseudo codes/Flow - charts for simple circuit formulations - K2, K3 Level.

**Course Outcome 2 (CO2):**

Explain the features of different numerical algorithms with respect to the requirements of circuit simulation: Questions in K1, K2 and K3 Level.

Compare the features of numerical simulation algorithms.  Numerical problems and questions in K1, K2 and K3 levels.

Explain the application-specific features of numerical methods in circuit simulation: Adaptive Step-Size, Artificial Ringing and damping - K1 and K2 level questions.

**Course Outcome 3 (CO3):**

Write circuit files for simple analogue passive and active circuits using standard SPICE notation. K1, K2 and K3 Level questions.

**Course Outcome 4 (CO4):**

Develop MATLAB scripts for solution of simple ODEs  - K2, K3 level questions.

Develop Simulink signal-flow diagrams for simulation of second order, first-order passive networks.  K2, K3 Level question.

**Model Question paper**

QP CODE: PAGES: 4

Reg. No:______________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEHR511.1**

**Course Name: DIGITAL SIMULATION**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Differentiate between DC simulation and Transient Simulation.
2. What is “convergence issue” in circuit simulation?
3. Differentiate between implicit and explicit numerical methods.
4. Define Local Truncation Error.
5. What is a “stiff system”? Give an example.
6. It is required to simulate a circuit with excessively oscillatory response. Out of Euler method and Trapezoidal method, which is suitable for this system, and why?
7. Write the SPICE circuit file to run the transient simulation of an RC circuit excited by a pulse source of amplitude 5 V and frequency 1 kHz. The RC time constant is 0.1 ms (You may choose any R, C values that satisfy this requirement). Use end time of 1 s. Assume any missing information appropriately.
8. Differentiate between ‘ .lib’ and ‘.inc' SPICE directives?
9. What is the output of the following MATLAB code:?

```
b = [3 8 9 4 7 5];
sum1 = 0;
for k = 1:4
        sum1 = sum1+b(k);
        end
sum1
```

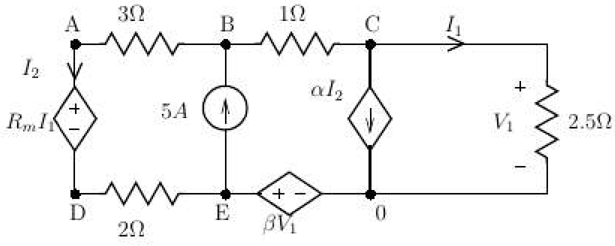
10. Write a MATLAB function to accept the coefficients of a quadratic polynomial and return the evaluated roots.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 marks.**

**Module 1**

11. (a).Figure 1 shows a network, with α=2, β=0.4 and $R_m$= 1 Ω. Formulate the Modified Nodal Analysis matrix from fundamental equations. (10)




(b). Explain how 'damping' can be used to improve convergence in nonlinear equation solutions using Newton-Raphson method. (4)

12. (a). For the circuit shown in Fig. 2, formulate the Sparse Tableau Analysis (STA) matrix from the fundamental equations. Take α=0.5. (10)

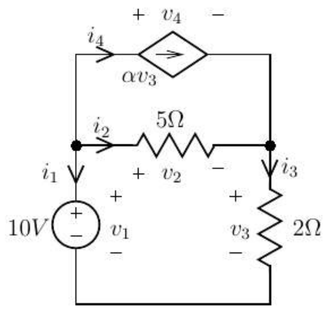



Figure 2: $\alpha = 0.5$

(b). What is Sensitivity Analysis? Explain with an example. (4)

**Module 2**

13. Solve

$\frac{dx}{dt} = -\frac{1}{2}x - 6te^{-t/2}$, $0 < t < 20$, $x_0$=3, for h = 0.01 and h= 0.05 using Trapezoidal method and forward Euler methods. Compare with the analytical solution $\hat{x}(t) = (2 - 3t^2)e^{-t/2}$. Find the global error at the final value. (14)

14. (a) What is 'Order' of a numerical method? Explain how order and step-size influence the accuracy and computational efficiency of numerical methods. (8)

(b). What are the sources of error in numerical methods? (6)

**Module 3**

15. Write the MNA equations for the circuit shown in Fig. 3 below: Apply Trapezoidal method on the resulting equations to obtain the corresponding numerical equations. (14)

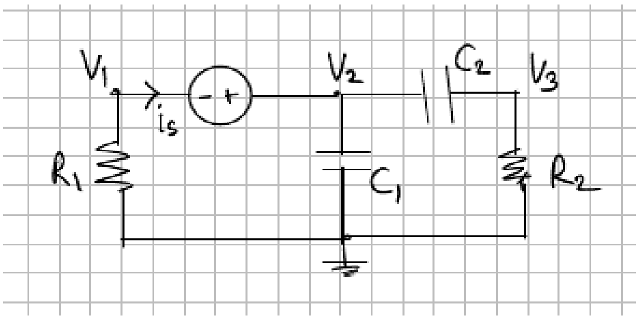



Fig. 3.

16. (a). Explain adaptive step-size in numerical simulation. What methodologies are used for adaptive step-size simulation? (10)

(b). What is 'artificial damping'? Explain with an example. (4)

**Module 4**

17. (a). Explain the use of .SUBCKT with an example, where the sub-circuit is an RC integrator circuit to be used in cascade with an RC differentiating circuit. The source is a pulse source of 5 V amplitude and 1 kHz frequency. Assume suitable values for the resistors and capacitors. Use an ideal pulse with no rise time, fall-time, delay time etc. Under what conditions/circumstances do you use a .MODEL instead of a .SUBCKT in a circuit simulation? (8)

(b). Write the circuit file for an RC coupled amplifier with npn transistors. Use suitable values for the circuit parameters. The simulation is to be set up for frequency response analysis. (6).

18. (a). Shown below is a SPICE circuit file/netlist. Inspect the circuit file description and draw the circuit. What kind of simulation is being intended here? Modify this with the source replaced by a single sine wave source of 1kHz and 0.5 mA amplitude, for a transient simulation with end time of 0.1 sec, and a maximum step size of 1 us. (8)

```
L1 OUT 0 1µ
C1 OUT 0 420p
L2 IN 0 1µ
C2 IN 0 420p
C3 OUT IN {C}
R1 OUT 0 300
I1 0 IN 0 AC 5m
R2 IN 0 300
.ac oct 200 5Meg 10Meg
.step param C 50p 150p 50p
.end
```

(b). Demonstrate the use of the SPICE directives: “.OP, .PARAM, and .IC” with suitable examples. (6).

**Module 5**

19. (a)Write a MATLAB function to solve an initial value problem given by: $\dot{x}=x-t^2+1;\ 0\leqslant t\leqslant 2;\ x(0)=0.5$, using the Trapezoidal method. The function should get the initial value, final value and the step through arguments. Modify this code to solve any general function described in another file, named fx.m? (8)

(b). Develop the simulation signal-flow diagram for the simulation of a parallel RLC network excited by a current source, from the fundamental equations. Use standard blocks such as gain, sum/difference, integrators etc. (6)

20. Develop a simulation (signal-flow) diagram for a DC series motor fed from a dc voltage source and connected to a mechanical load. Take $k_b$ as the back-emf constant and $k_t$ as the torque constant of the motor, $R_a$ the armature resistance, $L_a$ the armature inductance, $R_f$, $L_f$ are the field resistance and inductance respectively, J is the combined moment of inertia, and B is the viscous friction constant. The simulation diagram should show how the armature current $i_a$ and the speed $\omega$ are derived. Show all the relevant equations from which the diagram is derived. (14)

## Syllabus

## Overview

**Module 1 (9 Hrs)**

**Introduction to Simulation:**

Types of simulation problems - DC Simulation - Transient Simulation - AC Simulation - Digital Circuit Simulation - Sensitivity Analysis - Noise Analysis. Examples.

**Problem formulation for circuit simulation:**

Nodal Analysis - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix.

Modified Nodal Analysis (MNA) - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course projects may be assigned for writing code to formulate the Matrix using any high-level language). Formulation Examples.

Sparse Tableau Approach - Formulation of STA matrix. Features and comparison with MNA approach. Formulation Examples.

Non-linear Circuits: Application of the Newton-Raphson method - General procedure for n-th order system of equations - Formulation of Jacobian - Examples - Resources required for simulation: Computation time.

Convergence issues -

Practical Limits due to finite precision. Damping.

(Assignments/Course projects may be given for writing code to formulate the Matrix using any high-level language/pseudo code).

**Module 2 (7 hours)**

**Fundamental Theory behind Transient Simulation:**

Introduction to transient simulation: Discretization of time, idea of time - step. - Review of backward Euler, forward Euler and trapezoidal methods.

Basic ideas of Accuracy and Stability (Qualitative description only) of methods of transient analysis using numerical techniques.

Basic ideas of Explicit and Implicit methods:

Concept of ‘order’ of a numerical method, Local Error (LE), Local Truncation Error (LTE) and Global Error. (No detailed derivations needed).

**Module 3:** (9 hours)

**Application to Circuit Simulation:**

Application to circuit simulation: Using BE and TRZ methods. - Second order Backward Difference Formula (BDF-2/Gear Formula, no derivation required). Equivalent Circuit Approach- Stiff systems - Features - Simple Examples.

Basic ideas behind Adaptive/variable step-size. (Qualitative treatment only).

Practical aspects in choosing numerical methods: Artificial damping and ringing induced by numerical algorithms - Assessment of accuracy -- The issue of Singular Matrix in initial/start-up condition.

**Module 4**

**Introduction to SPICE: (10 Hrs).**

Types of simulation tools: Circuit simulation tools: SPICE, equation solvers: MATLAB®/Scilab®/Octave - Features, similarities and differences.

Circuit Simulation using SPICE.

Writing SPICE circuit files: SPICE Syntax - SPICE directives ( Dot commands: .END, .FUNC, .NET .OPTIONS )

Performing different kinds of simulation and analysis - DC, DC sweep, AC, Transient and noise analyses. (Use of .OP, .PARAM, .TRAN, .DC, .STEP, .IC .MEASURE, .FOUR, .NOISE, .TEMP, .WAVE)

Developing circuit files for simple circuits like CE amplifiers, passive linear/non-linear circuits (Familiar Circuits with R, L, C, Diodes, Transistors).

Developing component models, subcircuits in SPICE. (Use of .MODEL, .SUBCKT, .LIB, .INC, .ENDS directives) - examples (BJTs/MOSFETs).

Simulation Demonstration with simple circuits. Setting-up simulation , and different types of simulation etc. shall be demonstrated by the course instructor.

*[LTspice®, a free SPICE version, is chosen here as reference due to wide availability, however, PSpice®, LTspice®, ngSpice, eSim or any available SPICE variants may be used for assignments/demonstrations, based on availability].*

**Module 5**

**Introduction to equation solver tools** (10 Hrs)

Introduction to scripting using MATLAB®: Language constructs - Basic Arithmetic Operations - Basic Operators and Special Characters Variables and Arrays - Complex numbers -Basic Handling of Arrays (Vectors and Matrices).

Control Structures (Conditional, looping - for loop, while loop, switch-case-otherwise - break -return) - functions.

Numerical Integration - ODE solvers - ode23, ode23t and ode45 - Examples - User-written functions to solve ODEs to implement the algorithms BE, FE, and TRZ only). Application examples. (Performance comparison of different solvers may be given as assignments).

Visual Modelling: Introduction to Simulink/Similar Causal modelling tools. Developing causal simulation diagrams using fundamental blocks (Gain, sum/difference, integrators, etc) for simple circuit models - first-order/second-order circuits, Separately excited DC Motor, from the ODE descriptions. Non-linear examples: DC Series Motor, Simple passive networks with switches.

Simulation Demonstration with different integration algorithms /step-sizes. [Only for practice/assignments].

(Instead of MATLAB/Simulink®, Octave and Scilab®/XCos® may be used for assignments/demonstrations).

**Text Books**


1. M. B. Patil, V. Ramanarayanan and V. T. Ranganathan, “Simulation of Power Electronic Circuits”, Narosa Publishing House.
2. Steven C. Chapra and Raymond P. Canale, “Numerical Methods for Engineers”, Tata-McGraw Hill, New Delhi, 2000.
3. Rudra Pratap, “Getting Started with MATLAB®: A Quick Introduction for Scientists & Engineers”, 2010, Oxford University Press.


**References**


1. LTSpice® [Online] http://www.ltwiki.org
2. MATLAB® [Online] https://in.mathworks.com/help/matlab/
3. Won Y. Yang, Wenwu Cao, Tae-Sang Chung and John Morris, “Applied Numerical Methods Using MATLAB®”


**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to Simulation and Problem Formulation. (9 Hrs).** | |
| 1.1 | Types of simulation problems - DC Simulation - Transient Simulation - AC Simulation - Digital Circuit Simulation - Sensitivity Analysis - Noise Analysis. Examples. | 2 |
| 1.2 | Problem formulation for circuit simulation:<br><br>Nodal Analysis - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course | 1 |

| | | |
|---|---|---|
| | projects may be assigned for writing code to formulate the Matrix using any high-level language). | |
| 1.3 | Modified Nodal Analysis (MNA) - General Rules/Steps to form the admittance matrix. Sample problems on formulation of the matrix. (Assignments/Course projects may be assigned for writing code to formulate the Matrix using any high-level language). Examples. | 2 |
| 1.4 | Sparse Tableau Approach - Formulation of STA matrix. Features and comparison with MNA approach. Examples. | 1 |
| 1.5 | Non-linear Circuits: Application of the Newton-Raphson method - General procedure for n-th order system of equations - Formulation of Jacobian - Examples - Resources required for simulation: Computation time. | 2 |
| 1.6 | Convergence issues - Limits due to finite precision. Damping. | 1 |
| **2** | **Fundamental Theory behind Transient Simulation: (7 Hrs).** | |
| 2.1 | Introduction to transient simulation: Discretization of time, idea of time - step. - Review of backward Euler, forward Euler and trapezoidal methods. | 1 |
| 2.2 | Basic ideas of Accuracy and Stability of methods of transient analysis using numerical techniques. | 1 |
| 2.3 | Basic ideas of Explicit and Implicit methods: | 1 |
| 2.4 | Concept of Order of a numerical method, Local Error (LE), Local Truncation Error (LTE) and Global Error. | 4 |
| **3.** | **Application to Circuit Simulation (9 Hrs)** | |
| 3.1 | Application to circuit simulation: Using Backward Euler, Trapezoidal and Second order backward differentiation formula (BDF2 - Gear's formula) methods in circuit simulation: Equivalent Circuit Approach - Equation formulation examples. | 4 |
| 3.2 | Stiff systems - Features - Examples. | 1 |
| 3.3 | Basic ideas behind Adaptive/variable step-size. (Qualitative treatment only). | 1 |
| 3.4 | Practical aspects in choosing numerical methods: Artificial damping and ringing induced by numerical algorithms. | 1 |
| 3.5 | Assessment of accuracy - The issue of Singular Matrix in initial/start-up condition. | 2 |
| **4** | **Introduction to SPICE: (10 Hrs)** | |

| | | |
|---|---|---|
| 4.1 | Types of simulation tools: Circuit simulation tools: SPICE, equation solvers: MATLAB®/Scilab®/Octave - Features, similarities and differences. | 1 |
| 4.2 | Circuit Simulation using SPICE.<br><br>Writing SPICE circuit files: SPICE Syntax - SPICE directives ( Dot commands: .end, .FUNC, .NET .OPTIONS ) | 2 |
| 4.3 | Performing different kinds of simulation - DC, DC sweep, AC, Transient and noise analyses. (.op, .param, .tran, .dc, .STEP, .IC .MEASURE, .FOUR, .NOISE, .TEMP, .WAVE | 2 |
| 4.4 | Developing simple circuit files for sample circuits like CE amplifier, passive linear/non-linear circuits (Familiar Circuits with R, L, C, Diodes). | 2 |
| 4.5 | Developing component models, sub-circuits in SPICE. (.model, .subckt, .lib, .inc, .ends directives) Example problems. Using datasheets to develop component models - examples (BJTs/MOSFETs) - Exercises. | 2 |
| 4.6 | Simulation Demonstration with simple circuits. Setting-up simulation, and different types of simulation etc., shall be demonstrated by the course instructor. Students shall be given SPICE circuit simulation assignments.<br><br>[LTspice®, a freeware SPICE version, is chosen here as reference due to wide availability, however, PSpice®, LTspice®, ngSpice or any available SPICE variants may be used for assignments/demonstrations]. | 1 |
| **5.** | **Introduction to MATLAB®/Simulink® (10 Hrs)** | |
| 5.1 | Introduction to MATLAB® scripting.<br><br>Language constructs - Basic Arithmetic Operations - Basic Operators and Special Characters - Variables and Arrays - Complex numbers - Basic Handling of Arrays (Vectors and Matrices). | 2 |
| 5.2 | Control Structures (Conditional, looping - for loop, while loop, switch-case-otherwise - break - return ) - functions. | 2 |
| 5.3 | Numerical Integration - ODE solvers - ode23, ode23t and ode45 - Examples | 1 |
| 5.4 | User-written functions to solve ODEs to implement the algorithms BE, FE, and TRZ only). Application examples. (Performance comparison of different solvers may be given as assignments). | 2 |
| 5.5 | Visual Modelling: Introduction to Simulink. Developing causal simulation diagrams using fundamental blocks for simple circuit models - first-order/second-order circuits, Separately excited DC Motor, from the ODE descriptions. | 2 |

| | | |
|---|---|---|
| 5.6 | Demonstration of simulation examples with different integration algorithms /step-sizes. [Only demonstration/practice/assignments].<br><br>(Instead of MATLAB®/Simulink®, Octave and Scilab®/XCos® may be used for assignments/demonstrations). | 1 |

# SEMESTER VI

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET601** | **LINEAR CONTROL SYSTEMS** | PCC | **2** | **2** | **0** | **4** |

**Preamble** : This course aims to provide a strong foundation on classical control theory. Modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach will be discussed. The compensator design of linear systems is also introduced.

**Prerequisite** : **Basics of Circuits and Networks, Signals and Systems**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Describe the role of various control blocks and components in feedback systems. |
| **CO 2** | Analyse the time domain responses of the linear systems. |
| **CO 3** | Apply Root locus technique to assess the performance of linear systems. |
| **CO 4** | Analyse the stability of the given LTI systems. |
| **CO 5** | Analyse the frequency domain response of the given LTI systems. |
| **CO 6** | Design compensators using time domain and frequency domain techniques. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 2** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 2 |
| **CO 3** | 3 | 3 | 3 | - | 2 | - | - | - | - | - | - | 2 |
| **CO 4** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 3 |
| **CO 5** | 3 | 3 | 3 | - | 2 | - | - | - | - | - | - | 3 |
| **CO 6** | 3 | 3 | 3 | 2 | - | - | - | - | - | - | - | 3 |

**Assessment Pattern:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 10 | 10 | 20 |
| Apply (K3) | 30 | 30 | 60 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**End Semester Examination Pattern** **:** There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

**Part B** contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

**Course Level Assessment Questions:**

**Course Outcome 1 (CO1)**

4. Derive and explain the transfer function of AC servo motor.
5. With the help of suitable sketches explain the need for a lead compensator.
6. Explain how does the feedback element affect the performance of the closed loop system.

**Course Outcome 2 (CO2):**

7. Obtain the different time domain specifications for a given second order system with impulse input.
8. Determine the value of the natural frequency of oscillation $\omega_n$ for the unity feedback system with forward transfer function $G_p(s) = \frac{K}{s(s+10)}$, which results in a critically damped response. Also analyse the effect of K on damping factor.
9. Problems related to static error constant and steady state error for a given input.

**Course Outcome 3(CO3):**

4. Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s\,(s+1)\,(s+4)}$ is oscillatory, using Root locus.
5. Construct the Root locus for the closed loop system with $G(s)H(s) = \frac{K}{s\,(s^2 + 2s + 2)}$ ? Determine the value of K to achieve a damping factor of 0.5?
6. Problems on root locus for systems with positive feedback.

**Course Outcome 4 (CO4):**

7. Problems related to application of Routh's stability criterion for analysing the stability of a given system.
8. Problems related to assess the stability of the given system using Bode plot.
9. Problem related to the analysis of given system using Nyquist stability criterion.

**Course Outcome 5 (CO5):**

1. Determine the value of K such that the gain margin for the system with $G(s)H(s) = \frac{K}{s\,(s+1)\,(s+5)}$ equals to 2.
2. Determine the phase margin to assess the stability of the system with $G(s)H(s) = \frac{2}{s\,(s+1)\,(s+4)}$
3. Derive and explain the dependence of resonant peak on damping factor.

**Course Outcome 6 (CO6):**

4. Problems related to the design of lead compensator using Bode plot.
5. Problems related to the design of lag compensator using Root locus technique.
6. Design the parameters of an electrical lag circuit with $f_1$= 200 Hz and $f_2$= 1kHz

**Model Question Paper** PAGES: 2

**QPCODE:**

Reg. No:____________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

Course Code**: 22EET601**

Course Name: **LINEAR CONTROL SYSTEMS**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

Give a comparison between open loop and closed loop control systems with suitable examples.

Derive the dependence of $\varphi_m$ and $\alpha$ of a lead compensator and hence explain the restrictions on the selection of α?

For a closed loop system with $G(s) = \frac{1}{s\,(s+5)}$; and H(s) = 0.05, calculate the steady state error constants.

Check the stability of the system given by the characteristic equation, $G(s) = s^5 + 2s^4 + 4s^3 + 8s^2 + 16s + 32$; using Routh criterion.

With suitable sketches explain how the addition of poles to the open-loop transfer function affect the root locus plots.

Explain Ziegler – Nichol's PID tuning rules.

Explain the features of non-minimum phase systems with a suitable example.

How do you determine the gain margin of a system, with the help of Bode plot?

State and explain Nyquist stability criterion.

Discuss the procedure for Lag compensator design using Root locus technique.

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

**11** Derive the transfer function of an Armature controlled dc servo motor. Assess the effect of time constants on the system performance. **(9)**

Compare the effect of H(s) on the pole-zero plot of the closed loop system with $G(s) = \frac{s+3}{(s^2 + 3s + 2)}$ with: i) derivative feed back H(s)= s; ii) integral feedback H(s)=1/s. **(5)**

**12** Why compensation is necessary in feedback control system? What are the factors to be considered for choosing the feedback compensation? **(6)**

With relevant characteristics explain the operation of the following control devices. i) Synchro error detector, ii) Tachogenerator. **(8)**

## Module 2

13 Derive an expression for the step response of a critically damped second order system? Explain the dependency of Mp on damping factor. **(9)**

Determine the value of K and the natural frequency of oscillation $\omega_n$ for the unity feedback system with forward transfer function $G(s) = \frac{K}{s(s+10)}$, which results in a critically damped response when subjected to a unit step input.

Also determine the steady state error for unit velocity input. **(5)**

14 A unity feedback system is characterized by an open loop transfer function $G(s) = \frac{20}{(s^2 + 5s + 5)}$. Determine the transient response when subjected to a unit step input and sketch the response. Evaluate the maximum overshoot and the corresponding peak time of the system. . **(9)**

Using Routh criterion determine the value of K for which the unity feedback closed loop system with $G(s) = \frac{K}{s(s^2 + 20s + 8)}$ is stable. . **(5)**

## Module 3

15 Design a lag lead compensator with open loop transfer function $G(s) = \frac{K}{s(s+0.5)}$ to satisfy the following specifications (i) damping ratio of the dominant closed loop poles is 0.5 (ii) Undamped natural frequency of the dominant closed loop poles $\omega_n$ = 5 rad/sec iii) Velocity error constant $K_v$ = 80. (10)

Compare between PI and PD controllers. (4)

16 Sketch root locus for a system with $G(s)H(s) = \frac{K(s+1)}{s(s+4)}$. Hence determine the range of K for the system stability. . (9)

With help of suitable sketches, explain how does Angle and Magnitude criteria of Root locus method help in control system design. (5)

## Module 4

17 The open-loop transfer function of a unity feedback system is G(s)=$\frac{K}{s(0.5s+1)(0.04s+1)}$.Use asymptotic approach to plot the Bode diagram and determine the value of K for a gain margin of 10 dB. (8)

Compare between the polar plots for $G(s)H(s) = \frac{K}{(s+4)}$ and $G(s)H(s) = \frac{K(s-4)}{(s+4)}$. (6)

18 Draw the polar plot of an open loop transfer function G(s)= $\frac{6}{(s+1)(s+2)}$ and comment on the phase margin and gain margin. (8)

Explain the detrimental effects of transportation lag, using Bode plot. (6)

## Module 5

**19** Draw Nyquist plot for the system whose open loop transfer function is $G(s)H(s) = \frac{K}{s(s+2)(s+10)}$. Determine the range of K for which the closed loop system is stable. (9)

Write a short note on Nichols chart. . (5)

**20** Design a phase lead compensator for a unity feedback system given by the open loop transfer function $G(s) = \frac{K}{s(S+1)}$ to meet the following specifications (i) phase margin of the system > 45 deg (ii) $e_{ss}$ for unit ramp <1/15 (iii) gain crossover frequency must be 7.5 rad/sec. . (11)

Explain the design constrains on the selection of corner frequencies of lag compensator. (3)

**Syllabus**

**Module 1**

**Feedback Control Systems (9 hours)**

Open loop and closed loop control systems- Examples of automatic control systems - Transfer function approach to feed back control systems – Effect of feedback

Control system components – Control applications of DC and AC servo motors, Tacho generator, Synchro, Gyroscope and Stepper motor

Controllers- Types of controllers & Compensators - Transfer function and basic characteristics of lag, lead and lag-lead phase compensators.

**Module 2**

**Performance Analysis of Control Systems (9 hours)**

Time domain analysis of control systems: Time domain specifications of transient and steady state responses- Impulse and Step responses of first and second order systems- Pole dominance for higher order systems.

Error analysis: Steady state error analysis and error constants -Dynamic error coefficients.

Stability Analysis: Concept of BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems - Routh's stability criterion- Relative stability

**Module 3**

**Root Locus Analysis and Compensator Design (11 hours)**

Root locus technique: Construction of Root locus- stability analysis- effect of addition of poles and zeroes- Effect of positive feedback systems on Root locus

Design of Compensators: Design of lag, lead and lag-lead compensators using Root locus technique.

PID controllers: PID tuning using Ziegler-Nichols methods.

Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for Root locus based analysis (Demo/Assignment only)

**Module 4**

**Frequency domain analysis (9 hours)**

Frequency domain specifications- correlation between time domain and frequency domain responses

Polar plot: Concepts of gain margin and phase margin- stability analysis

Bode Plot: Construction- Concepts of gain margin and phase margin- stability analysis,

Effect of Transportation lag and Non-minimum phase systems.

**Module 5**

**Nyquist stability criterion and Compensator Design using Bode Plot (9 hours)**

Nyquist criterion: Nyquist plot- Stability criterion- Analysis

Introduction to Log magnitude vs. phase plot and Nichols chart (concepts only) - Compensator design using Bode plot: Design of lag, lead and lag-lead compensator using Bode plot.

Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent for various frequency domain plots and analysis (Demo/Assignment only).

**Textbooks**

10. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
11. Ogata K, Modern Control Engineering, 5/e, Prentice Hall of India.
12. Nise N. S, Control Systems Engineering, 6/e, Wiley Eastern
13. Dorf R. C. and Bishop R. H, Modern Control Systems, 12/e, Pearson Education

**Reference Books**

6. Kuo B. C, Automatic Control Systems, 7/e, Prentice Hall of India
7. Desai M. D., Control System Components, Prentice Hall of India, 2008
8. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill.
9. Imthias Ahamed T. P, Control Systems, Phasor Books, 2016

**Course Contents and Lecture Schedule:**

| Module | Topic coverage | No. of Lectures |
|---|---|---|
| **1** | **Feedback Control Systems (9 hours)** | |
| 1.1 | Terminology and basic structure of Open loop and Closed loop control systems- Examples of Automatic control systems (block diagram representations only) | 2 |
| 1.2 | Transfer function approach to feed back control systems- Effect of feedback- Characteristic equation- poles and zeroes- type and order. | 2 |
| 1.3 | Control system components: Transfer functions of DC and AC servo motors –Control applications of Tacho generator, Synchro, Gyroscope and Stepper motor | 3 |
| 1.4 | Need for controllers: Types of controllers – Feedback, Cascade and Feed forward controllers<br>Compensators: Transfer function and basics characteristics of lag, lead, and lag-lead phase compensators | 2 |
| **2** | **Performance Analysis of Control Systems (9 hours)** | |
| 2.1 | Time domain analysis of control systems:<br>Time domain specifications of transient and steady state responses- Impulse and Step responses of First order systems- Impulse and Step responses of Second order systems- Pole dominance for higher order systems | 3 |
| 2.2 | Error analysis:<br>Steady state error analysis - static error coefficient of Type 0, 1, 2 systems. Dynamic error coefficients | 2 |
| 2.3 | Stability Analysis:<br>Concept of stability-BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems | 2 |
| 2.4 | Application of Routh's stability criterion to control system analysis- Relative stability | 2 |
| **3** | **Root Locus Analysis and Compensator Design (11 hours)** | |
| 3.1 | Root locus technique:<br>General rules for constructing Root loci – stability from root loci - | 3 |
| 3.2 | Effect of addition of poles and zeros on Root locus | 1 |
| 3.3 | Effect of positive feedback systems on Root locus | 1 |

| | | |
|---|---|---|
| 3.4 | Design using Root locus: Design of lead compensator using root locus. | 2 |
| 3.5 | Design of lag compensator using root locus. | 1 |
| 3.6 | Design of lag-lead compensator using root locus | 1 |
| 3.7 | PID Controllers: Need for P, PI and PID controllers | 1 |
| 3.8 | Design of P, PI and PID controller using Ziegler-Nichols tuning method. | 1 |
| 3.9 | Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent simulation software and tool boxes for Root locus based analysis (Demo/Assignment only) | |
| **4** | **Frequency domain analysis (9 hours)** | |
| 4.1 | Frequency domain specifications- correlation between time domain and frequency domain responses | 2 |
| 4.2 | Polar plot: Concepts of gain margin and phase margin- stability analysis | 2 |
| 4.3 | Bode Plot: Construction of Bode plots- gain margin and phase margin- Stability analysis based on Bode plot | 4 |
| 4.4 | Effect of Transportation lag and Non-minimum phase systems | 1 |
| **5** | **Nyquist stability criterion and Compensator Design using Bode Plot (9 hours)** | |
| 5.1 | Nyquist stability criterion: Nyquist plot- Stability criterion- Analysis | 3 |
| 5.2 | Introduction to Log magnitude vs. phase plot and Nichols chart | 1 |
| 5.3 | Design using Bode plot: Design of lead compensator using Bode plot. | 2 |
| 5.4 | Design of Lag compensator using Bode plot. | 2 |
| 5.5 | Design of Lag- lead compensator using Bode plot | 1 |
| 5.6 | Simulation based analysis: Introduction to simulation tools like MATLAB/ SCILAB or equivalent simulation software and tool boxes for various frequency domain plots and analysis (Demo/Assignment only). | |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET602** | **POWER SYSTEMS II** | **PCC** | **3** | **1** | **0** | **4** |

**Preamble** : The basic objective of this course is to deliver fundamental concepts in power system **analysis**. The steady state and transient analysis of electrical power system is comprehensively covered in this course ranging extensively using the conventional methods as well as advanced mathematics.

**Prerequisite** : **EET 301 Power Systems I**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Apply the per unit scheme for any power system network and compute the fault levels. |
| **CO 2** | Analyse the voltage profile of any given power system network using iterative methods. |
| **CO 3** | Analysethe steady state and transient stability of power system networks. |
| **CO 4** | Model the control scheme of power systems. |
| **CO 5** | Schedule optimal generation scheme. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | 2 | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | 2 | | | | | | | | | 1 |
| **CO 4** | 3 | 2 | | | | | | | | | | |
| **CO 5** | 3 | 3 | 1 | | | | | | | | 3 | 1 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 10 | 10 | 20 |
| Apply (K3) | 30 | 30 | 60 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Why do we adopt per unit scheme of representation? (K2)
2. Which is the most frequent fault and which is the most severe fault? Substantiate with equation. (K2, K3)

**Course Outcome 2 (CO2):**

1. How is consistency followed in load flow studies? (K4)
2. How does acceleration factor improve convergence in Gauss Siedel Load flow? (K4)

**Course Outcome 3 (CO3):**

1. Differentiate between steady state and transient stability? (K1, K2)
2. Derive a swing equation. (K3)

**Course Outcome 4 (CO4):**

1. What is the significance of Inertia constant? (K3)
2. Draw the schematic representation of AGC. Show the frequency deviation pattern. (K1, K2, K3)

**Course Outcome 5 (CO5):**

1. What are penalty factors? Explain the significance. (K2, K3)
2. Why do we need Unit commitment? Explain with an example. (K3)

**Model Question paper**
**QP CODE:** PAGES:5
Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EET602**

**Course Name: POWER SYSTEMS II**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

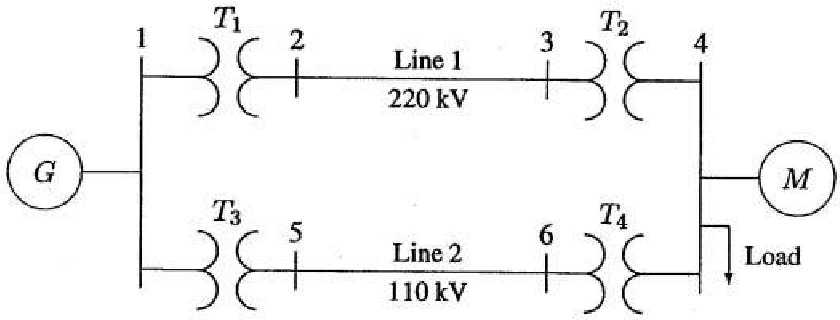
1. The generator neutral grounding impedance appears as 3Zn in the zero-sequencenetwork.Why?
2. A single-phase transformer is rated at 110/440 V, 3 KVA. Its leakage reactance measured on 110 V side is 0.05 ohm. Determine the leakage impedance referred to 440 V side.
3. What is the need of slack bus in load flow analysis?
4. A power system consists of 300 buses out of which 20 buses are generator buses and 25 buses are provided with reactive power support. All other buses are load buses. Determinethe size of the Newton Raphson load flow Jacobian matrix.
5. Explain critical clearing angle and its significance with respect to the stability ofa power system.
6. Explain Equal Area criterion and state the assumptions made.
7. Draw the basic block diagram of Automatic Voltage Regulator.
8. Discuss the application of SCADA in power system monitoring
9. Explain unit commitment? List out the constraints on unit commitment.
10. Write the conditions for the optimal power dispatch in a lossless system.

**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module I**

1. a)The one-line diagram of a threephase power system is shown in figure below. Select the common base of 100 MVA and 22 kV on the generator side. Draw an impedance diagram with all impedances including the load impedance marked in per unit. The manufacturer's data for each device is given as follows. The three phase load at bus 4 absorbs 57 MVA, .6 power factor lagging at 10.45 kV. Line1 and Line 2 have reactances of 48.4Ω and 65.43Ω, respectively.

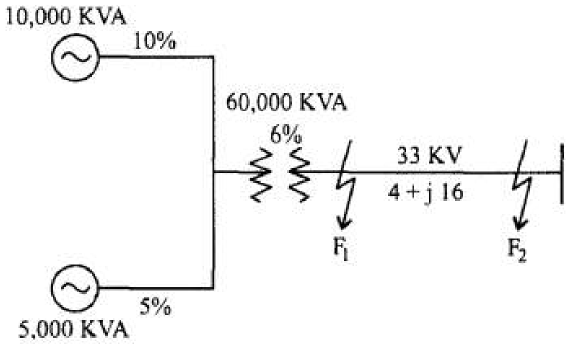
| | | | |
|---|---|---|---|
| G | 90 MVA | 22 kV | X=18% |
| $T_1$ | 50 MVA | 22/220 kV | X=10% |
| $T_2$ | 40 MVA | 220/11 kV | X=6% |
| $T_3$ | 40 MVA | 22/110 kV | X=6.4% |
| $T_4$ | 40 MVA | 110/11 kV | X=8% |
| M | 66.5 MVA | 10.45 kV | X=18.5% |




**(10)**

b) What are the advantages of pu system? Obtain the expression for converting the per unit impedance expressed on one base to another. **(4)**

2. a) A 33 KV line has a resistance of 4 ohm and reactance of 16 ohm respectively. The line is connected to a generating station bus bars through a 6000 KVA stepup transformer which has a reactance of 6%. The station has two generators rated 10,000 KVA with 10% reactance and 5000 KVAwith 5% reactance. Calculate the fault current and short circuit KVA when a 3-phase fault occurs at the HV terminals of the transformers and at the load end of the line.

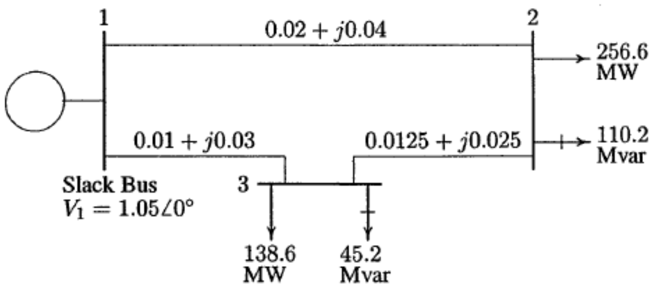



3. **(10)**

b) Explain the different types of current limiting reactors. **(4)**

## Module II

4. a)For the system shown in figure obtain the load flow solution at the end of 2 iterations by Gauss Seidel method . The line impedances are marked in per unit on a 100 MVA base.




**(10)**

b) Explain DC load flow. **(4)**

5. Considerthe three bus system shown below. Each of the three lines have aseries impedance of 0.02+j0.08 pu and atotal shunt admittance of j0.02 pu. The specified quantities at the buses are tabulated below.

| Bus | Real load Demand, $P_D$ | Reactive load demand, $Q_D$ | Real power Generation, $P_G$ | Reactive power Generation, $Q_G$ | Voltage specification |
|---|---|---|---|---|---|
| 1 | 2.0 | 1.0 | Unspecified | Unspecified | $V_1 = 1.04 + j0$ |
| 2 | 0.0 | 0.0 | 0.5 | 1.0 | Unspecified |
| 3 | 1.5 | 0.6 | 0.0 | $Q_{G3} =$ ? | $\lvert V_3 \rvert = 1.04$ |

Controllable reactive power source is available at bus 3 with the constraint $0 \leq Q_{G3} \leq 1.5$pu. Find the load flow solution using FDLF method (one iteration).

**(14)**

## Module III

6. a) Starting from first principles, derive swing equation of a synchronous machine. **(6)**

b) Two generators rated at 4-pole, 50 Hz, 50 MW 0.85 p.f (lag) with moment of inertia28,000 kg-m$^2$ and 2-pole, 50Hz, 75 MW 0.82 p.f (lag) with moment of inertia 5,000 kg-m$^2$ are connected by a transmission line. Find the inertia constant of each machine and the inertia constant of single equivalent machine connected to infinite bus. Take 100 MVA base. **(8)**

7. a) A 50 Hz generator is delivering 50% of the power that it is capable of delivering through a transmission line to an infinite bus. A fault occurs that increases the reactance between the generator and the infinite bus to 500% of the value before the fault. When the fault is isolated, the maximum power that can be delivered is 75% of the original maximum value. Determine the critical clearing angle for the condition described. **(10)**

b) Explain Equal Area criterion and state the assumptions made. **(4)**

## Module IV

8. a)Two turboalternators rated for 110 MW and 210 MW have governor drop characteristics of 5 per cent from no load to full load. They are connected in parallel to share a load of 250 MW. Determine the load shared by each machine assuming free governor action. **(10)**

b) Enumerate the reasons for keeping strict limits on the system frequency variations. **(4)**

9. a) Develop and explain the block diagram of automatic load frequency control of anisolated power system. **(10)**

b) A 100 MVA synchronous generator operates on full load at a frequency of 50 Hz. Inertia constant is 8 MJ/MVA. The load is suddenly reduced 100 MW. Due to time lag in governor system, the steam valve begins to close after 0.4 seconds. Determine the change in frequency that occurs in this time. **(4)**

## Module V

10. a)The fuel inputs per hour of plants 1 and 2 are given as

$F_1 = 0.2\ P_1{}^2 + 40\ P_1 + 120$ Rs. per hr

$F_2 = 0.25\ P_2{}^2 + 30\ P_2 + 150$Rs. per hr

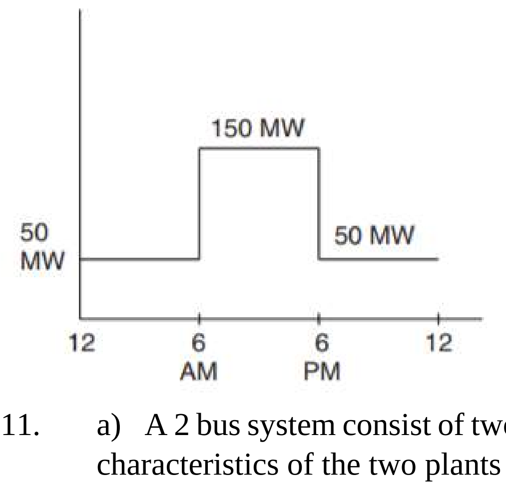
Determine the economic operating schedule and the corresponding cost of generation if the maximum and minimum loading on each unit is 100 MW and 25 MW, the demand is 180 MW, and transmission losses are neglected. If the load is equally shared by both the units, determine the saving obtained by loading the units as per equal incremental productioncost. **(6)**

b) Assume that the fuel input in Btu per hour for units 1 and 2 are given by

$F_1 = (8P_1 + 0.024\ P_1{}^2 + 80)10^6$

$F2 = (6P_2 + 0.04\ P_2{}^2 + 120)10^6$

The maximum and minimum loads on the units are 100 MW and 10 MW respectively. Determine the minimum cost of generation when the following load (as per Figure given below) is supplied. The cost of fuel is Rs. 2 per million Btu.




**(8)**

11. a) A 2 bus system consist of two power plants connected by a transmission line. The cost curve characteristics of the two plants are

$C_1 = 0.01P_1{}^2 + 16P_1 + 20$ Rs/hr

$C_2 = 0.02P_2{}^2 + 20P_2 + 40$ Rs/hr

When a power of 120 MW is transmitted from plant 1 to load (near to plant 2), a loss of 14 MW is occurred. Determine the optimal scheduling of plants and load demand, if cost of received power is 30 Rs./MWhr. **(10)**

b) The incremental fuel cost of two generating units $G_1$ and $G_2$ is given by $IC_1 = 25+0.2P_1$, $IC_2 = 32+0.2P_2$, where $P_1$ and $P_2$ are real powers generated by the unit. Find the economic allocation for a total load of 250 MW. Neglect the transmission losses. **(4)**

## Syllabus

**Module I (10 hours)**

Per unit quantities-single phase and three phase- Symmetrical components- sequence networks- Fault calculations-symmetrical and unsymmetrical- Fault level of installations- Limiters - Contingency ranking.

**Module II (8 hours)**

Load flow studies – Introduction-types-network model formulation and admittance matrix, Gauss-Siedel (two iterations), Newton-Raphson (Qualitative analysis only) and Fast Decoupled method (two iterations) - principle of DC load flow - Introduction to distribution flow.

**Module III (10 hours)**

Power system stability - steady state, dynamic and transient stability-power angle curve-steady state stability limit -mechanics of angular motion-swing equation - solution of swing equation - Point by Point method - RK method - Equal area criterion application - methods of improving stability limits - Phasor Measurement Units- Wide Area Monitoring Systems

**Module IV (10 hours)**

Turbines and speed governors-Inertia-Automatic Generation Control: Load frequency control: single area and two area systems - Subsynchronous Resonance - Automatic voltage control - Exciter Control- SCADA systems

**Module V (8 hours)**

Economic Operation - Distribution of load between units within a plant - transmission loss as a function of plant generation - distribution of load between plants - method of computing penalty factors and loss coefficients. Unit commitment: Introduction — constraints on unit commitments: spinning reserve, thermal unit constraints- hydro constraints.

**References:**


1. Hadi Saadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2. D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009.
3. Kundur P., *Power system Stability and Control*, McGraw Hill, 2006
4. Cotton H. and H. Barbera, Transmission & Distribution of Electrical Energy, 3/e, Hodder and Stoughton, 1978.
5. Gupta B. R., *Power System Analysis and Design*, S. Chand, New Delhi, 2006.
6. Gupta J.B., Transmission *& Distribution of Electrical Power*, S.K. Kataria& Sons, 2009.
7. Soni, M.L., P. V. Gupta and U. S. Bhatnagar, *A Course in Electrical Power*, Dhanpat Rai& Sons, New Delhi, 1984.
8. John J Grainger and William D Stevenson, *Power System Analysis*, 4/e, McGraw Hill, 1994.
9. Uppal S. L. and S. Rao, *Electrical Power Systems*, Khanna Publishers, 2009.
10. Wadhwa C. L., *Electrical Power Systems*, 33/e, New Age International, 2004.
11. Weedy B. M., B. J. Cory, N. Jenkins, J. B. Ekanayake and G. Strbac, *Electric Power System*, John Wiley & Sons, 2012.

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Module I(10 hours)** | |
| 1.1 | Per unit quantities-single phase and three phase.- -Numerical Problems | 2 |
| 1.2 | Symmetrical components- sequence networks-Numerical Problems | 3 |
| 1.3 | Fault calculations-symmetrical and unsymmetrical-Numerical Problems | 3 |
| 1.4 | Fault level of installations- Limiters-Numerical Problems | 2 |
| **2** | **Module 2(8 Hours)** | |
| 2.1 | Load flow studies – Introduction-types | 1 |
| 2.2 | Network model formulation and admittance matrix-Numerical Problems | 2 |
| 2.3 | Gauss-Siedel (two iterations) -Numerical Problems not more than three buses | 1 |
| 2.4 | Newton-Raphson (Qualitative analysis only) | 2 |
| 2.5 | Fast Decoupled method (two iterations) -Numerical Problems not more than three buses | 1 |
| 2.6 | Principle of DC load flow. Introduction to distribution flow. | 1 |
| **3** | **Module 3(10 hours)** | |
| 3.1 | Power system stability steady state, dynamic and transient stability--Numerical Problems | 2 |
| 3.2 | power angle curve-steady state stability limit --Numerical Problems | 2 |
| 3.3 | Point by Point method Equal area criterion application-Numerical Problems. RK method-(Abstract idea only) | 2 |
| 3.4 | Methods of improving stability limits-Numerical Problems | 2 |
| 3.5 | Contingency ranking-SSR-(Abstract idea only) – PMUs and Wide area monitoring systems | 2 |
| **4** | **Module IV (10 hours)** | |
| 4.1 | Turbines and speed governors-inertia. | 2 |
| 4.2 | Automatic Generation Control: Load frequency control: single area and two area systems-Numerical Problems | 3 |
| 4.3 | Automatic voltage control -Exciter Control. | 2 |

| | | |
|---|---|---|
| 4.4 | SCADA systems--(Abstract idea only) | 1 |
| 4.5 | Phasor Measurement Unit- Wide Area Monitoring Systems-(Abstract idea only) | 2 |
| **5** | **Module V (8 hours)** | |
| 5.1 | Economic Operation Distribution of load between units within a plant transmission loss as a function of plant generation distribution of load between plants-Numerical Problems | 3 |
| 5.2 | Method of computing penalty factors and loss coefficients-Numerical Problems | 2 |
| 5.3 | Unit commitment: Introduction — Constraints on unit commitments: Spinning reserve, Thermal unit constraints- Hydro constraints-Numerical Problems. | 3 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EET603** | **POWER ELECTRONICS** | **PCC** | **3** | **1** | **0** | **4** |

**Preamble** : To impart knowledge about the power semiconductor devices, the operation of various power converters and its applications.

**Prerequisite** : Basics of Electrical Engineering / Introduction to Electrical Engineering/ Basics of Electronics Engineering

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Explain the operation of modern power semiconductor devices and its characteristics. |
| **CO 2** | Analyse the working of controlled rectifiers. |
| **CO 3** | Explain the working of AC voltage controllers, inverters and PWM techniques. |
| **CO 4** | Compare the performance of different dc-dc converters. |
| **CO 5** | Describe basic drive schemes for ac and dc motors. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | - | 1 | - | - | - | - | - | - | - | - |
| **CO 2** | 3 | 2 | 1 | 2 | - | - | - | - | - | - | - | 2 |
| **CO 3** | 3 | 3 | - | - | - | - | - | - | - | - | - | - |
| **CO 4** | 3 | 3 | 2 | 2 | - | - | - | - | - | - | - | 2 |
| **CO 5** | 3 | 2 | - | - | - | - | - | - | - | - | - | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 20 | 20 | 30 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the working and switching characteristics of SCR, MOSFET, IGBT (K1)
2. Give a brief description on wide band-gap power devices (K1)
3. Draw and explain the switching characteristics of SCR (K1, K2)
4. Discuss the protection circuits for SCR (K2)
5. Explain different types of isolation in gate drive for power converter circuits (K1, K2)

**Course Outcome 2 (CO2):**

1. Describe the working with waveforms of single phase half wave rectifiers for different firing angles. (K1)
2. Describe the working with waveforms of single phase fully controlled rectifiers for different firing angles and loads.(K2)
3. Describe the working with waveforms of single phase half controlled rectifiers for different firing angles and loads.(K2)
4. Describe the working with waveforms of three phase rectifiers for different firing angles and loads. (K2)
5. Problems in finding the average output voltage of rectifier. (K2, K3)

**Course Outcome 3 (CO3):**

1. Explain the working of ACVC with R and RL loads. (K1)
2. Explain single phase inverter for R and RL loads, problems in finding the output voltage, THD of inverter. (K2, K3)
3. Explain 3 phase mode $120^0$ and $180^0$ conduction modes. (K4)
4. Explain single phase current source inverter PWM Inverter. (K1)
5. Explain single pulse PWM, multiple pulse, and sinusoidal PWM technique (K1, K2)

**Course Outcome 4 (CO4):**

1. Explain the working of step up and step down converters. (K1, K2)
2. Problems related to step up and step down converters. (K2, K3)
3. Analyse the working of Buck, Boost & Buck Boost regulators. (K3, K4)
4. Design the value of filter inductor & capacitance in regulators. (K3, K4)
5. Problems in Buck, Boost & Buck Boost regulators. (K2, K3)

**Course Outcome 5 (CO5):**

1. Explain the block diagram of an electric drive (K1,K2)
2. Explain the working of single phase rectifier fed DC drive (K2, K3)
3. Explain the chopper controller DC drive (K2,K3)
4. Explain the four quadrant operation of a DC drive (K2, K3)
5. Explain the v/f control of Induction motor drive (K3,K4)

**Model Question paper**

**QP CODE:**

PAGES:2

Reg.No:_______________
Name:_______________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**
**Course Code: 22EET603**

**Course Name: POWER ELECTRONICS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain different turn on methods of SCR.
2. Describe the reverse recovery characteristics of a power diode.
3. Draw the input and output voltage waveforms of single phase half controlled rectifier feeding RL load in continuous and discontinuous conduction mode.
4. Explain with neat sketches, the input and output voltage waveforms of 3ø half controlled rectifier with R load for a firing angle of $30^0$.
5. Compare voltage source and current source inverters.
6. Explain the terms modulation index and frequency modulation ratio related to pulse width modulation.
7. Explain time ratio control method to vary the output voltage in choppers.
8. Derive the expression for output voltage of a Buck Converter.
9. What are the advantages of electric drives?
10. Explain regenerative braking control in drives.

**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a) Explain the two transistor analogy of SCR. **(6)**

    b) Compare the switching characteristics of IGBT. **(8)**

12. a) Explain the structural details of MOSFET. **(8)**

    b) Write short note on wideband gap devices. **(6)**

**Module 2**

13. a) Explain the operation of single phase full wave controlled rectifier without freewheeling diode, when feeding RL load. **(10)**

b) Write short notes on pulse transformer. **(4)**

14. a) The full-wave controlled bridge rectifier has an AC input of 220 V rms at 50 Hz and a 20 ohm load resistor. The delay angle is $40^0$. Determine the average current in the load, the power absorbed by the load, and the source volt-amperes. **(7)**

b) Draw the circuit of 3 phase fully controlled rectifier with RLE load and explain the working for $\alpha=60^0$ with necessary waveforms. Derive the expression for output voltage. **(7)**

**Module 3**

15. a) Explain the $120^0$ conduction mode of a three-phase bridge inverter with output voltage waveforms, indicating the devices conducting in each state. **(10)**

b) Write short notes of THD. **(4)**

16. a) Explain sinusoidal PWM technique for varying the magnitude of output voltage in a single-phase inverter. **(6)**

b) Briefly explain current source inverter **(8)**

**Module 4**

17. a) Explain the working of a Buck-Boost regulator, showing relevant waveforms and derive the expression for its output voltage. **(8)**

b) Design a DC-DC Converter with 12 V input and 200 V output at upto 50 W. The ripple in the output voltage and input current should not exceed +- 5% and +- 20% respectively. Select suitable device and switching frequency. **(6)**

18. a) Describe the working of four quadrant chopper in all the four quadrants with relevant circuit diagrams. **(10)**

b) Briefly explain the current limit control in dc-dc converter **(4)**

**Module 5**

19. a) Explain the working of a single phase full converter drive **(8)**

b) Explain the working of a four quadrant chopper drive **(6)**

20. a) Explain the stator voltage control for Induction motor drive **(8)**

b) Explain the working of v/f control of Induction motor drive **(6)**

## Syllabus

**Module 1 - 11 hrs**

**Introduction to Power Electronics-**Scope and applications-power electronics vs signal electronics (1 hr)
**Structure and principle of operation of power devices**- Power diode, Power MOSFET & IGBT – switching characteristics - comparison. Basic principles of wideband gap devices-SiC, GaN (4 hrs)
**SCR-** Structure, Static characteristics & Switching (turn-on & turn-off) characteristics - di/dt& dv/dt protection – Turn-on methods of SCR - Two transistor analogy (5 hr)

**Gate triggering circuits** – Requirements of isolation and synchronization in gate drive circuits-Opto and pulse transformer based isolation (1hr)

**Module 2 - 9 hrs**

**Controlled Rectifiers (Single Phase)** – Half-wave controlled rectifier with R load– Fully controlled and half controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – Output voltage equation- related simple problems (5 hrs)

**Controlled Rectifiers (3-Phase) -** 3-phase half-wave controlled rectifier with R load – Fully controlled & half-controlled bridge converter with RLE load (continuous conduction, ripple free) – Output voltage equation - Waveforms for various triggering angles (detailed mathematical analysis not required) (4 hrs)

**Module 3 - 9 hrs**

**AC voltage controllers (ACVC)** – 1-phase full-wave ACVC with R, & RL loads – Waveforms – RMS output voltage, Input power factor with R load (2 hrs)

**Inverters** – Voltage Source Inverters– 1-phase half-bridge & full bridge inverter with R and RL loads – THD in output voltage – 3-phase bridge inverter with R load – 120° and 180° conduction modes– Current Source Inverters- 1-phase capacitor commutated CSI. (5 hrs)

**Voltage control in 1-phase inverters** – Pulse width modulation – Single pulse width, Multiple pulse width and Sine-triangle PWM (unipolar & bipolar modulation) – Modulation Index - Frequency modulation ratio. (2 hrs)

**Module 4 - 8 hrs**

**DC-DC converters** – Step down and Step up choppers – Single-quadrant, Two-quadrant and Four quadrant chopper – Pulse width modulation & current limit control in dc-dc converters. (4 hrs)
**Switching regulators** – Buck, Boost & Buck-boost –Operation with continuous conduction mode – Waveforms – Design of Power circuits (switch selection, filter inductance and capacitance) (4 hrs)

**Module 5 - 11 hrs**

**Electric Drive**: Introduction to electric drives – Block diagram – advantages of electric drives- types of load – classification of load torque (2 hrs)

**DC Drives:** Single phase semi converter and single phase fully controlled converter drives. Dual Converters for Speed control of DC motor-1-phase and 3-phase configurations; Simultaneous and Non-simultaneous operation. Chopper controlled DC drives- Single quadrant chopper drives- Regenerative braking control- Two quadrant chopper drives- Four quadrant chopper drives (6 hrs)

**AC Drives:** Three phase induction motor speed control. Stator voltage control – stator frequency control - Stator voltage and frequency control (v/f) (3 hrs)

(It is expected to emphasize the ease of independent control of field flux and armature flux in SEDC motor and relate the same with Induction motor)

**Text Books**

Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education

Daniel W. Hart, Power Electronics, Tata McGraw-Hill Education

3. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi

**References:**

1. Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters, Applications & Design, Wiley-India
2. Fundamentals of Power Electronics, Erickson, Robert W., and Maksimovic, Dragan.
3. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
4. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India
5. Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.
6. Joseph Vithayathil, Power Electronics: Principles and Applications, McGraw-Hill College; International edition ,1995
7. Application notes on SiC and GaN, www.infineon.com. [online]
8. Evolution of wide Band-gap Semi-conductors for power devices expanding field of applications. Technical review, Vol 4, Toshiba Corporation, 2018
9. Milligan, J. W., Sheppard, S., Pribble, W., Wu, Y.-F., Muller, G., &Palmour, J. W. (2007). SiC and GaN Wide Bandgap Device Technology Overview, 2007 IEEE Radar Conference. doi:10.1109/radar.2007.374395.
10. VedamSubramaniam "Electric drives (concepts and applications)", Tata McGraw-Hill, 2001.
11. G. K. Dubey, Fundamentals of Electric Drives, Narosa publishers, second edition, 2010.

**Course Contents and Lecture Schedule:**

| No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Power Devices (11 hours)** | |
| 1.1 | Introduction to Power Electronics: Scope and applications-power electronics vs signal electronics. | 1 |
| 1.2 | Structure, principle of operation, switching characteristics of Power Devices- Power Diode, Power MOSFET & IGBT – Comparison | 3 |
| 1.3 | Basic principles of wideband gap devices-SiC, GaN | 1 |
| 1.4 | SCR- Structure, Static characteristics & Switching (turn-on & turn-off) characteristics - di/dt& dv/dt protection – Turn-on methods of SCR - Two transistor analogy | 5 |
| 1.5 | Requirements of isolation and synchronization in gate drive circuits- Opto and pulse transformer based isolation | 1 |
| **2** | **Single phase and three phase controlled rectifiers (9 hours)** | |
| 2.1 | Half-wave controlled rectifier with R load | 2 |
| 2.2 | 1-phase fully controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – Output voltage equation | 2 |
| 2.3 | 1-phase half controlled bridge rectifier with R, RL and RLE loads | 1 |
| 2.4 | 3-phase half-wave controlled rectifier with R load | 2 |
| 2.5 | 3-phase fully controlled & half-controlled converter with RLE load (continuous conduction, ripple free) – Output voltage equation. | 2 |
| **3** | **Inverters and Voltage control in single phase inverters (9 Hours)** | |
| 3.1 | Applications of AC-AC converters – Single phase full-wave AC voltage controllers with R, & RL loads- Waveforms | 1 |
| 3.2 | RMS output voltage, Input power factor with R load | 1 |
| 3.3 | Voltage Source Inverters– 1-phase Half-bridge & Full bridge inverter with R and RL loads– THD in output voltage | 2 |
| 3.4 | 3-phase bridge inverter with R load – 120° and 180° conduction modes | 2 |
| 3.5 | Current Source Inverters-1-phase capacitor commutated CSI. | 1 |
| 3.6 | Pulse Width Modulation – Single pulse width, Multiple pulse width and Sine-triangle PWM (bipolar modulation) – Modulation Index - Frequency modulation ratio. | 2 |
| **4** | **DC-DC converters (8 Hours)** | |
| 4.1 | Step down and Step up choppers – Single-quadrant chopper | 2 |
| 4.2 | Two-quadrant and Four-quadrant chopper – Pulse width modulation & current limit control in dc-dc converters. | 2 |
| 4.3 | Buck, Boost & Buck-boost –Operation with continuous conduction mode – Waveforms | 3 |

| | | |
|---|---|---|
| 4.4 | Design of Power circuits (switch selection, filter inductance and capacitance) | 1 |
| **5** | **Electric drives (11 Hours)** | |
| 5.1 | Electric Drive: Introduction to electric drives – Block diagram – advantages of electric drives- types of load – classification of load torque | 2 |
| 5.2 | DC Drives: Single phase semi converter and single phase fully controlled converter drives. Dual Converters for Speed control of DC motor-1-phase and 3-phase configurations; Simultaneous and Non-simultaneous operation. | 3 |
| 5.3 | Chopper controlled DC drives. Single quadrant chopper drives. Regenerative braking control. Two quadrant chopper drives. Four quadrant chopper drives | 3 |
| 5.4 | AC Drives: Three phase induction motor speed control. Stator voltage control – stator frequency control - Stator voltage and frequency control (v/f) (3 hrs) | 3 |

# SEMESTER VI
# (PROGRAM ELECTIVE I)

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEE604.1 | BIOMEDICAL INSTRUMENTATION | PEC | 2 | 1 | 0 | 3 |

**Preamble** :**Nil**

**Prerequisite** :**Measurements and Instrumentation**

**Course Outcomes** **:**After the completion of the course, the student will be able to:

| | |
|---|---|
| **CO 1** | Explain the basics of anatomy and physiology of human body. |
| **CO 2** | Explain different techniques for the measurement of various physiological parameters. |
| **CO 3** | Describe modern imaging techniques for medical diagnosis |
| **CO 4** | Identify the various therapeutic equipments used in biomedical field |
| **CO 5** | Discuss the patient safety measures and recent advancements in medical field. |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | - | - | - | - | 2 | - | - | - | - | - | - |
| **CO 2** | 2 | - | 2 | - | - | 2 | - | - | - | - | - | - |
| **CO 3** | 2 | - | 2 | - | - | 2 | - | - | - | - | 2 | - |
| **CO 4** | 2 | 2 | - | - | - | 2 | - | - | - | - | 2 | - |
| **CO 5** | 2 | 2 | 2 | - | - | 2 | - | - | - | - | - | 1 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 15 | 15 | 30 |
| Understand | 20 | 20 | 40 |
| Apply | 15 | 15 | 30 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Pattern** : There will be two parts; Part A and Part B. **Part A**contain 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions.

**Part B** contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the anatomy of heart and cardiac system.
2. Describe the physiology of respiratory system.

3. Discuss the generation and propagation of action potential with neat sketches.
4. Explain electrode theory and Nernst equation.
5. Draw and explain the equivalent circuit of skin electrode interface.
6. Discuss about surface electrodes.
7. What are the applications of needle electrodes?
8. What are microelectrodes?
9. What are the different bioelectrical potentials generated in human body?

**Course Outcome 2 (CO2):**

1. What are the problems encountered in measuring living systems?
2. Explain the direct method of blood pressure measurement.
3. Explain the indirect method of blood pressure measurement.
4. Explain the Oscillometric method of blood pressure measurement.
5. Explain the Ultrasonic method of blood pressure measurement.
6. Explain the method of blood flow measurement using electromagnetic blood flowmeter.
7. Explain the method of blood flow measurement using Ultrasonic blood flowmeter.
8. Explain the measurement of Cardiac output.
9. What is phonocardiography?
10. Explain the measurement of respiratory parameters using spirometer.

**Course Outcome 3(CO3):**

1. Explain ECG with a neat block diagram.
2. What is Einthoven triangle?
3. With neat sketches explain the different electrode placement schemes of ECG.
4. Explain the 10-20 system of EEG electrodes placement.
5. Draw and explain the block diagram of EEG machine.
6. Draw and explain the block diagram of EMG recorder.
7. What are the applications of EEG waveforms?
8. Draw the different EEG waveforms and state its frequency.

**Course Outcome 4 (CO4):**

1. Explain the generation of X-rays and also mention its applications in biomedical engineering.
2. What are the types of CAT scanning?
3. Explain the principle of MRI scanning.
4. Explain the principle of PET scanning.
5. Explain demand pacemaker with a neat block diagram.
6. Why a dual peak DC defibrillator preferred over DC defibrillator?
7. Explain artificial kidney with neat sketches.
8. Explain shortwave diathermy.
9. Explain microwave diathermy.

**Course Outcome 5 (CO5):**

1. Discuss the need for ventilators.
2. Draw and explain the block diagram of infant incubator.
3. Explain lithotripsy.
4. What is a heart lung machine**?**
5. What are the different methods of accident prevention in hospitals?

6. Differentiate between macro shock and micro shock.
7. Explain the physiological effects of electric current.
8. Draw the block diagram of a telemetry system.
9. What are the chemical blood tests carried out in a clinical laboratory?
10. Enumerate the application of robotics in medical field.

**Model Question paper**
**QP CODE:**

PAGES: 2

Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEE604.1**

**Course Name: Biomedical Instrumentation**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. What are Microelectrodes?
2. What are the different bioelectrical potentials generated in human body?
3. Explain the measurement of Cardiac output.
4. What is Phonocardiography?
5. What are the applications of EEG waveforms?
6. Explain the 10-20 system of EEG electrodes placement.
7. What are the types of CAT scanning?
8. Explain the principle of MRI scanning.
9. What are the different methods of accident prevention in hospitals?
10. Discuss the need for ventilators.

**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a) Discuss the generation and propagation of action potential with neat sketches. **(8)**
    b) Draw and explain the equivalent circuit of skin electrode interface. **(6)**
12. a) Briefly explain different Bio potential electrodes. **(10)**
    b) Discuss about surface electrodes. **(4)**

**Module 2**

13. a) Explain the Ultrasonic method of blood pressure measurement. **(7)**
    b) Explain the method of blood flow measurement using electromagnetic blood flow meter **(7)**
14. a) Explain the direct method of blood pressure measurement. **(7)**
    b) Explain the measurement of respiratory parameters using Spirometer **(7)**

**Module 3**

15. a) Draw and explain the block diagram of EEG machine. **(8)**

b) Explain the significance of Einthoven triangle. **(6)**

16. a)Draw the different EEG waveforms and state its frequency **(7)**

b) Explain ECG with a neat block diagram **(7)**

**Module 4**

17. a) Explain the generation of X-rays and also mention its applications in biomedical engineering. **(14)**

18. a) Explain the principle of CAT scanning **(7)**

b) Explain the principle of MRI scanning **(7)**

**Module 5**

19. a) Draw the block diagram of infant incubator and explain **(10)**

b) Write a note on medical robotics **(4)**

20. a) What are the chemical blood tests carried out in a clinical laboratory **(10)**

b) Explain artificial kidney with neat sketches **(4)**

## Syllabus

**Module 1**

Human Physiological systems: Brief discussion of Heart and Cardio-vascular system- Physiology of Respiratory system - Anatomy of Nervous and Muscular systems - Problems encountered in measuring living systems

Bioelectric potential: Resting and action potential - Generation and propagation - Bioelectric potentials associated with physiology systems (ECG, EEG and EMG).

Bio potential Electrodes: Theory – Surface electrode – Microelectrode - Needle electrodes.

Transducers for biomedical applications: Transducers for the measurement of pressure, temperature and respiration rate.

**Module 2**

Measurement of blood pressure: Direct and indirect measurement – Oscillometric method – Ultrasonic method - Measurement of blood flow and cardiac output - Plethysmography –Photo electric and Impedance Plethysmographs - Measurement of heart sounds –Phonocardiography.

Cardiac measurements: Electro-conduction system of the heart - Electro-cardiography – Electrodes and leads – Einthoven triangle- ECG read out devices - ECG machine – block diagram

**Module 3**

Measurements from the nervous system: Neuronal communication - EEG waveforms and features - 10-20 electrode measurement - EEG Block diagram – Brain - Computer interfacing.

Muscle response: Electromyography- Block diagram of EMG recorders – Nerve conduction velocity measurement

Measurements of respiratory parameters: Spiro meter - Pneumograph

**Module 4**

Modern Imaging Systems: Basic X-ray machines - CAT scanner - Principle of operation - scanning components - Ultrasonic Imaging principle - types of Ultrasound Imaging - MRI and PET scanning (Principle only).

Therapeutic equipment: Cardiac Pacemakers - De-fibrillators - Hemodialysis machines - Artificial kidney – Lithotripsy - Short wave and Micro wave Diathermy machines

**Module 5**

Ventilators - Heart Lung machine - Infant Incubators

Instruments for clinical laboratory: Test on blood cells – Chemical tests

Electrical safety: Physiological effects of electric current – Shock hazards from electrical equipment – Method of accident prevention.

Introduction to Tele- medicine - Introduction to medical robotics

**Text Books**

L. Cromwell, F. J. Weibell and L. A. Pfeiffer, “Biomedical Instrumentation Measurements”, Pearson education, Delhi, 1990.

J. G. Webster, “Medical Instrumentation, Application and Design”, John Wiley and Sons

**Reference Books**

1. R. S. Khandpur, “Handbook of Biomedical Instrumentation”, Tata McGraw Hill
2. J. J. Carr and J. M. Brown, “Introduction to Biomedical Equipment Technology”, Pearson Education
3. Achim Schweikard, “Medical Robotics”, Springer

**Course Contents and Lecture Schedule**

| Sl. No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Human Physiology Systems and Transducers (8 hours)** | |
| 1.1 | Problems encountered in measuring living systems - Cardio-vascular – Respiratory - nervous and muscular systems of the body. | 2 |
| 1.2 | Electrode theory-Bioelectric potential - Resting and action potential - Generation and propagation. | 1 |
| 1.3 | Bioelectric potentials associated with physiology systems (ECG, EEG and EMG). | 1 |
| 1.4 | Electrodes Theory - Surface electrode - Needle electrode - Microelectrode | 2 |
| 1.5 | Transducers for the measurement of Pressure, temperature and respiration rate. | 2 |
| **2** | **Cardio Vascular System Measurements(8 hours)** | |
| 2.1 | Measurement of blood pressure – direct and indirect measurement – Oscillometric measurement –Ultrasonic method | 2 |
| 2.2 | Measurement of blood flow and cardiac output -Plethysmography – Photo electric and Impedance Plethysmographs | 3 |
| 2.3 | Measurement of heart sounds –Phonocardiography. | 1 |
| 2.4 | Electro-conduction system of the heart - Electro Cardiography – Electrodes and leads – Einthoven triangle. | 1 |
| 2.5 | ECG read out devices - ECG machine – Block diagram | 1 |
| **3** | **Nervous System and its Measurements(7 hours)** | |
| 3.1 | Neuronal communication - Measurements from the nervous system. | 1 |
| 3.2 | Electroencephalography- Lead system -10-20 Electrode system, | 1 |

| | | |
|---|---|---|
| 3.3 | EEG Block diagram - EEG waveforms and features – Brain -Computer interfacing. | 2 |
| 3.4 | Electromyography- Block diagram of EMG recorders - Nerve conduction velocity | 2 |
| 3.5 | Respiratory parameters measurements – Spiro meter - Pneumography. | 1 |
| **4** | **Modern Imaging Systems and Therapeutic Equipment(7 hours)** | |
| 4.1 | Basic X-ray machines | 1 |
| 4.2 | CAT Scanner- Principle of operation - Scanning components | 1 |
| 4.3 | Ultrasonic imaging principle - Types of Ultrasound imaging - MRI and PET scanning(Principle only). | 2 |
| 4.4 | Cardiac pace makers - De-fibrillators | 1 |
| 4.5 | Hemo-dialysis machines - Artificial kidney - Lithotripsy | 1 |
| 4.6 | Short wave and Micro wave diathermy machines | 1 |
| **5** | **Instrumentation for Patient Support and Safety(6 hours)** | |
| 5.1 | Ventilators - Heart lung machine - Infant incubators | 1 |
| 5.2 | Instruments for clinical laboratory – Test on blood cells – Chemical tests | 1 |
| 5.3 | Electrical safety– Physiological effects of electric current | 1 |
| 5.4 | Shock hazards from electrical equipment - Method of accident prevention | 1 |
| 5.5 | Introduction to tele- medicine | 1 |
| 5.6 | Introduction to medical robotics | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| 22EEE604.2 | RENEWABLE ENERGY SYSTEMS | PEC | 2 | 1 | 0 | 3 |

**Preamble** : This course introduces about different new and renewable sources of energy. Design of some of the systems are also discussed

**Prerequisite** : **Power Systems I**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Describe the environmental aspects of renewable energy resources. |
| **CO 2** | Explain the operation of various renewable energy systems. |
| **CO 3** | Design solar PV systems. |
| **CO 4** | Explain different emerging energy conversion technologies and storage. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** **:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the environmental impacts of wind energy systems. (K1)
2. Explain the limitations of renewable energy systems (K2)

**Course Outcome 2 (CO2):**

1. With the help of a block diagram, explain the working of a wind energy conversion system. (K2)

2. Explain the working of a small hydro power plant with the help of a diagram. (K2)

**Course Outcome 3 (CO3):**

1. Design a grid connected solar photovoltaic system. (K3).
2. Design a solar photovoltaic system for a water pumping system. (K3).

**Course Outcome 4 (CO4):**

1. Explain how energy can be generated from alcohol. (K2)
2. Explain the need for energy storage systems. Discuss how energy can be stored in batteries. (K2).

**Model Question paper**
**QP CODE:**

PAGES: 2

Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**
**Course Code: 22EEE604.2**

**Course Name: RENEWABLE ENERGY SYSTEMS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. What do you mean by global warming? Explain its adverse effects.
2. Write notes on Indian energy scenario.
3. Determine the local apparent time corresponding to 11.30 IST on July 1, at Delhi (280 35' N,770 12'E). The equation of time correction on July 1 is -4 minutes.
4. Draw and explain the V- I characteristics of a solar cell.
5. Define tip speed ratio, cut in speed and cut out speed of a wind turbine.
6. Explain the factors to be considered for the selection of small hydro plants.
7. Discuss the advantages and disadvantages of tidal power plants.
8. Explain the principle of operation of an OTEC plant. What are its advantages?
9. Explain how power can be derived from satellite stations.
10. Explain how energy can be stored using flywheels.

**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**
**Module 1**

11. a. Illustrate the relation between energy and sustainable development. **(4)**

b. Compare the advantages and disadvantages of different conventional sources ofenergy. **(10)**

**12.** a. Write notes on Kyoto protocol. **(4)**

b. List out the advantages and disadvantages of different non-conventional sources of energy. **(10)**

**Module 2**

13. a. With the help of a diagram, explain the working of a pyrheliometer. **(7)**

b. Explain how a standalone solar PV system can be designed. **(7)**

**14.** a. With the help of a diagram, explain the working of a flat plate collector. **(7)**

b. Explain how Maximum Power Point Tracking can be done using a buck boost converter. **(7)**

**Module 3**

15. a. Derive an expression for power derived from wind. Explain the characteristic of a wind turbine. **(7)**

b. A propeller wind machine has rotor diameter of 40 m. It is operating at location having wind speed of 35kmph and rotating at 20 rpm. Calculate theoretically the power which the machine can extract from the wind considering both wake rotation and effect of drag. Assume $\xi$=.012. **(7)**

16. a. With the help of a diagram, explain a wind energy conversion system with variable speed drive scheme. **(8)**

b. Explain the different types of turbines used in small hydro plants. **(6)**

**Module 4**

**17.** With the help of a diagram, explain the working of different types of tidal powerplants. **(14)**

18. a. With the help of a diagram, explain the working of an OTEC system using hybridcycle. **(10)**

b. Write notes on the factors to be considered for site selection of OTEC plants. **(4)**

**Module 5**

19. a. With the help of a diagram, explain biomass gasification based electric power generation. **(8)**

b. Explain the working of a fuel cell with the help of a diagram **(6)**

20. a. With the help of a diagram, explain the working of KVIC model biogas plant. **(10)**

b. Write notes on pumped storage plants (4)

## Syllabus

### Module 1

Introduction, Environmental Aspects Of Energy-Ecology-Greenhouse Effect-Global Warming-Pollution-Various Pollutants and their Harmful Effects-Green Power-The United Nations Framework Convention On Climate Change (UNFCC)- Environment-Economy-Energy and Sustainable development-Kyoto Protocol -Classification of Energy Resources; Conventional Energy Resources -Availability and their limitations; Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario.

### Module 2

SOLAR THERMAL SYSTEMS: Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data(Numerical Problems)–Pyranometer and Pyrheliometer - Solar Thermal Collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators(Parabolic trough, Parabolic dish, Central Tower Collector)

SOLAR ELECTRIC SYSTEMS: Introduction- Solar Photovoltaic –Solar Cell fundamentals, characteristics, classification, construction of Module, Panel and Array-Effect of shadowing-.Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems – stand-alone and grid connected-Design steps for a Stand-Alone system; Applications –Street lighting, Domestic lighting and Solar Water pumping systems.

### Module 3

Wind Energy–Introduction–Wind Turbine Types (HAWT and VAWT) and their construction-Wind power curve-Betz's Law-Power from a wind turbine(Numerical Problems)-Wind energy conversion system(WECS) – Fixed–speed drive scheme-Variable speed drive scheme.-Effect of wind speed and grid condition(system integration).

Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection

### Module 4

ENERGY FROM OCEAN: Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP), Classification of Tidal Power Plants, Advantages and Limitations of TPP.

Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation –Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Site-selection criteria, Biofouling, Advantages & Limitations of OTEC.

### Module 5

BIOMASS ENERGY: Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies, Urban waste to Energy Conversion, factors affecting biogas generation, types of biogas plants –KVIC and Janata model;.

EMERGING TECHNOLOGIES: Fuel Cell, Hydrogen Energy, alcohol energy and power from satellite stations.

ENERGY STORAGE: Necessity Of Energy Storage-Pumped storage-Compressed air storage-Flywheel storage-Batteries storage-Hydrogen storage.

**References:**


1. A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977
2. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001.
3. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd, Renewable energy systems, Pearson 2017
4. Boyle G. (ed.), Renewable Energy -Power for Sustainable Future, Oxford University Press, 1996
5. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
6. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978
7. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002
8. J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994
9. Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy –Sources for Fuel and Electricity, Earth scan Publications, London, 1993.
10. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
11. D.P.Kothari, K.C.Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009
12. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999.
13. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
14. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
15. Tiwari G. N., Solar Energy-Fundamentals, Design, Modelling and Applications, CRC Press, 2002.


**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Environmental impacts of various energy resources. (7 hours)** | |
| 1.1 | Introduction, Environmental Aspects Of Energy-Ecology-Greenhouse Effect-Global Warming | 1 |
| 1.2 | Pollution-Various Pollutants and their Harmful Effects-Green Power -The United Nations Framework Convention On Climate Change (UNFCC) | 2 |
| 1.3 | Environment-Economy-Energy and Sustainable development-Kyoto Protocol -Classification of Energy Resources | 1 |
| 1.4 | Conventional Energy Resources -Availability and their limitations | 1 |
| 1.5 | Non-Conventional Energy Resources –Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario. | 2 |
| **2** | **Solar radiation data, solar thermal and electric systems. (7 hours)** | |
| 2.1 | Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data(Numerical Problems)–Pyranometer and Pyrheliometer | 2 |
| 2.2 | Solar Thermal Collectors –General description and characteristics –Flat plate collectors –Heat transfer processes | 1 |

| | | |
|---|---|---|
| 2.3 | Solar concentrators(Parabolic trough, Parabolic dish, Central Tower Collector) | 1 |
| 2.4 | Solar Photovoltaic –Solar Cell fundamentals, characteristics, classification, construction of Module, Panel and Array-Effect of shadowing | 1 |
| 2.5 | Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected-Design steps for a Stand-Alone system | 1 |
| 2.6 | Applications –Street lighting, Domestic lighting and Solar Water pumping systems. | 1 |
| **3** | **Wind energy and small hydro plant (6 Hours)** | |
| 3.1 | Wind Energy–Introduction–Wind Turbine Types (HAWT and VAWT) and their construction | 1 |
| 3.2 | -Wind power curve-Betz's Law-Power from a wind turbine(Numerical Problems) | 1 |
| 3.3 | Wind energy conversion system(WECS) – Fixed–speed drive scheme- | 1 |
| 3.4 | Variable speed drive scheme.-Effect of wind speed and grid condition(system integration) | 1 |
| 3.5 | Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection | 2 |
| **4** | **Energy from ocean (7 Hours)** | |
| 4.1 | Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP) | 2 |
| 4.2 | Classification of Tidal Power Plants, Advantages and Limitations of TPP. | 1 |
| 4.3 | Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation | 1 |
| 4. 4 | Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) | 1 |
| 4. 5 | Hybrid cycle (block diagram description of OTEC) | 1 |
| 4. 6 | Site-selection criteria, Biofouling, Advantages & Limitations of OTEC. | 1 |
| **5** | **Emerging technologies (9 Hours)** | |
| 5.1 | Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies | 2 |
| 5.2 | Urban waste to Energy Conversion, factors affecting biogas generation, types of biogas plants –KVIC and Janata model | 2 |
| 5.3 | Types of biogas plants –KVIC and Janata model | 1 |
| 5.4 | Fuel Cell, Hydrogen Energy | 1 |
| 5.5 | Alcohol energy and power from satellite stations. | 1 |
| 5.6 | Necessity Of Energy Storage-Pumped storage-Compressed air storage | 1 |
| 5.7 | Flywheel storage-Batteries storage-Hydrogen storage. | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEE604.3 | COMPUTER ORGANIZATION | PEC | 2 | 1 | 0 | 3 |

**Prerequisite** : The basic objective of this course is to lay the foundation of hardware organization of digital computers. The basic organizational concepts of Processor, Control Unit, Memory and I/O units are systematically included in this course. The knowledge on interplay between various building blocks of computer is also covered in this syllabus.

**Course Outcomes** : After the completion of the course, the student will be able to:

| | |
|---|---|
| **CO 1** | Identify the functional units of a digital computer and understand the bus structure to do data transfer. |
| **CO 2** | Identify the pros and cons of different types of control unit design for various architectures |
| **CO 3** | Explain the principle of operation of ALU for typical arithmetic and logic operations |
| **CO 4** | Identify memory organization, Cache memory and virtual memory techniques. |
| **CO 5** | Select appropriate interfacing standards for I/O devices. |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | | | 1 | | | | | | | 1 |
| **CO 2** | 3 | 1 | | | | | | | | | | 1 |
| **CO 3** | 3 | 1 | | | 1 | | | | | | | 1 |
| **CO 4** | 2 | | | | | | | | | | | 1 |
| **CO 5** | 2 | | | | | | | | | | | 1 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand | 15 | 15 | 40 |
| Apply | 25 | 25 | 40 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. The register R1 = 12, and R2= 13. The instruction ADD R1, R2 is in memory location 2000H. After the execution of the instruction, write the value of PC, MAR, IR and R1. Explain the instruction cycle highlighting the sub-cycles.

2. The execution time of a program on machine X is 22 nanoseconds and execution time of the same program on machine Y is 0.1 microsecond. What is the speedup of machine X over machine Y?
3. Differentiate between RISC and CISC systems.

**Course Outcome 2 (CO2):**

4. Consider a processor having single bus organization of the data path inside a processor. Write the sequence of control steps required for instruction: Add the contents of memory location NUM to register R1.

5. With a neat block diagram, explain in detail about micro programmed control unit and explain its operations.

**Course Outcome 3 (CO3):**

6. Explain the different methods for representing integers in computer systems.
7. Explain Booth's multiplication algorithm with an example.

**Course Outcome 4 (CO4):**

8. Show the organization of virtual memory address translation based on fixed length pages
9. Illustrate the implementation of cache memory with any two mapping functions.

**Course Outcome 5 (CO5):**

10. How vectored interrupts are implemented in processors?
11. Explain DMA method of data transfer in detail with suitable diagrams

**Model Question paper**

**QP CODE:**

PAGES:2

Reg.No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEE604.3**

**Course Name:** Computer Organization

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain Von-Neumann architecture
2. Differentiate between direct and indirect addressing modes with suitable examples
3. List the steps of a typical memory read operation.
4. Explain control word and microroutine.
5. Explain floating point representation of an integer.
6. What is the binary representation of decimal number 124.25?
7. What does memory hierarchy mean? What is its significance?
8. Explain the importance of cache memory in computer system.
9. Enlist characteristics of I/O devices
10. What are vectored interrupts?

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a). With the help of a block schematic explain the basic organizational units of a digital computer. **(7)**
b). What is meant by addressing mode? Explain absolute and indirect addressing modes with suitable examples. **(7)**

12. a). With the help of suitable diagrams explain the single bus and multi bus organization of a computer **(8)**
b). Differentiate between RISC and CISC systems. **(6)**

**Module 2**

13. a). Differentiate the design and working of hard wired and micro programmed control unit. **(8)**
b). Write notes on instruction sequencing. **(6)**

14. a). Consider a 32-bit machine where an instruction (ADD R1, R2) is stored at location 102A (in hexadecimal). How many memory accesses are required to execute this instruction? In addition, what will be the content of PC after the instruction is fetched? Individual instruction is 16-bit. Also write the steps carried out for executing this instruction. **(8)**

b). Illustrate the load and store cycle with an example? **(6)**

## Module 3

15. a).Explain the different methods for representing integers in computer systems. **(6)**

b). Explain Booth's multiplication algorithm with an example. **(8)**

16. a) Illustrate the methods used for representing a character **(5)**

b). Explain non-restoring division algorithm with an example **(9)**

## Module 4

17. a) Illustrate the implementation of cache memory. **(6)**

b). Write notes on any two mapping function related to cache memory. **(8)**

18. a). How pipelining is carried out effectively in a computer system. **(8)**

b). Differentiate various pipeline hazards **(6)**

## Module 5

19. a)Explain the different types and characteristics of I/O devices. **(5)**

b).Explain DMA method of data transfer in detail. **(9)**

20. a). Explain interrupt driven I/O techniques **(9)**

b). Discuss the advantages and disadvantages of setting interrupt priorities **(5)**

## Syllabus

### Module 1

Basic Structure of Computers- functional units--Von-Neumann architecture- basic operational concepts, Introduction to buses, Measuring performance: evaluating, comparing and summarizing. Representation of Instructions: Instruction formats -Operands- Addressing modes, Instruction set architectures - CISC and RISC architectures.

### Module 2

Processor and Control Unit: Fundamental Concepts, multiple bus organization of CPU, memory read and memory write operations - Data transfer using registers. Execution of a complete instruction -sequencing of control signals. Hardwired Control, Micro programmed Control

### Module 3

Data representation: Signed number representation, fixed and floating point representations, character representation. Computer Arithmetic: Integer Addition and Subtraction - Booths Multiplication- Division- non- restoring and restoring techniques.

### Module 4

Memory Organization: - Memory cells- Basic Organization. Memory hierarchy - Caches - Cache performance - Virtual memory - Common framework for memory hierarchies Introduction to Pipelining- Pipeline Hazards

### Module 5

Input/output organisation- Characteristics of I/O devices, Data transfer schemes -Programmed controlled I/O transfer, Interrupt controlled I/O transfer. Organization of interrupts - vectored interrupts – Servicing of multiple input/output devices – Polling and daisy chaining schemes. Direct memory accessing (DMA).

### Text Books

1. Hamacher C., Z. Vranesic and S. Zaky, Computer Organization, 5/e, McGraw Hill, 2011.
2. William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson, 9/e, 2013.

### Reference Books

1. Patterson D.A. and J. L. Hennessey, Computer Organization and Design, 5/e, Morgan Kauffmann Publishers, 2013.
2. Heuring V. P. and Jordan H. F., Computer System Design and Architecture, Addison Wesely, 2/e,

**Course Contents and Lecture Schedule**

| Sl. No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Module 1 (8 hours)** | |
| 1.1 | Basic Structure of Computers- functional units-basic operational concepts | 1 |
| 1.2 | Introduction to buses,Performance of computer | 2 |
| 1.3 | Representation of Instructions: Machine instructions-Operands-Addressing modes | 2 |
| 1.4 | Instruction formats, Instruction sets, Instruction set architectures | 2 |
| 1.5 | CISC and RISC architectures. | 1 |
| **2** | **Module 2(8 hours)** | |
| 2.1 | Processor and Control Unit : Some Fundamental Concepts | 1 |
| 2.2 | Execution of a Complete Instruction | 2 |
| 2.3 | Multiple Bus Organization | 2 |
| 2.4 | Hardwired Control, Microprogrammed Control | 3 |
| **3** | **Module 3(8 hours)** | |
| 3.1 | Computer arithmetic: Signed and unsigned numbers - Addition and subtraction | 2 |
| 3.2 | Booths algorithm, | 2 |
| 3.3 | Division algorithm | 2 |
| 3.4 | Floating point representation | 2 |
| 4 | **Module 4(6 hours)** | |
| 4.1 | Memory Organization: - Memory cells- Basic Organization | 1 |
| 4.2 | Memory hierarchy - Caches - Cache performance | 2 |
| 4.3 | Virtual memory | 2 |
| 4.4 | Introduction to pipelining-pipeline Hazards | 1 |
| **5** | **Module 5(6 hours)** | |
| 5.1 | Input-Output Organization: Characteristics, data transfer schemes | 2 |

| | | |
|---|---|---|
| 5.2 | Organization of interrupts - vectored interrupts | 1 |
| 5.3 | Polling and daisy chaining schemes. | 1 |
| 5.4 | Direct memory accessing (DMA). | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| 22EEE604.4 | HIGH VOLTAGE ENGINEERING | PEC | 2 | 1 | 0 | 3 |

**Preamble** : This course introduces basic terms and techniques applicable to high voltage ac and dc networks. Generation of different type of High voltage waveforms, their measurement and analysis including the insulation coordination of different equipments and machinery used in HV applications. It also provides a basic idea of FACTS devices and testing with the help of different testing circuits.

**Prerequisite** : **Basics of Electrical Engineering / Introduction to Electrical Engineering**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Identify different high voltage and current waveform generation circuits. |
| **CO 2** | Implement different sensing & measurement techniques for high voltage and current measurement |
| **CO 3** | Describe insulation coordination and surge arrestor design |
| **CO 4** | Interpret different FACTS devices and their application in HV systems |
| **CO 5** | Implement different testing methods for equipments and applications of HV systems |

**Mapping of course outcomes with programoutcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | 2 | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | 2 | | | | | 2 |
| **CO 5** | 3 | 3 | | | | | 2 | | | | | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain generation of high voltage AC, DC, impulse voltage and impulse current (K2)

2. Problems on high voltage generator circuits (K2, K3)

**Course Outcome 2 (CO2):**

3. Explain HV measurement techniques including measurement of peak and rms values (K2)
4. Explain dielectric measurements and partial discharge measurements (K2)
5. Problems on different HV measurement techniques (K2, K3)

**Course Outcome 3 (CO3):**

6. Explain procedure of insulation coordination (K2)
7. Selection criterion of surge arrester (K2, K3)

**Course Outcome 4 (CO4):**

8. Describes general principles and main components of HVDC system (K2, K3)
9. Explain FACTS devices used in HV systems (K2)

**Course Outcome 5 (CO5):**

10. Interpret the testing methods of various components (K2,K3)
11. Explains the applications of HV in various fields (K2)

**Model Question paper**

**QP CODE:**

PAGES:2

Reg. .No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEE604.4**

**Course Name: HIGH VOLTAGE ENGINEERING**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain the principle of impulse current generation
2. Explain the working of Cockcroft-Walton voltage multiplier circuit
3. State the different factors affecting the spark over voltage of sphere gap
4. Differentiate between internal and external partial discharges
5. Explain the role of surge arrestors
6. Explain insulation coordination
7. With the help of diagram explain the working of SVC and UPFC
8. State the main components of HVDC links
9. Explain the field testing of HV transformer bushings
10. Explain the objectives of High voltage testing

**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a)With the help of diagram explain the generation of rectangular current pulses **(10)**
b)Explain impulse current generator. **(4)**

12. a) Explain the construction and operation of Marx circuit for multistage impulse generation **(10)**
b) Discuss the working principle of series resonant circuit used for the generation of high voltage AC **(4)**

**Module 2**

13. a)Explain how a sphere gap can be used for the measurement of peak voltages **(10)**
b)Explain the working principle of generating voltmeter. **(4)**

14. a) Explain the operation of Rogowski coil and how it is used for the measurement of high impulse currents. **(10)**

b) Discuss the disadvantages of sphere gap measurement. **(4)**

**Module 3**

15. a) Explain how a lightning arrestor location is selected and the rating of the arrestor is selected **(10)**

b) Differentiate between surge absorber and diverter **(4)**

16. a) An overhead line having surge impedance of 400ohms bifurcates into two lines having surge impedances 400ohm and 40 ohms respectively. Calculate the values of voltage and current for bifurcated lines if a surge voltage of 20kV incidence on the OH line **(10)**

b) Explain the role of surge arrestor as a shunt protective device. **(4)**

**Module 4**

17. Elaborate on the main components of HVDC links **(14)**

18. Explain in detail the principle and operation of series compensator andSTATCOM **(14)**

**Module 5**

19. a) Give a detailed note on insulation systems for impulse voltages **(7)**

b)Describe in detail electrostatic particle precipitation **(7)**

20. a) Explain any one method of non-disruptive testing for early detection of insulation faults **(4)**

b)List the various tests performed on high voltage cables (**10)**

## Syllabus

### Module 1

### Generation of High Voltage and Currents

Generation of High DC and AC Voltages- half-wave rectifier circuit- Cockroft-Walton voltage multiplier circuit- Electrostatic generator- Generation of high AC voltages-Cascaded Transformers- Series resonant circuit

Generation of Impulse Voltages and Currents- Impulse voltage- Impulse generator circuits- Multistage impulse generator circuit- Construction of impulse generator- Triggering of impulse generator-Impulse current generation

### Module 2

### HV measuring techniques

High Voltage Measurement Techniques -Measuring Spark Gaps - Sphere-to-sphere Spark Gap -Rod-to-rod Spark Gap - Electrostatic Voltmeter- Field Sensors - Electrically Short Sensors, Electrically Long Sensors, Potential-free Probes, Generator-mode Sensors, Electro-optical and Magneto-optical Field Sensors - Voltage Dividers - Instrument Transformers - Measurements of R.M.S. Value, Peak Value and Harmonics - Current Measurement

Dielectric measurements- Dissipation Factor and Capacitance, Insulation Resistance, Conductivity, Dielectric System Response-Partial discharge measuring technique- Requirements on a partial discharge measuring system - Measuring systems for apparent charge – Partial discharge measurements on high-voltage transformers, high-voltage cables, high-voltage gas-insulated substations

### Module 3

### Insulation Coordination and surge arresters

Classification of Voltages and Overvoltages-Origin of Overvoltages – Representative Overvoltages- Performance Criterion –Withstand voltage.

Insulation Coordination Procedure- Determination of Representative Voltages and Overvoltages-Continuous Power Frequency Voltage, Temporary Overvoltages, Slow-Front Overvoltages, Fast-Front Overvoltages

Determination of Coordination Withstand Voltage (Ucw)-Deterministic Approach, Statistical Approach: Risk of Failure - Determination of Required Withstand Voltage (Urw)-Altitude Correction Factor, Safety Factor (Ks )- Selection of Standard Withstand Voltage (Uw)- Surge Arresters- Rated Voltage- Discharge Current- Impulse Current Tests- Residual Voltages- Arrester Durability Requirements

### Module 4

### HVDC and FACTS

HVDC transmission –General principles-VSC HVDC-Main components of HVDC links- Thyristor valves, Converter transformer, Control equipment, AC filters and reactive power control, Smoothing reactor and DC filter, Switchgear, Surge arresters, Valve cooling, Auxiliary supplies

Converter building - Power electronic support for AC systems- Static var compensators (SVCs), STATCOM, Series compensators, Unified power flow controller (UPFC)

**Module 5**

**Testing of HV Systems**

High voltage Testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables
Insulation Systems for AC Voltages -Cables, bushings and transformers-Insulation Systems for DC Voltages- Capacitors, HVDC bushings and Cables-Insulation Systems for Impulse Voltages -Electrical Stress and Strength -Energy Storage -Impulse Capacitors (Energy Storage or Surge Capacitors)
Lightning Protection- Light and Laser Technology- X-ray Technology-Electrostatic Particle Precipitation, Ionization- Spark plugs

**Text Books**


1. C L Wadhwa, "High Voltage Engineering", New Age International Publishers, 2011.
2. Andreas Kuchler, " High Voltage Engineering Fundamentals – Technology – Applications", Springer, 2018


**References:**


1. Naidu M.S. and Kamaraju V., “High voltage Engineering”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2004.
2. Farouk A.M. Rizk&Giao N. Trinh, “High Voltage Engineering”, CRC Press, 2014.
3. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India P Ltd, 2005.
4. Hugh M. Ryan, “High-Voltage Engineering and Testing”, IET Power and energy series, 2013.
5. N.G. Hingorani and L.Gyugyi,“Understanding FACTS”,IEEE Press, 2000.

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Generation of High Voltage and Currents(7 hours)** | |
| 1.1 | Generation of High DC and AC Voltages- half-wave rectifier circuit-Cockcroft-Walton voltage multiplier circuit | 2 |
| 1.2 | Electrostatic generator- Generation of high AC voltages-Cascaded Transformers - Series resonant circuit | 2 |
| 1.3 | Generation of Impulse Voltages and Currents- Impulse voltage- Impulse generator circuits | 1 |
| 1.4 | Multistage impulse generator circuit- Construction of impulse generator-Triggering of impulse generator-Impulse current generation | 2 |
| **2** | **HV measuring techniques (7hours)** | |
| 2.1 | High Voltage Measurement Techniques -Measuring Spark Gaps - Sphere-to-sphere Spark Gap -Rod-to-rod Spark Gap | 1 |
| 2.2 | Electrostatic Voltmeter- Field Sensors - Electrically Short Sensors, Electrically Long Sensors, Potential-free Probes, Generator-mode Sensors, Electro-optical and Magneto-optical Field Sensors | 1 |
| 2.3 | Voltage Dividers - Instrument Transformers - Measurements of R.m.s. Value, Peak Value and Harmonics - Current Measurement | 2 |
| 2.4 | Dielectric measurements- Dissipation Factor and Capacitance, Insulation Resistance, Conductivity, | 1 |
| 2.5 | Dielectric System Response-Partial discharge measuring technique-Requirements on a partial discharge measuring system | 1 |
| 2.6 | Measuring systems for apparent charge – Partial discharge measurements on high-voltage transformers, high-voltage cables, high-voltage gas-insulated substations | 1 |
| **3** | **Insulation Coordination and surge arresters(8 Hours)** | |
| 3.1 | Classification of Voltages and Overvoltages-Origin of Overvoltages – Representative Overvoltages- Performance Criterion –Withstand voltage. | 2 |
| 3.2 | Insulation Coordination Procedure- Determination of Representative Voltages and Overvoltages-Continuous Power Frequency Voltage, Temporary Overvoltages, Slow-Front Overvoltages, Fast-Front Overvoltages | 2 |
| 3.3 | Determination of Coordination Withstand Voltage (Ucw)-Deterministic Approach, Statistical Approach: Risk of Failure - Determination of Required Withstand Voltage (Urw)-Altitude Correction Factor, Safety Factor (Ks )- Selection of Standard Withstand Voltage (Uw) | 2 |

| | | |
|---|---|---|
| 3.4 | Surge Arresters- Rated Voltage- Discharge Current- Impulse Current Tests- Residual Voltages-Arrester Durability Requirements | 2 |
| **4** | **HVDC and FACTS (6 Hours)** | |
| 4.1 | HVDC transmission –General principles-VSC HVDC -Main components of HVDC links- Thyristor valves, Converter transformer, | 2 |
| 4.2 | Control equipment, AC filters and reactive power control, Smoothing reactor and DC filter, Switchgear, Surge arresters, Valve cooling, Auxiliary supplies | 2 |
| 4.3 | Converter building - Power electronic support for AC systems- Static var compensators (SVCs), STATCOM, Series compensators, Unified power flow controller (UPFC) | 2 |
| **5** | **Testing of HV Systems (8 Hours)** | |
| 5.1 | High voltage Testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables | 2 |
| 5.2 | Insulation Systems for AC Voltages -Cables, bushings and transformers-Insulation Systems for DC Voltages- Capacitors | 2 |
| 5.3 | HVDC bushings and Cables-Insulation Systems for Impulse Voltages -Electrical Stress and Strength-Energy Storage -Impulse Capacitors (Energy Storage or Surge Capacitors) | 2 |
| 5.4 | Applications-Lightning Protection- Light and Laser Technology- X-ray Technology-Electrostatic Particle Precipitation, Ionization- Spark plugs | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEE604.6** | **MATERIAL SCIENCE** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble** **:**This course introduces different types of materials used in electrical engineering such as conductors, semiconductors, insulators, solar energy materials, biomaterials, nanomaterials, superconducting materials and magnetic materials. Also, this gives a detailed explanation on dielectrics, polarisation, modern techniques in material science and their applications.

**Prerequisite** **:Basic Electrical Engineering,Basic Electronics Engineering**

**Course Outcomes** **:**After the completion of the course, the student will be able to:

| | |
|---|---|
| **CO 1** | Describe the characteristics of conductor,semiconductor and solar energy materials. |
| **CO 2** | Classify different insulating materialsand describe polarisation in dielectrics. |
| **CO 3** | Explain the mechanisms of breakdown in solids, liquids and gases. |
| **CO 4** | Classify and describe magnetic materials and superconducting materials. |
| **CO 5** | Explain the recent developments in materials science, modern techniques and their applications in important walks of life. |

**Mapping of course outcomes with program outcomes**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | - | 1 | - | - | - | 2 | - | - | - | - | - |
| **CO 2** | 3 | - | 1 | - | - | - | - | - | - | - | - | - |
| **CO 3** | 3 | - | 1 | - | - | - | 1 | - | - | - | - | - |
| **CO 4** | 3 | - | - | - | - | - | - | - | - | - | - | - |
| **CO 5** | 3 | - | - | - | 2 | 2 | 2 | - | - | - | - | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 15 | 15 | 30 |
| Understand | 35 | 35 | 70 |
| Apply | | | |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Describe the dependence of conductivity of conductor materialson temperature and composition.
2. Compare the properties of compound, amorphous and organic semiconductors.
3. Differentiate between intrinsic and extrinsic semiconductors.
4. Derive the expression for conductivity.
5. Write notes on organic solar cell.
6. Explain the different solar selective coatings.
7. What are the different materials used for manufacturing solar cells?

**Course Outcome 2 (CO2):**

1. Derive Clausius – Mosotti Relation.
2. Explain with examples the different types of polarisation in dielectrics.
3. Classify insulating materials based on their temperature withstanding capability.
4. Explain in detail the properties and applications of SF6 gas.
5. Write short notes on Ferro electricity.
6. Describe the different capacitor materials used in various applications.

**Course Outcome 3(CO3):**

1. Explain the current voltage characteristics in Townsend's mechanism.
2. Explain the breakdown criteria in Townsend's mechanism.
3. Write notes on streamer mechanism of breakdown in gaseous dielectrics.
4. Explain any one mechanism of breakdown in vacuum insulation.
5. Describe with necessary diagram the treatment of transformer oil.
6. With the help of a circuit diagram, explain the testing of transformer oil.
7. Compare the suspended particle theory and bubble theory mechanisms of breakdown in liquid dielectrics.
8. Write short notes on any one mechanisms of breakdown in solid dielectrics.

**Course Outcome 4 (CO4):**

1. How are magnetic materials classified?
2. Differentiate between soft and hard magnetic materials.
3. Explain Curie – Weiss law.
4. Write short notes on Ferrites.
5. Define Superconductivity. Explain the characteristics of superconductors.
6. Differentiate between type I and type II superconductors.

**Course Outcome 5 (CO5):**

1. Compare the top-down and bottom-up growth techniques of nanomaterials.
2. Mention the names of any three non-lithographic growth techniques.Explainany one in detail.
3. Write short notes on Scanning Probe Microscopy.
4. What is a transmission electron microscope?
5. Write a short note on Carbon nanotube.
6. What are the applications of biomaterials?

**Model Question paper**

**QP CODE:**

PAGES:2

Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR**

**Course Code: 22EEE604.6**

**Course Name: MATERIAL SCIENCE**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

17. What are the different materials used for manufacturing solar cells?
18. What is an organic solar cell? Explain.
19. Explain the concept of Ferro-electricity.
20. Mention the different types of polarisation in dielectrics.
21. What is treeing and tracking? Explain.
22. Draw the current-voltage characteristics in Townsend's mechanism.
23. How are magnetic materials classified?
24. Why do certain materials exhibit superconductivity?
25. Write a short note on Carbon nanotube.
26. What are the applications of biomaterials?

**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

27. a) What is the effect of alloying of metals in their conduction? Illustrate with an example. **(5)**

b) Compare the properties of compound, amorphous and organic semiconductors. **(9)**

28. a) Derive the expression for conductivity. Describe the dependence of conductivity of conductor materials on temperature and composition. **(9)**

b) What is intrinsic breakdown? **(5)**

## Module 2

29. a)Derive Clausius-Mosotti relation. **(7)**
    b)Classify insulating materials based on their temperature withstanding capability. **(7)**
30. a) Explain in detail the properties and applications of SF6 gas. **(4)**

    b) Describe the different capacitor materials used in various applications. **(10)**

## Module 3

31. a)Compare the suspended particle theory and bubble theory mechanisms of breakdown in liquid dielectrics. **(10)**
    b) List out the breakdown criteria in Townsend's mechanism. **(4)**
32. a) What is meant by transformer oil testing? Why is it done? Explain the tests on transformer oil. **(9)**

    b) Elucidate any one mechanism of breakdown in vacuum. **(5)**

## Module 4

33. a) Discuss the application of magnetic materials used in electrical machines, instruments and relays. Justify with reasons. **(10)**

    b) Write short notes on Ferrites. **(4)**

34. a) What do you mean by superconductivity? Explain the characteristics and properties of superconducting materials. **(8)**
    b) What are type I and type II superconductors? **(6)**

## Module 5

35. a) Compare the top-down and bottom-up growth techniques of nanomaterials. **(8)**

    b) Write short notes on Scanning Probe Microscopy. **(6)**

36. a) Mention the names of any three nonlithographic growth techniques. Explain any one in detail. **(8)**
    b) What is a transmission electron microscope? **(6)**

## Syllabus

### Module 1

Conducting Materials: Conductivity- dependence ontemperature and composition – Materials for electricalapplications such as resistance, machines, solders etc.

Semiconductor Materials: Concept, materials and properties– Basic ideas of Compound semiconductors, amorphous andorganic semiconductors- applications.

Solar Energy Materials: Solar selective coatings for enhanced solar thermal energy collection. Solar cells -Silicon, Cadmium sulphide and Gallium arsenic – Organic solar cells.

### Module 2

Dielectrics: Introduction to Dielectric polarization andclassification–Clausius-Mosotti relation.

Insulating materials and classification- properties- Common insulating materials used in electrical apparatus-Inorganic, organic, liquid and gaseous insulators- capacitor materials.

Electro-negative gases- properties and applications of SF6 gas and its mixtures with nitrogen
Ferro electricity.

### Module 3

Dielectric Breakdown: Mechanism of breakdown in gases, liquids and solids –basic theories including Townsend's criterion, Streamer mechanism.

Mechanism of breakdown in liquids and solids - suspended particle theory, Bubble theory, Stressed oil Volume Theory, intrinsic breakdown, electro-mechanical breakdown, Thermal breakdown, Treeing and Tracking.

Application of vacuum insulation- Breakdown in high vacuum.
Basics of treatment and testing of transformer oil.

### Module 4

Magnetic Materials: Classification of magnetic materials -Curie-Weiss law-Application of iron and its alloys- Hard and soft magnetic materials– Ferrites- Magnetic materials used in electrical apparatus.

Superconductor Materials:-Basic Concept- types, characteristics- applications.

### Module 5

Novel materials: Introduction to Biomaterials, Nano-materials and their significance. Growth techniques of nano-materials – Top-down and Bottom-up techniques, Lithographic and Non-lithographic processes (qualitative study only), Characterisation tools of nanomaterials – SPM, AFM, SEM and TEM (qualitative study only), Special topics in nanotechnology – nanostructures of carbon, nanoelectronics, nanobiometrics(qualitative study only).

**Text Books**

1. Dekker A.J.: Electrical Engineering Materials, Prentice Hall of India.
2. G.K.Mithal: Electrical Engineering Material Science. Khanna Publishers.
3. K.K. Chattopadhyay, A. N. Banerjee: Introduction to nanoscience and nanotechnology, PHI Learning Pvt. Ltd.

**Reference Books**

1. Naidu M. S. and V. Kamaraju, *High Voltage Engineering*, Tata McGraw Hill, 2004
2. Indulkar O.S.&Thiruvegadam S., An Introduction to Electrical Engineering Materials, S.Chand.
3. Joon Bu Park, Biomaterials Science and Engineering, Plenum Press, New York, 1984

**Course Contents and Lecture Schedule**

| Sl. No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Conducting Materials, Dielectrics, Semiconductors (8 hours)** | |
| 1.1 | Conducting Materials: Conductivity | 1 |
| 1.2 | Dependence ontemperature and composition – Materials for electricalapplications such as resistance, machines, solders etc | 2 |
| 1.3 | Semiconductor Materials: Concept, materials and properties | 2 |
| 1.4 | Basic ideas of Compound semiconductors, amorphous andorganic semiconductors- applications. | 1 |
| 1.5 | Solar Energy Materials: Solar selective coatings for enhanced solar thermal energy collection. | 1 |
| 1.6 | Solar cells -Silicon, Cadmium sulphide and Gallium arsenic – Organic solar cells. | 1 |
| **2** | **Insulating materials(8 hours)** | |
| 2.1 | Dielectrics: Introduction to Dielectric polarization andclassification. | 1 |
| 2.2 | Clausius- Mosotti relation. | 1 |
| 2.3 | Insulating materials and classification- properties | 2 |
| 2.4 | Common insulating materials used in electrical apparatus-Inorganic,organic, liquid and gaseous insulators- capacitor materials. | 1 |
| 2.5 | Electro-negative gases- properties and applications of SF6 gas and itsmixtures with nitrogen. | 2 |
| 2.6 | Ferro electricity | 1 |

| | | |
|---|---|---|
| **3** | **Dielectric Breakdown(8hours)** | |
| 3.1 | Mechanism of breakdown in gases– Townsend's criterion | 2 |
| 3.2 | Streamer theory | 1 |
| 3.3 | Mechanism of breakdown in liquids - suspended particle theory, Bubble theory, Stressed oil Volume Theory. | 1 |
| 3.4 | Mechanism of breakdown in solids - intrinsic breakdown, electro-mechanical breakdown, Thermal breakdown, Treeing and Tracking. | 1 |
| 3.5 | Application of vacuum insulation- Breakdown in high vacuum. | 1 |
| 3.6 | Basics of treatment and testing of transformer oil | 2 |
| **4** | **Magnetic Materials, Superconductors, Solar Energy materials (5 hours)** | |
| 4.1 | Magnetic Materials: Classification of magnetic materials –Curie-Weiss law | 1 |
| 4.2 | Application of iron and its alloys- Hard and soft magnetic materials– Ferrites- Magnetic materials used in electrical apparatus. | 2 |
| 4.3 | Superconductor Materials:-Basic Concept- types, characteristics-applications. | 2 |
| **5** | **Novel materials(7 hours)** | |
| 5.1 | Introduction to biomaterials, nanomaterials and their significance | 2 |
| 5.2 | Growth techniques of nano materials-Top-down and Bottom-up techniques, Lithographic and Non-lithographic processes | 2 |
| 5.3 | Characterisation tools of nanomaterials – SPM, AFM, SEM and TEM | 2 |
| 5.4 | Special topics in nanotechnology – nanostructures of carbon, nanoelectronics, nanobiometrics | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEE604.7** | **SOFT COMPUTING** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble** : This course gives an introduction to some new fields in soft computing.It combines the fundamentals of neural network, fuzzy logic, and genetic algorithm which in turn offers the superiority of humanlike problem solving capabilities. This course provides a broad introduction to machine learning, data clustering algorithms and support vector machines.

**Prerequisite : Digital Electronics**

**Course Outcomes** : After the completion of the course, the student will be able to:

| | |
|---|---|
| **CO 1** | Explain various constituents of soft computing and artificial neural networks. |
| **CO 2** | Explain the different learning methods for training of ANNs. |
| **CO 3** | Apply fuzzy logic techniques to control a system. |
| **CO 4** | Utilize genetic algorithm techniques to find the optimal solution of a given problem. |
| **CO 5** | Explain the basics of machine learning, data clustering algorithms and support vector machines. |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | - | - | - | - | - | - | - | - | - | - | 2 |
| **CO 2** | 3 | 1 | 1 | 1 | - | - | - | - | - | - | - | 2 |
| **CO 3** | 3 | 1 | 1 | 1 | 2 | - | - | - | - | - | - | 2 |
| **CO 4** | 3 | 1 | 1 | 1 | - | - | - | - | - | - | - | 2 |
| **CO 5** | 3 | 1 | 2 | 1 | 2 | - | - | - | - | - | - | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand | 20 | 20 | 40 |
| Apply | 20 | 20 | 40 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Compare Soft and Hard computing.
2. Define ANN. What are the characteristics of ANN?
3. Realize using McCulloch Pitts neuron model (i) a 2-input AND logic and (ii) a 2-input NOR logic considering +1 as the bias value of the neuron.
4. Draw the non-linear model of a neuron and explain the basic elements of the neuronal model.
5. Explain any five types of activation functions used in neural network models.
6. Explain how a biological neuron transmits signals in the human brain with the help of neat diagrams.

**Course Outcome 2 (CO2):**

1. Describe learning. What are the different learning methods in ANN?
2. Explain the different architectures of neural networks.
3. Explain error correction learning algorithm.
4. What is meant by feedforward network? Compare SLFFN and MLFFN.
5. Compare supervised learning and unsupervised learning methods.
6. Derive the expression for local gradient of an output neuron, in back propagation algorithm.

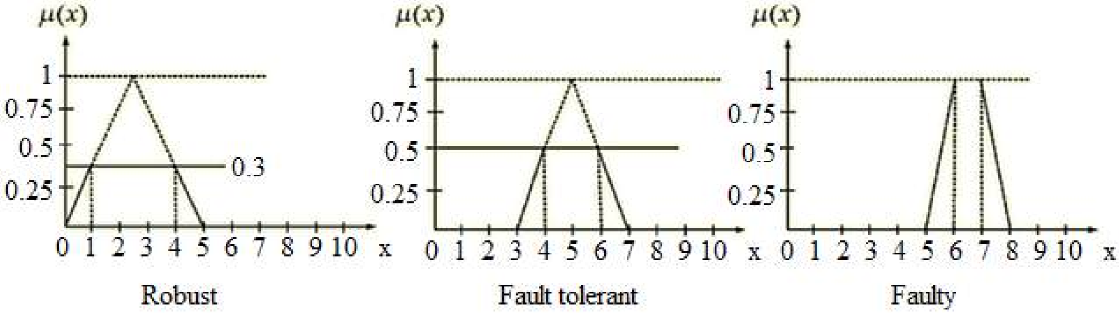
**Course Outcome 3(CO3):**

1. Define membership function. Also give any three features of a membership function.
2. Define (i) core (ii) support (iii) boundary and crossover points of membership function.
3. Given two fuzzy sets:
   $\tilde{A}$ : Mary is efficient, T ($\tilde{A}$) = 0.8
   $\tilde{B}$ : Ram is efficient, T ($\tilde{B}$) = 0.65
   Find (i) Mary is not efficient (ii) Mary is efficient and so is Ram (iii) Either Mary or Ram is efficient (iv) If Mary is efficient.
4. P represents a set of four varieties of paddy plants, D represents the four diseases affecting the plants, and S represents the common symptoms of the diseases. $P=\{P_1,P_2,P_3,P_4\}, D=\{D_1,D_2,D_3,D_4\}, S=\{S_1,S_2,S_3,S_4\}$. R is a relation on $P\times D$ representing which plant is susceptible to which diseases and T is another relation on $D\times S$ and is stated as

$$R=\begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array}\begin{array}{c} \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{bmatrix} 0.6 & 0.6 & 0.9 & 0.8 \\ 0.1 & 0.2 & 0.9 & 0.8 \\ 0.9 & 0.3 & 0.4 & 0.8 \\ 0.9 & 0.8 & 0.4 & 0.2 \end{bmatrix} \end{array}, \qquad T=\begin{array}{c} \\ D_1 \\ D_2 \\ D_3 \\ D_4 \end{array}\begin{array}{c} \begin{array}{cccc} S_1 & S_2 & S_3 & S_4 \end{array} \\ \begin{bmatrix} 0.1 & 0.2 & 0.7 & 0.9 \\ 1 & 1 & 1 & 0.6 \\ 0 & 0 & 0.5 & 0.9 \\ 0.9 & 1 & 0.8 & 0.2 \end{bmatrix} \end{array}$$

   Obtain the association of plants with the different symptoms of the disease using max-min composition.
5. Discuss any two common membership functions used in fuzzy logic.
6. $\tilde{A}=\{(x_1,0.3),(x_2,0.5),(x_3,0.6)\}, \tilde{B}=\{(x_1,0.2),(x_2,0.8),(x_3,0.9)\}$. Find (i) $\tilde{A}\cup\tilde{B}$ (ii) $\tilde{A}\cap\tilde{B}$ (iii) $\tilde{A}-\tilde{B}$ (iv) $\tilde{A}\oplus\tilde{B}$.

7. List out the various operations on Fuzzy sets.
8. Explain simple fuzzy logic controllers.
9. The faulty measure of a circuit is defined fuzzily by three fuzzy sets namely Robust (*R*), Fault tolerant (*FT*) and Faulty (*F*), defined by three membership functions with number of faults occur, as universe of discourse as




Reliability is measured as $r = R \cup FT \cup F$ . Determine the crisp value of *r* using centroid method, COS method and weighted average methods of defuzzification.

**Course Outcome 4 (CO4):**

1. Draw a neat architecture of Adaptive Neuro Fuzzy Inference System (ANFIS)**.**
2. Explain any two types of encoding used in GA.
3. Discuss selection operation in GA. Explain briefly Roulette wheel selection.
4. What is Genetic Algorithm? What are the various methods of selecting chromosomes of parents to crossover?
5. What is crossover? Explain any three types of crossover operators in GA.
6. Define (i) Population (ii) Fitness (iii) Selection (iv) Mutation.

**Course Outcome 5 (CO5):**

1. What is “Machine Learning”? Give examples of learning machines.
2. Explain different types of machine learning models.
3. Explain different types of Machine Learning Architecture.
4. Explain, K-Means Clustering algorithm. What are its applications?
5. Compare SVM and SVR.
6. ExplainHierarchical clustering technique. What are its limitations?

**Model Question paper**

**QP CODE:**

PAGES:2

Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR**

**Course Code: 22EEE604.7**

**Course Name: SOFT COMPUTING**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks.**

1. Compare the structure of a biological neuron with an artificial neuron.
2. What is a perceptron? Explain the training process in perceptron.
3. Describe learning. What are the different learning methods in ANN?
4. Explain the architecture of a Hopfield network.
5. The two fuzzy sets representing an *apple* and an *orange* are:

$$Apple = \left\{ \frac{0.4}{orange} + \frac{0.5}{chair} + \frac{0.8}{table} + \frac{0.9}{apple} + \frac{0.3}{plate} \right\}$$
$$Orange = \left\{ \frac{0.6}{orange} + \frac{0.3}{chair} + \frac{0.4}{table} + \frac{0.5}{apple} + \frac{0.4}{plate} \right\}$$

Find the following:

$i)\, Apple \cup \overline{Orange}\;\; ii)\, Apple \cap Orange\;\; iii)\, \overline{Apple \cap Orange}$
$iv)\, Apple \cup \overline{Apple}$

6. With a neat block diagram, explain the fuzzy inference system.
7. Write short notes on any two methods used for selection process in GA.
8. Explain two different types of crossover used in a genetic algorithm.
9. What is a linear learning machine?
10. List out any 4 applications of support vector machines.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks.**

**Module I**

| | | | |
|---|---|---|---|
| 11 | a | Realize using McCulloch Pitts neuron model (i) a 2-input AND logic and (ii) a 2-input NOR logic considering +1 as the bias value of the neuron. | **(9)** |
| | b | Explain any five types of activation functions used in neural network models. | **(5)** |

| | | | |
|---|---|---|---|
| 12 | a | Explain the architecture of ADALINE and MADALINE networks. | **(9)** |
| | b | Draw the non-linear model of a neuron and explain the basic elements of the neuronal model. | **(5)** |

## Module II

| | | | |
|---|---|---|---|
| 13 | a | Explain back propagation algorithm with the help of a block diagram and a suitable example. | **(9)** |
| | b | Explain radial basis function network. | **(5)** |
| 14 | a | Explain reinforcement learning with the help of a block diagram. | **(7)** |
| | b | Explain Kohonen Self organizing map. | **(7)** |

## Module III

15 a P represents a set of four varieties of paddy plants, D represents the four diseases affecting the plants, and S represents the common symptoms of the diseases. $P=\{P_1,P_2,P_3,P_4\}, D=\{D_1,D_2,D_3,D_4\}, S=\{S_1,S_2,S_3,S_4\}$. R is a relation on $P\times D$ representing which plant is susceptible to which diseases and T is another relation on $D\times S$ and is stated as **(9)**

$$R=\begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array}\begin{array}{c} \begin{array}{cccc} D_1 & D_2 & D_3 & D_4 \end{array} \\ \begin{bmatrix} 0.6 & 0.6 & 0.9 & 0.8 \\ 0.1 & 0.2 & 0.9 & 0.8 \\ 0.9 & 0.3 & 0.4 & 0.8 \\ 0.9 & 0.8 & 0.4 & 0.2 \end{bmatrix} \end{array}, \qquad T=\begin{array}{c} \\ D_1 \\ D_2 \\ D_3 \\ D_4 \end{array}\begin{array}{c} \begin{array}{cccc} S_1 & S_2 & S_3 & S_4 \end{array} \\ \begin{bmatrix} 0.1 & 0.2 & 0.7 & 0.9 \\ 1 & 1 & 1 & 0.6 \\ 0 & 0 & 0.5 & 0.9 \\ 0.9 & 1 & 0.8 & 0.2 \end{bmatrix} \end{array}$$

Obtain the association of plants with the different symptoms of the disease using max-min composition.

| | | | |
|---|---|---|---|
| | b | Discuss any two common membership functions used in fuzzy logic. | **(5)** |
| 16 | | With the help of an example, explain the working of a fuzzy logic controller. | **(14)** |

## *Module IV*

| | | | |
|---|---|---|---|
| 17 | a | Describe the steps involved in solving an optimization problem using Genetic Algorithm. Illustrate the steps with a suitable example | **(14)** |
| 18 | a | Explain Adaptive Neuro-Fuzzy Inference System (ANFIS) with the help of a block diagram. | **(9)** |
| | b | What is the role of 'mutation' in GA based optimizationprocess? What is the usual range of probability value given for mutation process**?** | **(5)** |

## *Module V*

| | | | |
|---|---|---|---|
| 19 | a | Describe Machine Learning. Write any three applications | **(9)** |
| | b | Briefly explain any one clustering algorithm with example. | **(5)** |
| 20 | a | Explain support vector regression. List any 2 applications. | **(9)** |
| | b | What are the common distance measures used in clustering algorithms? | **(5)** |

## Syllabus

### Module 1

Introduction: Soft and Hard Computing, Evolution of soft computing, Soft computing constituents.

Artificial Neural Networks: Biological foundations –ANN models - Characteristics of ANN- Types of activation function - McCulloch-Pitts neuron model, Realization of logic gates using McCulloch-Pitts neuron model - simple perceptron, Adaline and Madaline.

### Module 2

Neural network architectures - single layer, multilayer, recurrent networks.

Knowledge representation - Learning process - Supervised and unsupervised learning, Learning algorithms–Errorcorrection learning - Hebbian learning – Boltzmann learning - competitive learning- Backpropagation algorithm- Case study-Radial basis function networks - Hopfield network- Kohonen Self organizing maps

### Module 3

Fuzzy Logic: Introduction to crisp sets and fuzzy sets, examples, Properties, Basic fuzzy set operations, examples. Fuzzy relations - Cardinality of Fuzzy relations - Operations on Fuzzy relations - Properties of Fuzzy relations. Membership functions - triangular, trapezoidal, bell shaped, Gaussian, sigmoidal.

Fuzzy logic controller (Block Diagram), Fuzzification, rule base, inference engine and defuzzification - Max-membership principle, Centroid method, Weighted Average Method, Mean-Max membership, Center of Sums, and Center of Largest area, First and Last of Maxima.

Simple fuzzy logic controllers with examples.

### Module 4

Genetic Algorithm: Introduction - basic concepts of Genetic Algorithm, encoding, fitness function, reproduction, cross over, mutation operator, bit-wise operators, generational cycle.

Hybrid Systems: Adaptive Neuro Fuzzy Inference System (ANFIS), Genetic algorithm based back propagation networks, fuzzy back propagation networks.

### Module 5

Machine Learning- Machine learning model-Approaches to machine learning- Machine learning architecture- Data Clustering Algorithms -Hierarchical clustering, K-Means Clustering

Support Vector Machines for Learning – Linear Learning Machines – Support Vector Classification – Support Vector Regression - Applications.

### Reference Books


1. S.Rajasekharan, G.A.Vijayalakshmi Pai, *Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications*, Prentice Hall India, 2003.
2. S.N.Sivanandam, S.N.Deepa, *Principles of Soft Computing*, Wiley India, 2007.
3. Simon Haykin, *Neural Networks a Comprehensive foundation*, Pearson Education, 1999.
4. Bart Kosko, *Neural Network and Fuzzy Systems*, Prentice Hall of India, 2002
5. Zurada J.M., *Introduction to Artificial Neural Systems*, Jaico Publishers, 2003.

6. Hassoun Mohammed H, *Fundamentals of Artificial Neural Networks*, Prentice Hall of India, 2002.J.-S.R.Jang, C.-T.Sun,E.Mizutani, *Neuro-Fuzzy and Soft Computing*, Prentice Hall, 1997.
7. Timothy J Ross, *Fuzzy logic with Engineering Applications*, McGraw Hill, New York.
8. Driankov D., Hellendoorn H., Reinfrank M, *An Introduction to Fuzzy Control*, Narosa Publications, 1993.
9. Ronald R Yager and Dimitar P Filev, *Essentials of Fuzzy Modelling & Control*, John Wiley & Sons, Inc, 2002.
10. SuranGoonatilake& Sukhdev Khebbal (Eds.), *Intelligent Hybrid Systems*, John Wiley,1995.
11. D.E.Goldberg, *Genetic Algorithms in Search Optimisation and Machine Learning*, Pearson Education, 1989.
12. Tom Mitchell,*Machine Learning*, McGraw Hill, 1997
13. Margaret H. Dunham, *Data Mining- Introductory & Advanced Topics*, Pearson Publication

**Course Contents and Lecture Schedule**

| Sl. No. | Topic | No. of Lectures |
|---|---|---|
| **1** | ***Introduction to Artificial Neural Networks*** | **5 hrs** |
| 1.1 | Introduction to soft computing, soft and hard Computing, Soft computing constituents | 1 |
| 1.2 | ANN- Biological foundations - ANN models - Characteristics of ANN - Types of activation function. | 1 |
| 1.3 | McCulloch-Pitts neuron model, Realization of logic gates using McCulloch-Pitts neuron model. | 2 |
| 1.4 | Simple perceptron, Adaline and Madaline. | 1 |
| **2** | ***Neural network architectures and Learning*** | **7 hrs** |
| 2.1 | Neural network architectures - single layer, multilayer, recurrent networks, Knowledge representation. | 1 |
| 2.2 | Learning process: Supervised and unsupervised learning. Learning algorithms- Errorcorrection learning. | 1 |
| 2.3 | Hebbian learning – Boltzmann learning - competitive learning. | 1 |
| 2.4 | Back propagation networks | 1 |
| 2.5 | Radial basis function networks - Hopfield network. | 2 |
| 2.6 | Kohonen Self organizing maps | 1 |
| **3** | ***Introduction to Fuzzy Logic*** | **11 hrs** |
| 3.1 | Introduction to crisp sets and fuzzy sets, examples, Properties. | 1 |
| 3.2 | Basic fuzzy set operations, examples. | 1 |
| 3.3 | Fuzzy relations- Cardinality of Fuzzy relations - Operations on Fuzzy relations - Properties of Fuzzy relations. | 2 |
| 3.4 | Membership functions - triangular, trapezoidal, bell shaped, Gaussian, sigmoidal. | 1 |

| | | |
|---|---|---|
| 3.5 | Fuzzy logic controller (Block Diagram), Fuzzification, rule base, inference engine | 2 |
| 3.6 | Defuzzification - Max-membership principle, Centroid method, Weighted Average Method, Mean-Max membership, Center of Sums, and Center of Largest area, First and Last of Maxima, Example problems. | 2 |
| 3.7 | Simple fuzzy logic controllers with examples | 2 |
| **4** | ***Introduction to Genetic Algorithms and Hybrid Systems*** | **7 hrs** |
| 4.1 | Basic concepts of Genetic Algorithm – encoding - fitness function – reproduction - cross over - mutation operator - bit-wise operators, generational cycle. | 3 |
| 4.2 | Hybrid Systems: Adaptive Neuro fuzzy Inference System (ANF1S) | 2 |
| 4.3 | Genetic algorithm based back propagation networks | 1 |
| 4.4 | Fuzzy back propagation networks | 1 |
| **5** | ***Introduction to Machine Learning*** | **6 hrs** |
| 5.1 | Machine Learning- Machine learning model- Approaches to machine learning- Machine learning architecture | **2** |
| 5.2 | Data Clustering Algorithms - Hierarchical clustering, K-Means Clustering | **2** |
| 5.3 | Support Vector Machines for Learning Support Vector Classification – Support Vector Regression - Applications | **2** |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EET607 | COMPREHENSIVE COURSE WORK | PCC | 1 | 0 | 0 | 1 |

**Preamble:** The objective of this Course work is to ensure the comprehensive knowledge of each student in the most fundamental Program core courses in the curriculum. Five core courses credited from Semesters 3, 4 and 5 are chosen for the detailed study in this course work. This course has an End Semester Objective Test conducted by the University for 50 marks. One hour is assigned per week for this course for conducting mock tests of objective nature in all the listed five courses.

**Prerequisite:** 1.EET 201 Circuits and Networks
2. EET 202 DC Machines and Transformers
3. EET 206 Digital Electronics
4. EET 301 Power Systems I
5. EET 305 Signals and Systems

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Apply the knowledge of circuit theorems to solve the problems in electrical networks |
| **CO 2** | Evaluate the performance of DC machines and Transformers under different loading conditions |
| **CO 3** | Identify appropriate digital components to realise any combinational or sequential logic. |
| **CO 4** | Apply the knowledge of Power generation, transmission and distribution to select appropriate components for power system operation. |
| **CO 5** | Apply appropriate mathematical concepts to analyse continuous time and discrete time signals and systems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 2 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | 1 | | 1 | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | 1 | 1 | 1 | | | 1 | 2 |
| **CO 5** | 3 | 3 | 1 | | 1 | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | End Semester Examination |
|---|---|
| Remember | 10 |
| Understand | 20 |
| Apply | 20 |
| Analyse | |
| Evaluate | |
| Create | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 50 | 0 | 50 | 1 hour |

**End Semester Examination Pattern:** Objective Questions with multiple choice (Four). Question paper include Fifty Questions of One mark each covering the five identified courses.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. A circuit with resistor, inductor and capacitor in series is resonant at $f_0$ Hz. If all the component values are now doubled, the new resonant frequency is

a) 2 $f_0$
b) Still $f_0$
c) $f_0$ /2
d) $f_0$ /4

2. The line A to neutral voltage is $10<15^0$ V for a balance three phase star connected load with phase sequence ABC. The voltage of line B with respect to line C is given by

a) $10\sqrt{3}<105^0$ V
b) $10<105^0$ V
c) $10\sqrt{3}<75^0$ V
d) $-10\sqrt{3}<90^0$ V

3. The average power delivered to an impedance (4-j3)Ω by a current $5\cos(100\pi t+100)$A is

a) 44.2 W
b) 50 W
c) 62.5 W
d) 125 W

**Course Outcome 2 (CO2)**

1. The DC motor which can provide zero speed regulation at full load without any controller is

a) Series
b) Shunt
c) Cumulatively compound
d) Differentially compound

2. For a single phase, two winding transformer, the supply frequency and voltage are both increased by 10%. The percentage changes in the hysteresis and eddy current loss, respectively are

a) 10 and 21
b) -10 and 21
c) 21 and 10
d) -21 and 10

3. Match the following

| List I-Performance Variables | List II-Proportional to |
|---|---|
| A. Armature emf (E) | 1. Flux (ϕ), speed ($\omega$), Armature Current(Ia) |
| B. Developed Torque (T) | 2. ϕ and $\omega$ only |
| C. Developed Power (P) | 3. ϕ and Ia only |
| | 4. Ia and $\omega$ only |
| | 5. Ia only |

Choices:

| | A | B | C |
|---|---|---|---|
| a) | 3 | 3 | 1 |
| b) | 2 | 5 | 4 |
| c) | 3 | 5 | 4 |
| d) | 2 | 3 | 1 |

**Course Outcome 3(CO3):**

1. The SOP (sum of products) form of a Boolean function is ∑(0, 1, 3, 7, 11), where inputs are A, B, C, D (A is MSB and D is LSB). The equivalent minimized expression of the function is

a) (B’+C)(A’+C)(A’+B’)(C’+D)
b) (B’+C)(A’+C)(A’+C’)(C’+D)
c) (B’+C)(A’+C)(A’+C’)(C’+D’)
d) (B’+C)(A+B’)(A’+B’)(C’+D)

2. A cascade of three identical modulo-5 counters has an overall modulus of

a) 5
b) 25
c) 125
d) 625

3. The octal equivalent of the HEX number AB.CD is

a) 253.314
b) 253.632
c) 526.314
d) 526.632

**Course Outcome 4 (CO4):**

1. Corona losses are minimized when

a) Conductor size is reduced
b) Smoothness of the conductor is reduced
c) Sharp points are provided in the line hardware
d) Current density in the conductors is reduced

2. Keeping in view the cost and overall effectiveness, the following Circuit Breaker is best suited for capacitor bank switching

a) Vacuum
b) Air Blast
c) $SF_6$
d) Oil

3. The horizontally placed conductors of a single phase line operating at 50Hz are having outside diameter of 1.6cm and the spacing between centres of the conductors is 6m. The permittivity of free space is 8.854 x $10^{-12}$ F/m. The capacitance to ground per kilometre of each line is

a) 4.2 x $10^{-9}$ F
b) 4.2 x $10^{-12}$ F
c) 8.4 x $10^{-9}$ F
d) 8.4 x $10^{-12}$ F

**Course Outcome 5 (CO5):**

1. Consider a continuous time system with input x(t) and output y(t) given by y(t)=x(t)cos(t). This system is

a) Linear and time invariant
b) Non-linear and time invariant
c) Linear and time varying
d) Non-linear time varying

2. Signal Flow Graph is used to obtain

a) Stability of the system
b) Transfer Function of a system
c) Controllability of a system
d) Observability of a system

3. The steady state error due to a step input for Type 1 system is

a) Zero
b) Infinity
c) 1
d) 0.5

**Syllabus**

Full Syllabus of all Five selected Courses.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Circuits and Networks | |
| 1.1 | Mock Test on Module 1 and Module 2 | 1 |
| 1.2 | Mock Test on Module 3, Module 4 and Module 5 | 1 |
| 1.3 | Feedback and Remedial | 1 |
| 2 | DC Machines and Transformers | |
| 2.1 | Mock Test on Module 1, Module 2 and Module 3 | 1 |
| 2.2 | Mock Test on Module 4 and Module 5 | 1 |
| 2.3 | Feedback and Remedial | 1 |
| 3 | Digital Electronics | |
| 3.1 | Mock Test on Module 1 and Module 2 | 1 |
| 3.2 | Mock Test on Module 3, Module 4 and Module 5 | 1 |
| 3.3 | Feedback and Remedial | 1 |
| 4 | Power Systems I | |
| 4.1 | Mock Test on Module 1, Module 2 and Module 3 | 1 |
| 4.2 | Mock Test on Module 4 and Module 5 | 1 |
| 4.3 | Mock Test on Module 1, Module 2 and Module 3 | 1 |
| 5 | Signals and Systems | |
| 5.1 | Mock Test on Module 1, Module 2 and Module 3 | 1 |
| 5.2 | Mock Test on Module 4 and Module 5 | 1 |
| 5.3 | Feedback and Remedial | 1 |

| CODE | COURSE | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEL608** | **POWER SYSTEMS LAB** | PCC | 0 | 0 | 3 | 2 |

**Preamble** : This Laboratory Course will provide a perfect platform for the students to do hands-on practise with hardware and software in Power Systems. The experiments include simulation of power system analysis in steady state and transient state. The Hardware experiments cover Protective Relaying and High Voltage Testing. Successful completion of this lab will certainly make the students equipped for any Power Industry.

**Prerequisite** : EET301 Power Systems I

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Develop mathematical models and conduct steady state and transient analysis of power system networks using standard software. |
| **CO 2** | Develop a frequency domain model of power system networks and conduct the stability analysis. |
| **CO 3** | Conduct appropriate tests for any power system component as per standards. |
| **CO 4** | Conduct site inspection and evaluate performance ratio of solar power plant. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | 3 | 3 | | | 3 | 2 | 3 | | 3 |
| **CO 2** | 3 | 2 | 1 | 3 | 3 | | | 1 | 2 | 3 | | 2 |
| **CO 3** | 3 | 1 | 1 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | | 3 |
| **CO 4** | 3 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |

**ASSESSMENT PATTERN:**

**Mark distribution** :

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 75 | 75 | 3 hours |

**Continuous Internal Evaluation (CIE) Pattern:**

| Attendance | Regular Lab work | Internal Test | Course Project | Total |
|---|---|---|---|---|
| 15 | 30 | 25 | 5 | 75 |

Internal Test Evaluation (Immediately before the second series test)

**End Semester Examination Pattern:**

The following guidelines should be followed regarding award of marks:

(a) Preliminary work ( Type of Test, circuit diagram and diagram for simulation) : 15 Marks
(b) Simulation in software and Conducting the experiment (Procedure) : 10 Marks

(c) Performance, result and inference (usage of equipment and troubleshooting) : 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

**General instructions :** Practical examination to be conducted immediately after the second series test covering the entire syllabus given. Each student has to do both software and hardware parts for the examination. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

**LIST OF EXPERIMENTS:**

**Part A: POWER SYSTEM SIMULATION EXPERIMENTS**

1. Y-Bus Formulation (Basic Programming): Effect of change in topology
2. Transmission Line Modelling (Basic Programming): ABCD constants
3. Load Flow Analysis –Gauss- Siedel Method, Newton- Raphson Method, Fast Decoupled Method – Effect of change in load/generation schedule
4. Load Flow Analysis –Gauss- Siedel Method, Newton- Raphson Method, Fast Decoupled Method – Effect of change in real power/reactive power limits
5. Short Circuit Analysis – Symmetrical Faults and Unsymmetrical Faults
6. Contingency Ranking
7. Transient Stability Analysis
8. Automatic Generation Control – Single Area, Two Area
9. Distribution Systems with Solar PV units
10. Reactive Power Control.
11. Ferranti Effect and Reactive Power Compensation.
12. Plot the IV characteristics of a PV module and determine Maximum Power Point.

**Part B: POWER SYSTEM COMPONENT TESTING (Hardware experiments)**

1. High voltage testing -Power frequency/Impulse
2. High voltage testing -DC
3. Smart metering
4. Relay Testing - Over current relay /Earth fault(Electromechanical/Static/Numerical)
5. Relay Testing –Voltage relay/ Impedance Relay (Electromechanical/Static/Numerical)
6. Insulation Testing – LT & HT Cable
7. Earth Resistance
8. Testing of CT and PT
9. Testing of transformer oil
10. Testing of dielectric strength of solid insulating materials
11. Testing of dielectric strength of air
12. Power factor improvement

**Instructions** :

Both software and hardware experiments are included. **At least 12 experiments (4 hardware experiments are mandatory) and one Mini Project.** Any additional experiment can be treated as Beyond the Syllabus. **Students have to do software simulation and a hardware testing for the End semester examination.**

**Mandatory Course Project:**

**Design a solar power plant (rooftop or ground mounted). Conduct site inspection and feasibility study. Design the components to be used and calculate the performance ratio. Prepare a concise project report giving justifications to the choices made and the economic analysis.**

Students have to do a mandatory course project (group size not more than 4 students- individual may be preferred). A report is also to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

**Reference Books:**


1. Hadi Saadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2. Kothari D. P. and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009
3. M. S. Naidu, V. Kamaraju, *High Voltage Engineering*, Tata McGraw-Hill Education, 2004
4. Wadhwa C. L., *Electrical Power Systems*, 3/e, New Age International, 2009.
5. IEC 61850.
6. IEEE 1547 and 2030 Standards.
7. IS Codes for Testing of Power System components.
8. IEC 61724-1:2017 Performance of Solar Power Plants.

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEL609** | **POWER ELECTRONICS LAB** | **PCC** | **0** | **0** | **3** | **2** |

**Preamble** **:** Impart practical knowledge for the design and setup of different power electronic converters and its application for motor control.

**Prerequisite** **:** Power Electronics (EET306)

**Course Outcomes** **:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Determine the characteristics of SCR and design triggering circuits for SCR based circuits. |
| **CO 2** | Design, set up and analyse single phase AC voltage controllers. |
| **CO 3** | Design, set up and test suitable gate drives for MOSFET/IGBT. |
| **CO 4** | Design, set up and test basic inverter topologies. |
| **CO 5** | Design and set up dc-dc converters. |
| **CO 6** | Develop simulation models of dc-dc converters, rectifiers and inverters using modern simulation tools. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | 2 | 2 | - | - | - | 3 | 2 | - | 3 |
| **CO 2** | 3 | 3 | 2 | 2 | 2 | - | - | - | 3 | 2 | - | 3 |
| **CO 3** | 3 | 3 | 2 | 2 | 2 | - | - | - | 3 | 2 | - | 3 |
| **CO 4** | 3 | 3 | 2 | 2 | 2 | - | - | - | 3 | 2 | - | 3 |
| **CO 5** | 3 | 3 | 2 | 2 | 2 | - | - | - | 3 | 2 | - | 3 |
| **CO 6** | 3 | 3 | 2 | 2 | 3 | - | - | - | 3 | 2 | - | 3 |

**ASSESSMENT PATTERN:**

**Mark distribution:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| **150** | 75 | 75 | 3 hours |

**Continuous Internal Evaluation (CIE) Pattern:**

| Attendance | Regular Lab work | Internal Test | Course Project | Total |
|---|---|---|---|---|
| 15 | 30 | 25 | 5 | **75** |

Internal Test Evaluation (Immediately before the second series test)**End Semester Examination (ESE) Pattern:**

The following guidelines should be followed regarding award of marks:

a) Preliminary Work : 15Marks

b) Implementing the work/Conducting the experiment : 10Marks

c) Performance, result and inference (usage of equipments and troubleshooting) : 25Marks

d) Viva voce : 20marks

e) Record : 5Marks

**General instructions :** Practical examination is to be conducted immediately after the second series test after conducting 12 experiments from the list of experiments given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

**LIST OF EXPERIMENTS :**

**(12 experiments are mandatory)**

**HARDWARE EXPERIMENTS**: (A minimum of 8 experiments are mandatory)

1. **Static characteristics of SCR**

**Aim:** To determine the minimum gate current & gate voltage required to trigger the SCR also to measure the latching current, holding current and to plot the static characteristics of SCR

2. **R and RC firing scheme for SCR control**

**Aim:** To design and set up a half wave controlled rectifier with R and RC firing circuits and plot voltage waveform across the load and thyristor for different firing angles. Also determine the minimum and maximum firing angles of this circuit.

3. **Line Synchronised Triggering Circuits of SCR**

**Aim:** To design and set-up line synchronized Ramp Trigger and Digital Trigger circuits of SCR and observe the waveforms

4. **AC Voltage Controller**

**Aim:** To study the single phase AC voltage controller using TRIAC/SCRs. Set-up a single phase AC voltage controller & observe waveforms across load resistance for different firing angles.

5. **Gate Driver Circuits for MOSFET/IGBT**

**Aim:** To design and test a gate driver circuit for triggering half bridge inverter using MOSFET / IGBT using industry-standard MOSFET drive ICs/Circuits. To test the driving of floating and ground-referenced configurations.

6. **Single Phase fully Controlled SCR bridge rectifier**

**Aim:** To design and set up a single phase full converter with RL/RLE loads and observe the waveforms with and without freewheeling diode.

7. **Design of Inductor/Transformer**

**Aim:** To design and fabricate an inductor/transformer to be used in power electronic circuits.

8. **Design and set-up buck/ boost / buck-boost converters**

**Aim:** To design and set up the buck/boost/buck-boost converter and analyse the characteristics of the same.

9. **Switching characteristics of MOSFET**

**Aim:** To study and understand the switching characteristics of a power MOSFET.

10. **Single-phase half bridge/full bridge inverter using power MOSFET/IGBT**

**Aim:** To design and set up a single phase half-bridge/full-bridge inverter and observe the waveforms across load and firing pulses.

11. **Single-phase sine PWM inverter with LC filter**

**Aim:** To design and set up a single phase sine PWM inverter with LC filter using microcontroller

12. **Three phase sine PWM Inverter using IGBT**

**Aim:** To set up a 3-phase PWM Inverter with RL load and observe the waveforms

13. **Speed control of DC motor using chopper**

**Aim:** To Control the speed of a DC motor using a step-down chopper

14. **Speed control of 3-phase induction motor**

**Aim:** To Control the speed of a 3-phase induction motor using V/f control method.

**SIMULATION EXPERIMENTS**: (A minimum of 4 experiments are mandatory)

15. **Simulation of 1-phase fully-controlled and half-controlled rectifier fed separately excited DC motor**

**Aim:** To simulate 1-phase fully-controlled and half-controlled rectifier fed Separately Excited DC motor and observe the speed, torque, armature current, armature voltage, source current waveforms and find the THD in source current and input power factor.

16. **Simulation of Dual Converter – 4 quadrant operation of separately excited DC motor**

**Aim:** To simulate a dual converter for a separately excited DC motor and to understand the four quadrant operation

17. **Simulation of buck/boost/buck-boost converters**

**Aim:** To simulate a buck, boost and buck boost converter using MATLAB/equivalent or any other simulation platform and analyse the performance under various duty ratio/ switching frequency.

18. **Simulation of single phase & three phase sine PWM inverters.**

**Aim**: To simulate a single phase and three phase sine PWM inverter using MATLAB/equivalent

19. **Simulation of 3-phase fully-controlled converter with R, RL, RLE loads**

**Aim:** To simulate a 3-phase fully controlled converter with R, RL and RLE loads and observe the waveform in MATLAB simulink/equivalent.

**20. Comparative study of PWM and Square wave inverters.**

**Aim:-**To analyse THD, fundamental component of output voltage in PWM and Square wave inverters (single phase) using MATLAB/equivalent.

**Mandatory Group Project Work :** Students have to do a mandatory micro project (group size not more than 5 students) preferably a simulation work. A report also is to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

**Reference Books:**


1. L. Umanand: Power Electronics – Essentials & Applications, Wiley-India
2. Mohan, Undeland, Robbins: Power Electronics, Converters, Applications & Design, Wiley-India
3. Muhammad H. Rashid: Power Electronics Circuits, Devices and Applications, Pearson Education
4. Ned Mohan A: "First course on power electronics and drives", MNPERE, 2003 Edn.

# SEMESTER VI
# (MINOR)

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEMR610.1** | **POWER SEMICONDUCTOR DRIVES** | **MINOR** | 3 | 1 | 0 | 4 |

**Preamble** : This course is intended to provide fundamental knowledge in dynamics and control of Electric Drives, to justify the selection of Drives for various applications and to familiarize the various semiconductor controlled drives employing various motors

**Prerequisite** : Basic knowledge of mathematics, basic electronics and analog electronics.

**Course Outcomes** : After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain dynamics and control of electric drives. |
| **CO 2** | Explain the performance of DC motor drives used in various applications. |
| **CO 3** | Explain control strategies for three phase induction motor drives. |
| **CO 4** | Explain variable speed synchronous motor drives. |
| **CO5** | Choose an appropriate drive system for a specific application. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 2** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 |
| **CO 3** | 3 | 3 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 4** | 3 | 3 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 5** | 3 | 2 | 1 | 2 | 2 | - | - | - | - | - | - | 1 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 20 | 20 | 40 |
| Apply | 20 | 20 | 40 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. **Part A** contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. **Part B** contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Draw and explain the typical toque speed characteristics of different types of mechanical loads pump, hoist, fan and traction loads. Write the various factors that influence the choice of electric drives?
2. Explain clearly, the four quadrant operation of a motor driving a hoist load.
3. Differentiate between passive and active load torques with example.

**Course Outcome 2 (CO2)**

1. Explain using suitable diagrams and wave forms, two quadrant operation of single phase full converter fed separately excited dc motor drive for continuous and discontinuous mode of operation and obtain the boundary between two modes. Derive the output voltage equation for both modes.
2. Draw the circuit diagram of a class-C chopper fed DC motor drive. Draw its V/I characteristics.
3. Explain the four quadrant operation of a chopper fed dc motor drive with the help of necessary circuit diagram and waveform

**Course Outcome 3 (CO3):**

1. Draw and explain the speed torque characteristics of a stator voltage controlled induction motor. Why stator voltage control is not suitable for speed control of induction motor with constant load torque.
2. Explain the static Kramer scheme for the speed control of a slip ring IM. How the slip power is effectively utilised in this drive?
3. Explain v/f control of induction motor. Draw the speed torque characteristics. How the speed of induction motor is controlled using Voltage source inverter?

**Course Outcome 4 (CO4):**

1. Explain power and torque capability curves of a synchronous motor drive. In variable frequency control of synchronous motor drive, why V/f ratio is maintained constant upto base speed and voltage constant above base speed.
2. Explain the true synchronous mode of operation of synchronous motor drive.
3. How can we control the speed of an ac motor drive using field oriented control? Explain with the help of a block diagram
4. With a suitable block diagram explain variable frequency control of synchronous motor drive in self control mode

**Course Outcome 5 (CO5):**

1. Differentiate trapezoidal type BLDC motor and sinusoidal type PMBLDC motor
2. With neat sketches explain the operation of a switched reluctance motor drive.
3. Explain the principle of operation of PMBLDC motor for $120^0$ commutation with neat circuit diagram.
4. With a block diagram explain the micro controller based PMSM drive

**Model Question Paper**

QP Code: Pages: 2

Reg No: ____________________

Name: _____________________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR**

**Course Code: 22EEMR610.1**

**Course Name: POWER SEMICONDUCTOR DRIVES**

Max. Marks: 100 Duration: 3 Hours

**PART A**
**Answer all Questions. Each question carries 3 Marks**

1. What are the different components of a load torque? Explain each components of load torque.
2. Derive the mathematical condition to obtain the steady state stability of an electric drive.
3. Which are the method of speed control suitable for getting speeds higher than base speed and lower than base speed in a dc motor?
4. Explain the regenerative braking operation of a chopper fed dc motor drive with the help of necessary circuit diagram.
5. Explain the speed control of three phase induction motor by varying stator voltage.
6. Explain v/f control of induction motor. Draw the speed torque characteristics.
7. How to control the speed of synchronous motor by using voltage source inverter?
8. Why the field oriented control of ac motor is superior to other types of speed control?
9. Explain about the classification of PM synchronous motor.
10. Compare the construction and performance of BLDC motor and PMAC motor.

**(10 x 3 =30)**

**PART B**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. (a) A motor load system has the following details: Quadrants I and II, T= 400-0.4N, N-m, where N is the speed in rpm. Motor is coupled to a active load torque, Tl= ± 200, N-m. Calculate motor speeds for motoring and braking in forward direction. When operating in quadrants III and IV, T= -400-0.4N, N-m. Calculate the equilibrium speed in quadrant III.

**(8)**

(b) What are the speed- torque characteristics of pump, fan and traction loads? **(6)**

12. (a) With the help of a neat sketch explain the multi quadrant operation of a motor driving hoist load **(8)**

(b) Explain the operation of closed loop control scheme? What are the importance of current control and speed control loops **(6)**

## Module 2

13. (a) A 220 V, 1500 rpm, 11.6 A separately excited motor is controlled by a l-phase fully controlled rectifier with an ac source voltage of 230 V, 50 Hz. Filter inductance is added to ensure continuous conduction for any torque greater than 25 percent of rated torque, Ra = 2 ohm . What should be the value of the firing angle to get the rated torque at 1000 rpm? Ca1culate the firing angle for the rated braking torque and - 1500 rpm. Also ca1culate the motor speed at the rated torque and $\alpha = 160^{o}$ for the regenerative braking in the second quadrant. **(7)**

(b) Explain the operation of four quadrant chopper fed separately excited DC motor drive with necessary diagrams. **(7)**

14. (a) A 220 V, 1000 rpm and 200 A separately excited dc motor has an armature resistance of 0.02Ω. The motor is fed from chopper which provides both motoring and braking operations. The source has a voltage of 230V. Assume CCM. (i) Calculate duty ratio of chopper for motoring operation at rated torque and 400 rpm. (ii)Calculate duty ratio of chopper for braking operation at rated torque and 400 rpm. **(8)**

(b) Draw the circuit diagram and waveforms of a class-C chopper fed DC motor. Explain. Draw its V/I characteristics. **(6)**

## Module 3

15. (a) Explain the static Kramer scheme for the speed control of a slip ring IM. Explain the firing angle control of thyristor bridge with constant motor field. **(8)**

(b) Explain the closed loop static rotor resistance control method for the speed control of a slip ring induction motor. What are the disadvantages of this method? **(6)**

16. (a) What is slip power recovery scheme? Describe static Scherbius drive and show that the slip at which it operates is given by S = - (aT /a) cosα, where a and aT pertain to per phase turns ratio for induction motor and transformer respectively. Why it is always suggested to use a transformer in line side converter for static Scherbius drive? **(10)**

(b) Compare speed control of induction motor using VSI and CSI **(4)**

## Module 4

17. (a) Explain the different mode of operation of synchronous motor drive by variable frequency control method. **(10)**

(b) Briefly explain the concept of space vector **(4)**

18. (a) With the help of block diagram explain the closed loop speed control of load commutated inverter fed synchronous motor. **(8)**

(b) Explain the frame transformation from three phase to synchronous reference frame. What is its significance in speed control? **(6)**

## Module 5

19. (a) With the help of schematic diagram explain microcontroller based permanent magnet synchronous motor drives **(7)**

(b) With suitable converter circuit diagram discuss the modes of operation of Switched Reluctance motor drive. (**7)**

20. Explain the principle of operation and control circuit of PMBLDC motor for 120° commutation with neat circuit diagram. **(14)**

# Syllabus

**Module 1**

**Introduction to electric drives** – Block diagram – advantages of electric drives – Dynamics of motor load system, fundamental equations, and types of load – classification of load torque, four quadrant operation of drives. Steady state stability. Introduction to closed loop control of drives.

**Module 2**

**DC motor drives-** constant torque and constant power operation, separately excited dc motor drives using controlled rectifiers, single phase semi converter and single phase fully controlled converter drives. Three phase semi converter and fully controlled converter drives.

**Chopper controlled DC drives.** Analysis of single quadrant chopper drives. Regenerative braking control. Two quadrant chopper drives. Four quadrant chopper drives.

**Module 3**

**Induction Motor Drives**-Three phase induction motor speed control using semiconductor devices. Stator voltage control – stator frequency control – Stator voltage and frequency control (v/f) - Voltage source inverter control - Current source inverter control. Rotor chopper speed control – slip power recovery control schemes – sub synchronous and super synchronous speed variations.

**Module 4**

**Synchronous motor drives** – Synchronous motor variable speed drives- variable frequency control- modes of variable frequency control. Closed loop speed control of load commutated inverter fed synchronous motor drive .Concept of space vector – Basic transformation in reference frame theory – field orientation principle.

**Module 5**

**Permanent Magnet and variable reluctance motor drives** – different types –Sinusoidal PMAC drives-Brushless DC motor drives- control requirements, converter circuits, modes of operation . Microcontroller based permanent magnet synchronous motor drives (schematic only). Switched Reluctance motor drive- converter circuits- modes of operation.

**Text Books**

1. Bimal K. Bose “Modern power electronics and AC drives” Pearson Education, Asia 2003
2. Gopal K. Dubey. “Fundamentals of Electric Drives” , second edition, Narosa Publishing house

**Reference Books**

1. Dewan S.B. , G. R. Slemon, A. Strauvhen, “Power semiconductor drives”, John Wiley and sons.
2. Dr. P. S. Bimbra “Power electronics”, Khanna publishers.
3. Dubey G. K. “Power semiconductor control drives” Prentice Hall, Englewood Cliffs, New Jersey, 1989.
4. N. K. De, P. K. Sen “Electric drives” Prentice Hall of India 2002.
5. Ned Mohan, Tore m Undeland, William P Robbins, “Power electronics converters applications and design”, John Wiley and Sons.

6. Pillai S. K. “A first course on electric drives”, Wieley Eastern Ltd, New Delhi.
7. Vedam Subrahmanyam, “Electric Drives”, MC Graw Hill Education, New Delhi.
8. 8.R. Krishnan , “Electric Motor Drives Modeling, Analysis and Control”, Prentice Hall of India 2007.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to electric drives (9 hours)** | |
| 1.1 | Block diagram – Parts of Electric Drives. advantages of electric drives | 2 |
| 1.2 | Dynamics of motor load system, fundamental torque equations, equivalent value of drive parameters ( both rotational and translational motion) | 2 |
| 1.3 | components of load torque ,types of load and classification of load torque | 2 |
| 1.4 | four quadrant operation of drives | 1 |
| 1.5 | Steady state stability- condition for stability of equilibrium point | 1 |
| 1.6 | Introduction to closed loop control of drives- speed, current, torque and position control | 1 |
| **2** | **DC motor drives (10 hours)** | |
| 2.1 | Speed control-constant torque and constant power operation | 2 |
| 2.2 | Separately excited dc motor drives using controlled rectifiers- single phase semi converter and single phase fully controlled converter drives. | 3 |
| 2.3 | Three phase semi converter and fully controlled converter drives. | 2 |
| 2.4 | Chopper controlled DC drives- Analysis of single quadrant chopper drives. Regenerative braking control. | 1 |
| 2.5 | Two quadrant chopper drives. Four quadrant chopper drives | 2 |
| **3** | **Induction Motor Drives (8 hours)** | |
| 3.1 | Three phase induction motor speed control using semiconductor devices. Stator voltage control – stator frequency control | 2 |
| 3.2 | Stator voltage and frequency control (v/f) | 1 |
| 3.3 | Voltage source inverter control - Current source inverter control. | 2 |
| 3.4 | Static Rotor resistance speed control using chopper | 1 |
| 3.5 | Slip power recovery control schemes – sub synchronous and super synchronous speed variations. | 2 |

| | | |
|---|---|---|
| **4** | **Synchronous motor drives (9 hours)** | |
| 4.1 | Synchronous motor variable speed drives- variable frequency control- modes of variable frequency control- true synchronous mode and self control mode | 3 |
| 4.2 | Closed loop speed control of load commutated inverter fed synchronous motor drive | 2 |
| 4.3 | Concept of space vector –Basic transformation in reference frame theory. | 2 |
| 4.4 | Principle of vector control- introduction to field oriented control of ac motor drives | 2 |
| **5** | **Permanent Magnet and variable reluctance motor drives (8 hours)** | |
| 5.1 | Different types –Sinusoidal PMAC drives- | 2 |
| 5.2 | Brushless DC motor drives- control requirements, converter circuits, modes of operation. | 3 |
| 5.3 | Microcontroller based permanent magnet synchronous motor drives (schematic only). | 1 |
| 5.4 | Switched Reluctance motor drive- converter circuits- modes of operation. | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEMR610.2** | **INSTRUMENTATION AND AUTOMATION OF POWER PLANTS** | **MINOR** | **3** | **1** | **0** | **4** |

**Preamble** : This course introduces measurements and instruments used in power plants. Automation of power plants and Supervisory control and data acquisition are also discussed.

**Prerequisite** : **Introduction to Power Engineering/ Energy Systems**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Analyse different instruments used for measuring parameters in a power plant. |
| **CO 2** | Explain various control systems in power plants. |
| **CO 3** | Identify different components of SCADA for applications in power plants. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 1 |
| **CO 2** | 3 | 3 | | | | | | | | | | 1 |
| **CO 3** | 3 | 3 | | | | | | | | | | 1 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**
**Course Outcome 1 (CO1):**

1. Explain the working of a digital frequency meter (K2)
2. Explain the working of a radiation detector (K2)

**Course Outcome 2 (CO2):**

1. Compare the performance of boiler following mode and turbine following mode of operation in power plants.  (K4).
2. Explain interlocks in boiler operation (K2).

**Course Outcome 3 (CO3):**

1. Discuss about the various SCADA architectures. Compare them.(K2, K3)
2. Explain the ladder logic approach of programming in a PLC(K2,).

**Model Question paper**
**QP CODE:**

PAGES:2

Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR**

**Course Code: 22EEMR610.2**

**Course Name: INSTRUMENTATION AND AUTOMATION OF POWER PLANTS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain briefly the working principle of an induction type wattmeter.
2. Discuss the role of dust monitor in power plants.
3. Write notes on temperature measurement techniques used in boilers?
4. Discuss how pedestal vibration is measured in boilers?
5. Explain what do you mean by co-ordinated control in boilers.
6. Discuss the role of distributed control system in a power plant.
7. List out the differences between RTUs and IEDs.
8. State the advantages and disadvantages of PLC.
9. Discuss the operating states of a power system.
10. Explain briefly what do you mean by Energy Management System.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a. With the help of a neat diagram, explain the working of a digital frequency meter. **(7)**
b. Explain how the flow of feed water is measured in power plants. **(7)**

12. a. With the help of a neat sketch, explain the working of a power factor meter. **(10)**
b. Explain the working of a radiation detector. **(4)**

**Module 2**

13. a. Explain how flame monitoring is done in boilers. **(6)**
b. Discuss the pressure measuring devices in boilers. **(7)**

14. a.Describe with a neat schematic, how shaft vibration can be detected. **(7)**

b. Explain the working of a non contact type speed measuring device. **(7)**

**Module 3**

15. a.Explain the control of boiler drum level in power plant operation. **(7)**

b. Explain how steam temperature can be controlled in boilers. **(7)**

16. a. Compare the performance of boiler following mode and turbine following mode of operation in power plants. **(7)**

b. Explain interlocks in boiler operation. **(7)**

**Module 4**

17. a. Describe the basic components of a SCADA system. **(4)**

b. Describe the components of an IED. **(4)**

c. Explain the ladder logic approach of programming in a PLC **(6)**

18. a. Explain the objectives of SCADA. **(4)**

b. Discuss about the various SCADA architectures. Compare them. **(10)**

**Module 5**

19. a. Discuss the main requirements of an Energy Management System. **(4)**

b. With the help of a diagram, explain what do you understand by an EMS framework. **(10)**

20. Explain the applications of SCADA in generation operation and management. **(14)**

## Syllabus

### Module 1

Measurements in power plants: Electrical measurements – current, voltage, power, frequency, power factor etc. – non electrical parameters – flow of feed water, fuel, air and steam with correction factor for temperature – steam pressure and steam temperature – drum level measurement – radiation detector – smoke density measurement – dust monitor.

### Module 2

Measurement in boiler and turbine: Metal temperature measurement in boilers, piping. System for pressure measuring devices - smoke and dust monitor - flame monitoring. Introduction to turbine supervising system - pedestal vibration - shaft vibration - eccentricity measurement. Installation of non-contracting transducers for speed measurement.

### Module 3

Controls in boilers: Boiler drum level measurement methods - feed water control - soot blowing operation - steam temperature control - Coordinated control - boiler following mode operation - turbine following mode operation - selection between boiler and turbine following modes. Distributed control system in power plants interlocks in boiler operation - Cooling system - Automatic turbine runs up systems.

### Module 4

Introduction to SCADA systems: - Elements of a SCADA system - benefits of SCADA system - SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system

SCADA System Components: - Remote Terminal Unit-(RTU), Intelligent Electronic Devices (IED) - PLC: Block diagram, Ladder diagram, Functional block diagram, Applications, Interfacing of PLC with SCADA.

### Module 5

SCADA Applications:  Operating states of a power system - Energy management System (EMS) – EMS framework – Generation operation and management – Load forecasting – unit commitment – hydrothermal co-ordination – Real time economic dispatch and reserve monitoring – real time automatic generation control

**Text books:**

1. P. K. Nag,"Power Plant Engineering" 2nd Edition, Tata McGraw-Hill Education, 2002.
2. R.K.Jain, "Mechanical and Industrial Measurements", 10th Edition, Khanna Publishers, New Delhi, 1995.
3. Sam. G.Dukelow, "The Control of Boilers", 2nd Edition, ISA Press, New York, 1991.
4. Stuart A. Boyer, 'SCADA-Supervisory Control and Data Acquisition', Instrument Society of America Publications,USA,2004.

**Reference Books:**

1. David Lindsley, "Boiler Control Systems", McGraw Hill, New York, 1991.
2. Jervis M.J, "Power Station Instrumentation", Butterworth Heinemann, Oxford, 1993.

**Course Contents and Lecture Schedule:**

| Sl. No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Measurements in a power plant (8 hours)** | |
| 1.1 | Electrical measurements – Current, voltage, power, frequency, power factor etc. | 2 |
| 1.2 | Non electrical parameters – Flow of feed water, fuel, air and steam with correction factor for temperature – Steam pressure and steam temperature | 2 |
| 1.3 | Drum level measurement – Radiation detector | 2 |
| 1.4 | Smoke density measurement – Dust monitor. | 2 |
| **2** | **Monitoring (9 hours)** | |
| 2.1 | Measurement in boiler and turbine: Metal temperature measurement in boilers, piping. | 2 |
| 2.2 | System for pressure measuring devices, smoke and dust monitor, flame monitoring. | 2 |
| 2.3 | Introduction to turbine supervising system, pedestal vibration | 1 |
| 2.4 | Shaft vibration, eccentricity measurement. | 2 |
| 2.5 | Installation of non-contracting transducers for speed measurement. | 2 |
| **3** | **Control systems (9 Hours)** | |
| 3.1 | Controls in boiler: Boiler drum level measurement methods, feed water control, soot blowing operation, steam temperature control | 2 |
| 3.2 | Coordinated control, boiler following mode operation, turbine following mode operation | 1 |
| 3.3 | Selection between boiler and turbine following modes. | 1 |
| 3.4 | Distributed control system in power plants interlocks in boiler operation. | 1 |
| 3.5 | Cooling system, Automatic turbine runs up systems. | 2 |
| **4** | **SCADA systems (10 Hours)** | |
| 4.1 | Introduction to SCADA systems: - Elements of a SCADA system - benefits of SCADA system | 1 |
| 4.2 | SCADA Architecture: □ Various SCADA architectures, advantages and | 2 |

| | | |
|---|---|---|
| | disadvantages of each system | |
| 4.3 | SCADA System Components: - Remote Terminal Unit-(RTU), | 3 |
| 4.4 | Intelligent Electronic Devices (IED) - PLC: Block diagram, Ladder diagram, Functional block diagram | 3 |
| 4.5 | Applications, Interfacing of PLC with SCADA. | 1 |
| **5** | **SCADA applications (9 Hours)** | |
| 5.1 | SCADA Applications:  Operating states of a power system | 2 |
| 5.2 | Energy management System (EMS) – EMS framework | 3 |
| 5.3 | Generation operation and management – Load forecasting – unit commitment | 2 |
| 5.4 | Hydrothermal co-ordination – Real time economic dispatch and reserve monitoring – real time automatic generation control | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEMR610.3** | **DIGITAL CONTROL** | **MINOR** | **3** | **1** | **0** | **4** |

**Preamble** : This course aims to provide a strong foundation in digital control systems. Modelling, time domain analysis, frequency domain analysis and stability analysis of sampled data control systems based on Pulse Transfer function (conventional) approach and State variable concept are discussed. The design of digital control is also introduced.

**Prerequisite** : **Basics of Circuits, Networks and Control Systems**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Describe the role of various control blocks and components in digital control systems. |
| **CO 2** | Analyse the time domain responses of the sampled data systems using Z Transform. |
| **CO 3** | Analyse the stability of the given discrete time system. |
| **CO 4** | Apply state variable concepts to assess the performance of linear systems |
| **CO 5** | Apply Liapunov methods to assess the stability of linear systems |
| **CO 6** | Explain control system design strategies in discrete time domain. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | - | - | - | - | - | - | - | - | - | 1 |
| **CO 2** | 3 | 2 | - | - | 2 | - | - | - | - | - | - | 1 |
| **CO 3** | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 4** | 3 | 2 | - | - | 2 | - | - | - | - | - | - | 1 |
| **CO 5** | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 6** | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 |

**Assessment Pattern:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 15 | 15 | 40 |
| Apply (K3) | 25 | 25 | 40 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

**Part B** contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

**Course Level Assessment Questions:**

**Course Outcome 1 (CO1)**

7. Derive the transfer function and obtain the frequency response characteristics of zero order hold circuit.
8. Explain how reconstruction of original signal is achieved from discrete time signals.
9. Explain any three factors to be considered for the choice of sampling frequency for a system.

**Course Outcome 2 (CO2):**

10. Derive the transfer function and obtain the frequency response characteristics of first order hold.
11. Problems related to steady state error.
12. Problems related to ZTF from difference equation form.

**Course Outcome 3(CO3):**

7. Problems related to the stability analysis using Jury's test
8. Problems related to the stability analysis using Bilinear Transformation
9. Problems to determine range of K or other TF parameter for stability/ oscillation.

**Course Outcome 4 (CO4):**

10. Problems related to canonical form representations
11. Problems based on state transition matrix
12. Problems to determine the solution of state equations.

**Course Outcome 5 (CO5):**

4. Check the stability of the given LTI system using Liapunov method.
5. Explain the physical relevance of Liapunov function.
6. Test the stability of the given nonlinear state model.

**Course Outcome 6 (CO6):**

7. Design a digital controller using root locus approach to meet the required specifications.
8. Problems on PID tuning and selection.
9. Pole placement problems for LTI systems.

**Model Question Paper** PAGES: 3

**QP CODE:**

Reg.No:____________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR**

Course Code**: 22EEMR610.3**

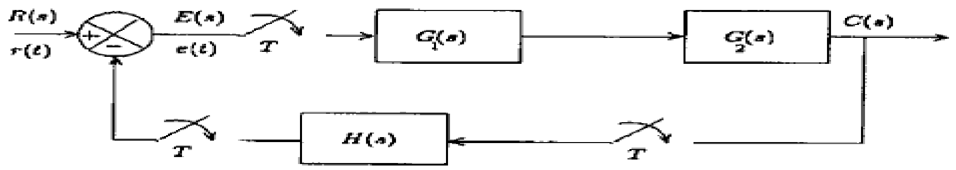
Course Name: **DIGITAL CONTROL**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Explain any four advantages of sampled data control systems.
2. Determine the z-transform of $x(n)=(1/2)^n u(-n)$.
3. Obtain the pulse transfer function for the given system.




4. Obtain the poles and zeroes of the system governed by the difference equation: $y(n)+\frac{5}{4}y(n-1)+\frac{3}{8}y(n-2)=2x(n)-x(n-1)$
5. Draw and explain the mapping between s- plane to z-plane for the constant frequency loci.
6. Explain how does the P- controller affect the performance of a DT system.
7. Obtain the diagonal canonical form of the system with $G(z)=\frac{z+0.5}{(z^2+1.4z+0.4)}$
8. Determine the state transition matrix for the DT system with state matrix $A=\begin{bmatrix}0 & 1\\ -0.15 & -1\end{bmatrix}$
9. State and explain the Liapunov stability theorem for LTI discrete time systems.
0. Determine the observability of the system with: $A=\begin{bmatrix}-5 & 0\\ -2 & -3\end{bmatrix}; C=[1 \quad -1]$

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

a) Derive the transfer function of a ZoH circuit. **(5)**

b) Determine the inverse z-transform of the following functions: $i) X(z)=\frac{2z^{-1}}{(1-0.25z^{-1})^2}; ROC: |z|>\frac{1}{4}, and, ii) F(z)=\frac{3z^{-1}}{(1-z^{-1})(1-2z^{-1})}; ROC: |z|>2$ **(9)**

a) Determine the Z transform of $H(s)=\frac{3}{s(s+2)^2}$ **(4)**

b) Write short notes on:
   i) Aliasing effect
   ii) Importance of First order hold circuit
   iii) Region of convergence for ZT **(10)**

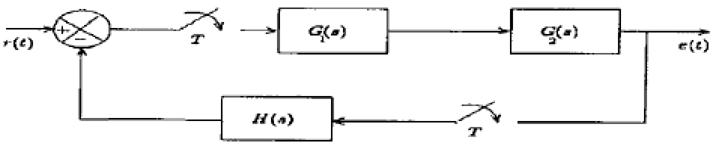
## Module 2

a) i) Obtain the direct form realization for the system described by the difference equation: $y(n)-\frac{5}{6}y(n-1)+\frac{1}{6}y(n-2)=2x(n)$

ii) Also determine the impulse response h(n) for the above system. **( 3+5 )**

b) Obtain the pulse transfer function for the unity feedback system with $G_1(s)=\frac{1}{s}$,

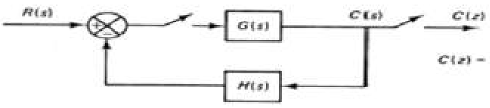
$G_2(s)=\frac{1}{(s+2)}$ and assume T=1 second




**(6)**

a) Obtain the unit impulse response C(n) of the following feedback DT system with

$G(s)=\frac{1}{(s+3)}$, . $H(s)=\frac{1}{s}$,




Assume ideal sampling and T=1 ms. **(9)**

b) Explain the factors on which the steady state error constants depend on? **(5)**

## Module 3

a) Check stability of the system described by the following characteristic equation, using Bilinear transformation: $z^3 - 0.2z^2 - 0.25z + 0.05 = 0$ **(7)**

b) With suitable characteristics compare between PI and PD controllers. **(7)**

a) For a unity feedback system with $G(z)=\frac{K}{z\,(z^2 - 0.2z - 0.25)}$ determine the range for K for ensuring stability, using Jury's test. **(5)**

b) With help of suitable sketches, explain how can you use root locus technique to design a digital controller. **(9)**

## Module 4

a) Obtain the phase variable representation for the system with $G(z)=\frac{z+0.5}{(z^3+1.4z^2+0.5\,z+0.2)}$ **(5)**

b) Determine the solution for the homogeneous system x(k+1)= G x(k), where: $G=\begin{bmatrix}0 & 1\\ -0.16 & -1\end{bmatrix}$ and $x(0)=\begin{bmatrix}1\\ -1\end{bmatrix}$ **(9)**

a) Determine the pulse transfer function Y(z)/U(z) for the system with:
x(k+1)= G x(k)+ Hu(k) and y(k)= Cx(k)+Du(k),
where $G=\begin{bmatrix}0 & 1\\ -0.16 & -1\end{bmatrix}$, $H=\begin{bmatrix}1\\ 1\end{bmatrix}$ $C=[1 \quad 0]$ and D=0 **(9)**

b) Show that for a given pulse transfer function, the states space representation is not unique. **(5)**

## Module 5

a) Determine the stability of the LTI system with state model using Liapunov method: **(9)**

$$\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -5 \end{bmatrix} X$$

b) Determine the controllability of the state model: $\dot{x} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 2 \\ 0 & -1 & -7 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$ **(5)**

a) Test stability of the nonlinear system given below, using Liapunov method. **(4)**

$$\dot{X} = \begin{bmatrix} -4 & 0 \\ 3{x_2}^2 & -2 \end{bmatrix} X$$

b) Design a state feedback controller for the following system such that the closed loop poles are placed at: -1 ± j2 and -10. $\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 2 \\ 0 & -1 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} u$ **(10)**

## Syllabus

**Module 1**

**Digital control system (10 hours)**

Basic block diagram of digital control system- Typical examples- Advantages of digital control systems.

Mathematical modelling of sampling process- sampling theorem- Aliasing effect- Impulse train sampling- Zero order and First order hold circuits- Signal reconstruction.

Discrete form of special functions- Discrete convolution and its properties.

Z Transform**:** Region of convergence- Properties of Z transform –- Inverse ZT- methods.

**Module 2**

**Analysis of LTI Discrete time systems (8 hours)**

Difference equation representations of LTI systems- Block diagram representation in Direct form

Z-Transfer function- Analysis of difference equation of LTI systems using Z transfer function.

Pulse transfer function: Pulse transfer function of closed loop systems.

Time responses of discrete data systems-Steady state performance-

Static error constants

**Module 3**

**Stability analysis and Digital controllers (9 hours)**

Stability analysis: Stability analysis of closed loop systems in the z-plane, Jury's stability test- Use of bilinear transformation for stability analysis.

Digital Controllers: Introduction to Digital Controllers- Root locus based design of digital Controllers.

PID controllers: Digital PID controller and design of PID controllers.

**Module 4**

**State space analysis (8 hours)**

State variable model of discrete data systems -Various canonical form representations- controllable, observable forms, Diagonal canonical and Jordan canonical forms

State transition matrix: Properties- Computation of state transition matrix using z-transform method -Solution of homogeneous systems

Determination of transfer function from state space model.

**Module 5**

**Pole placement design and Liapunov stability analysis (10 hours)**

Controllability and observability for continuous time systems

Pole placement design using state feedback for continuous time systems

Controllability and observability for discrete time systems- Digital control design using state feedback discrete time systems

Liapunov stability Analysis: Liapunov function- Liapunov methods to stability of linear and nonlinear systems- Liapunov methods to LTI continuous time systems

Liapunov methods to LTI Discrete time systems (Theorem only).

**Text Books:**


1. Ogata K., Discrete Time Control Systems, 2/e, Pearson Education.
2. Kuo B. C, Digital Control Systems, 2/e, Saunders College Publishing, Philadelphia, 1992.
3. Gopal M**,** Digital Control and State Variable Methods, 2/e, Tata McGraw Hill
4. Philips C. L., Nagle H. T. and Chakraborthy A,, Digital Control Systems, 4/e, Pearson


**References:**


1. Constantine H. Houpis and Lamont G. B., Digital Control Systems Theory, Hardware Software, 2/e, McGraw Hill.
2. Isermann R., Digital Control Systems, Fundamentals, Deterministic Control, 2/e, Springer Verlag, 1989.
3. Liegh J. R, Applied Digital Control, 2/e, Dover Publishers.
4. Gopal M, Modern Control System Theory, 2/e, New Age Publishers


**Course Contents and Lecture Schedule:**

| Module | Topic coverage | No. of Lectures |
|---|---|---|
| **1** | **Digital control system (10 hours)** | |
| 1.1 | Basic block diagram of digital control system- Typical examples-Advantages of digital control systems. | 1 |
| 1.2 | Mathematical modelling of sampling process -sampling theorem- Aliasing effect- Impulse train sampling | 2 |
| 1.3 | Zero order and First order hold circuits- Signal reconstruction | 2 |
| 1.4 | Discrete form of special functions- Discrete convolution and its properties | 1 |
| 1.5 | Z Transform**:** Region of convergence- Properties of the Z transform – | 2 |
| 1.6 | Inverse ZT- methods | 2 |
| **2** | **Analysis of LTI Discrete time systems (8 hours)** | |
| 2.1 | Difference equation representations of LTI systems- Delay operator and block diagram representation in Direct form | 1 |
| 2.2 | Z-Transfer function- Analysis of difference equation of LTI systems using ZTF | 2 |
| 2.3 | Pulse transfer function: Pulse transfer function of closed loop systems | 2 |
| 2.4 | Time responses of discrete data systems-Steady state performance-static error constants | 3 |
| **3** | **Stability analysis and Digital controllers (9 hours)** | |
| 3.1 | Stability analysis: Stability analysis of closed loop systems in the z-plane, Jury's stability test. | 2 |
| 3.2 | Use of bilinear transformation and extension of Routh-Hurwitz criterion for stability. | 2 |
| 3.3 | Digital Controllers:<br>Introduction to Digital controllers- Root locus based design of Digital controllers. | 3 |
| 3.4 | PID controllers: Digital PID controller and design of PID controllers. | 2 |

| | | |
|---|---|---|
| **4** | **State space analysis (8 hours)** | |
| 4.1 | State variable model of discrete data systems -Various canonical form representations-controllable and observable forms | 2 |
| 4.2 | Diagonal canonical and Jordan forms | 2 |
| 4.3 | State transition matrix- properties- Computation of state transition matrix using z-transform method | 2 |
| 4.4 | Solution of homogeneous systems | 1 |
| 4.5 | Determination of pulse transfer function from state space model | 1 |
| **5** | **Pole placement design and Liapunov Stability Analysis (10 hours)** | |
| 5.1 | Controllability and observability for continuous time systems | 2 |
| 5.2 | Pole placement design using state feedback for continuous time systems | 2 |
| 5.3 | Controllability and observability for discrete time systems- Digital control design using state feedback discrete time systems | 3 |
| 5.4 | Liapunov stability Analysis: Liapunov function- Liapunov methods to stability of linear and nonlinear systems- Liapunov methods to LTI continuous time systems | 2 |
| 5.5 | Liapunov methods to LTI Discrete Time systems (Theorem only). | 1 |

# SEMESTER VI
# (HONOURS)

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEHR611.1** | **GENERALIZED MACHINE THEORY** | **HONOURS** | **4** | **0** | **0** | **4** |

**Preamble** :**Nil**

**Prerequisite** :**DC Machines and Transformers. Synchronous and Induction machines**

**Course Outcomes** :After the completion of the course, the student will be able to:

| | |
|---|---|
| **CO 1** | Develop the basic two pole model representation of electrical machines using the basic concepts of generalized theory. |
| **CO 2** | Develop the linear transformation equations of rotating electrical machines incorporating the concept of power invariance. |
| **CO 3** | Apply linear transformation for the steady state and transient analysis of different types of rotating electrical machines. |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | 2 | 2 | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |
| **CO 2** | 3 | 3 | 2 | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |
| **CO 3** | 3 | 3 | 3 | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| Remember | 5 | 5 | 10 |
| Understand | 10 | 10 | 20 |
| Apply | 35 | 35 | 70 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**End Semester Examination Pattern** :There will be two parts; Part A and Part B.

**Part A** contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions.

**Part B** contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

**Part A:** 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain Kron's Primitive Machine of rotating electrical machines.

2. Describe the essential features of rotating electrical machines.

3. Draw the basic two pole machine diagram of DC Compound Machine.

4. Develop an expression for the electrical torque of the Kron's Primitive Machine.

**Course Outcome 2 (CO2):**

1. What are the advantages of having power invariance in transformations.
2. Deduce Parks transformations relating three phase currents to its corresponding d- q axis currents.
3. Draw the generalized model of a DC series machine and derive the voltage equation in matrix form.
4. Explain the physical significance of Park's transformations.

**Course Outcome 3 (CO3):**

1. Explain the steady state analysis of a separately excited DC motor and derive the expression for electromagnetic torque. Also plot the shunt characteristics and speed versus armature voltage characteristics.

2. Obtain the expression for the steady state torque when balanced poly phase supply is impressed on the stator winding of three phase Induction motor

3. Draw the equivalent circuit of a three phase induction motor with the help of its generalized model.

4. Investigate the transient behaviour of a separately excited DC generator under the following operating condition: sudden application of a step field excitation to the field under no load, $i_a = 0$ and for constant no load speed $\omega_{r0}$ and explore the variation of armature voltage.

**Model Question paper**

**QP CODE:**

PAGES: 2

Reg.No:______________
Name:________________

**TKM COLLEGE OF ENGINEERING**
**SIXTH SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR**

**Course Code: 22EEHR611.1**

**Course Name: GENERALIZED MACHINE THEORY**

**Max. Marks: 100** **Duration: 3 Hrs**

## PART A

**Answer all questions. Each Question Carries 3 marks**

1. Sketch the basic two pole representation of the following machines
   i) DC shunt machine with inter poles ii) DC compound machine
2. Explain linear transformations as used in electrical machines.
3. What is Kron's primitive machine?
4. Enumerate the limitations of generalized theory of electrical machines.
5. Derive an expression for rotational mutual inductance or motional inductance of DC generator
6. Derive the transfer function of separately excited DC motor under on no load operation.
7. Draw the power angle characteristics of salient pole and cylindrical rotor synchronous machine.
8. Draw the torque slip characteristics of three phase Induction motor.
9. Explain equivalent circuit of single phase Induction motor.
10. Compare single phase and poly phase Induction motor.

## PART B

**Answer any one full question from each module. Each question carries 14 marks.**

**Module 1**

11. a) Write the voltage equations for Kron's primitive machine in matrix form. **(9)**
    b) Derive the expression for transformer and speed voltages in the armature along the quadrature axis. **(5)**
12. Derive electrical torque expression of Kron's primitive machine in terms of reluctance and show that no torque is produced by interaction between flux and current on the same axis. **(14)**

**Module 2**

13. Explain Park's transformations to transform currents between a rotating balanced three phase (a, b, c) winding to a pseudo stationary two phase (d, q) winding. Assume equal number of turns on all coils **(14)**

14. a) Explain the physical concept of Park's transformation **(7)**

    b) Explain the term invariance of power as applied to electrical machines. Show the power invariance is maintained under this transformation. **(7)**

## Module 3

15. a) Derive the voltage and torque equation of a DC series motor from its generalized mathematical model. **(7)**

b) Obtain the steady state analysis of a separately excited DC motor and plot the shunt characteristics. Also derive the expression for torque. **(7)**

16. a) A separately excited DC generator gives a no load output voltage of 240 V at a speed of ωr and a field current of 3 A. Find the generated emf per field ampere, Kg. **(5)**

b) Investigate the transient behaviour of a separately excited DC generator under the following operating condition:

i) Sudden application of a step field excitation to the field under no load, $i_a$ =0 and for constant no load speed ωr0 and explore the variation of armature voltage. **(9)**

## Module 4

17) a) Derive the power expression for salient pole synchronous machine in terms of load angle δ and draw the power angle characteristics. **(7)**

b) Derive the voltage equations in matrix form for a three phase synchronous machine with no amortisseurs. **(7)**

18) Derive the equivalent circuit of a poly phase induction motor with the help of its generalized mathematical model. **(14)**

## Module 5

19) Derive the electromagnetic torque equations from the primitive machine model of a single phase induction motor by applying cross field theory. **(14)**

20) Explain the double field revolving theory of single phase Induction motor. **(14)**

## Syllabus

**Module 1**

Unified approach to the analysis of electrical machine performance - per unit system - Basic two pole model of rotating machines- Primitive machine - Conventions -transformer and rotational voltages in the armature voltage and torque equations, resistance, inductance and torque matrix.

**Module 2**

Transformations-passive linear transformation in machines-invariance of power-transformation from a displaced brush axis-transformation from three phase to two phase and from rotating axes to stationary axes -Physical concept of Park's transformation.

**Module 3**

DC Machines: Application of generalized theory to separately excited DC generator: steady state and transient analysis, Separately excited DC motor- steady state and transient analysis, Transfer function of separately excited DC generator and motor- DC shunt and series motors: Steady state analysis and characteristics.

**Module 4**

Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves.

Induction Machines: Primitive machine representation. Transformation- Steady state operation - Equivalent circuit. Torque slip characteristics.

**Module 5**

Single phase induction motor- Revolving Field Theory equivalent circuit- Voltage and Torque equations-Cross field theory-Comparison between single phase and poly phase induction motor.

**Text Books**

1) Bhimbra P. S., "Generalized Theory of Electrical Machines", Khanna Publishers, 6$^{th}$edition, Delhi 2017.
2) Charles V. Johnes, "Unified Theory of Electrical Machines". New York, Plenum Press, 1985.
3) Bernad Adkins, Ronald G Harley, "General theory of AC Machines". London, Springer Publications, 2013.

**Reference Books**

1) Charles Concordia," Synchronous Machines- Theory and Performance", John Wiley and Sons Incorporate, Newyork.1988.
2) Say M. G., "Introduction to Unified Theory of Electrical Machines", Pitman Publishing, 1978.
3) Alexander S Langsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill, 2$^{nd}$ revised edition, 2001.

**Course Contents and Lecture Schedule**

| Sl. No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Two pole Model (10 Hours)** | |
| 1.1 | Introduction- Essentials of rotating machines-Electromechanical energy conversion. Conventions. | 1 |
| 1.2 | Idealised machine diagram of DC Compound machine, DC shunt machine, Synchronous motor, Induction motor, Single phase AC motor. | 2 |
| 1.3 | Per unit system, Advantages of per unit system, Expression for self inductance of a machine, Mutual flux linking. | 1 |
| 1.4 | Transformer and speed voltages in the armature, transformer with movable secondary. | 2 |
| 1.5 | Kron's primitive machine, Leakage flux in machines with more than two windings. Fundamental assumptions. | 2 |
| 1.6 | Voltage equations, Stator field coils, Armature coils, Equations of armature voltage in matrix form, | 2 |
| **2** | **Linear Transformations (8 Hours)** | |
| 2.1 | Linear transformation in machines- power invariance, Transformations from a displaced brush axis. | 2 |
| 2.2 | Transformations from three phase to two phase (a,b,c) to (α,β,0) transformation matrix. | 3 |
| 2.3 | Transformation from rotating axes (α,β,0) to stationary axes (d,q,0). | 2 |
| 2.4 | Power invariance: problems on transformations | 1 |
| **3** | **DC Machines (10 Hours)** | |
| 3.1 | DC machines, Separately excited DC generators, Rotational mutual inductance, Steady state and transient analysis, Armature terminal voltage. | 2 |
| 3.2 | Transfer function of DC machines, Separately excited generator under no load and loaded condition, Numerical Problems. | 2 |
| 3.3 | Steady state analysis and Shunt characteristics of DC machine. | 2 |

| | | |
|---|---|---|
| 3.4 | DC series motor, Schematic diagram of Primitive model, Interconnection between armature and field, Torque and speed expression, Different characteristics. | 2 |
| 3.5 | DC shunt motor, Schematic diagram, primitive model, Steady state analysis, Torque-Current and Speed-Current characteristics, Condition for maximum torque. | 2 |
| **4** | **Synchronous and Three Phase Induction Motors (10 Hours)** | |
| 4.1 | Poly phase Synchronous machine, Basic structure, Assumptions, Parameters, Synchronous resistance, inductance and mutual inductance between armature and field. | 2 |
| 4.2 | Armature self-inductance, Armature mutual inductance, General synchronous machine parameters, Amplitude of second harmonic component. | 2 |
| 4.3 | Steady state power angle characteristics, reluctance power, Cylindrical rotor machine and salient pole machine, Phasor diagram, Pull out torque, Maximum power. | 2 |
| 4.4 | Polyphase induction machine, Voltage expression, Transformations from $\alpha\beta$ to d-q and vice versa, Expression for electromagnetic torque. | 2 |
| 4.5 | Steady state analysis, Voltage equation in new variables, Connection matrix, | 1 |
| 4.6 | Equivalent circuit of an induction machine, Short circuited and open circuited two winding transformer. | 1 |
| **5** | **Single Phase Induction Motors (7 Hours)** | |
| 5.1 | Single phase induction motor, Basic structure, Assumptions, Primitive Machine Model. | 2 |
| 5.2 | Electrical Performance Equations, Voltage Matrix. | 2 |
| 5.3 | Steady state analysis, Equivalent Circuit | 2 |
| 5.4 | Numerical Problems | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEHR611.2** | **ANALYSIS OF POWER ELECTRONIC CIRCUITS** | **HONOURS** | 3 | 1 | 0 | 4 |

**Preamble** : To impart knowledge about analysis and design of various power converters.

**Prerequisite** : Electric circuit theory

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Choose appropriate power semiconductor device along with its driver circuits and protection. |
| **CO 2** | Analyse the operation of controlled rectifier circuits and PWM rectifiers. |
| **CO 3** | Analyse inverter circuits with different modulation strategies. |
| **CO 4** | Analyse the operation of DC-DC converters andAC voltage controllers. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | | | | | | | | | | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 40 |
| Analyse (K4) | | | |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1): Choose appropriate power semiconductor device along with its driver circuits and protection.**

1. Compare ideal and real power electronic switches. (K1)
2. Explain the static and dynamic characteristics MOSFET and IGBT. (K2)
3. Choose the appropriate power electronic switch for a converter. (K3)
4. Illustrate the operation of driver and snubber circuits for power electronic switches. (K2)
5. Design a heat sink for a power electronic switch. (K3)

**Course Outcome 2 (CO2): Analyse the operation of controlled rectifier circuits and PWM rectifiers.**

1. Analyse the operation of full and semi converters for single and three phase applications working with RLE loads. (K2), (K3)
2. Analyse the effect of source inductance in full converters. (K2), (K3)
3. Explain the operation of phase controlled rectifiers in inversion mode.(K2)
4. Explain the different topologies and control of PWM rectifiers. (K2)
5. Mathematically show the effect of single phase rectifiers on neutral currents in three phase four wire systems. (K2), (K3)

**Course Outcome 3 (CO3): Analyse inverter circuits with different modulation strategies.**

1. Analyse the operation of single and three phase inverters with RL loads. (K2), (K3)
2. Explain unipolar and bipolar sinusoidal pulse width modulation. (K2)
3. Design output filters for inverters. (K3)
4. Describe the types and working of multilevel inverters. (K1), (K2)
5. Explain the various current control methods of voltage source inverter. (K2)

**Course Outcome 4 (CO4): Analyse the operation of DC- DC converters and AC voltage controllers.**

1. Analyse the operation of single, two and four quadrant dc choppers. (K4)
2. Describe the control methods of dc choppers. (K2)
3. Design input filter for dc choppers. (K4)
4. Explain the working of multiphase choppers. (K2)
5. Analyse the operation of three phase ac voltage controllers with R load. (K4)

**Model Question paper**

**QP CODE:**

PAGES: 2

Reg. No:_______________

Name:_______________

**TKM COLLEGE OF ENGINEERING**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION,MONTH & YEAR**

**Course Code: 22EEHR611.2**

**Course Name: ANALYSIS OF POWER ELECTRONIC CIRCUITS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Draw and explain a snubber circuit for a power MOSFET.
2. Compare the characteristics of ideal and real switches.
3. Why do the triple harmonics dominate in three phase four wire system with balanced rectifier loads?
4. Derive the expression for output voltage of half wave controlled rectifier with resistive load.
5. What is the significance of common mode voltage in inverters.
6. What are the merits of unipolar modulation technique for inverters over bipolar.
7. Derive an expression for average output voltage in terms of input dc voltage andduty cycle for a step down dc chopper.
8. Using a two phase dc chopper, bring out its advantages compared to a single chopper.
9. Develop the expression for power factor for an ac voltage controller using integral cycle control.
10. List the merits and demerits of Hysteresis current controller.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

a) A 100 V dc supply is connected to a resistance of 7 Ohms through a series static controlled switch. The ON state forward voltage drop of the switch is 2 V. Its forward leakage current in the OFF state is 2 mA. It is operated with a switching frequency of 1 kHz and a duty cycle of 30%. Neglect the switching transition times and determine the peak and average power dissipation in the switch. Also find the proportion in which this power dissipation is shared between the ON state dissipation and OFF state dissipation. **(5)**

b) Draw and explain the static and dynamic characteristics of IGBT. **(9)**

a) Explain the design of a driver circuit for MOSFET. **(7)**

b) A MOSFET that is used in a dc-dc converter is dissipating 50W. The thermal resistance to conduction from the junction to the case is 0.5 deg K/W and the thermal resistance to conduction from the case to the heat sink is 1.5 deg K/W. If the ambient temperature in the neighbourhood of the heat sink is 50 deg C, then calculate the thermal resistance requirement for the heat sink if the junction temperature does not exceed 100 deg C. **(7)**

**Module 2**

a) Derive the input PF of a single phase controlled rectifier with continuous and ripple-free load current. **(6)**

b) With necessary mathematical analysis, show the effect of source inductance on the output voltage of a single phase controlled bridge rectifier. **(8)**

a) Describe the working of 3-phase fully controlled converter with the help of circuit diagram. **(6)**

b) A three phase fully controlled bridge converter is connected to 415 V supply, having a reactance of 0.3 Ohm/phase and resistance of 0.05 Ohm/phase. The converter is working in the inversion mode at a firing advance angle of 35 deg. Compute the average generator voltage. Assume $I_d$ = 60 A and thyristor drop = 1.5 V. **(8)**

**Module 3**

A single phase bridge inverter supplies an R-L load with R=10 Ohms and L=50mH from a 220 V dc supply. If the inverter frequency is 50 Hz, calculate i) rms value of fundamental component of load current ii) THD of load current iii) total power delivered to the load and iv) fundamental power output. **(14)**

Three single phase H bridge inverter circuits are available. What is the level of multilevel inverter that can be formed using them? Draw its circuit diagram and the important waveforms. Give a table showing the switch combination to be turned ON to get each level. **(14)**

**Module 4**

With a neat circuit diagram and waveforms, explain how four-quadrant operation is achieved in a Type-E Chopper. **(14)**

a) Explain the working of two quadrant type-A chopper with relevant waveforms. **(8)**

b) A step up chopper has input voltage of 120V and output voltage of 360 V. Ifthe conducting time of the thyristor chopper is 100 μs, compute the pulse width of output voltage. **(6)**

**Module 5**

A three phase three wire bidirectional controller supplies a star connected resistive load of R=5 Ohms and the line to line input voltage is 210 V, 50 Hz. The firing angle is $\pi/3$. Determine i) the rms output phase voltage ii) the input power factor and iii) the expression for the instantaneous output voltage of phase a. **(14)**

(a) What are the challenges faced by the conventional rectifier circuits? Justify. **(5)**

Explain the working of any two PWM rectifier circuits to mitigate these issues. With block diagrams, discuss their control strategy. **(9)**

## Syllabus

**Module 1** **(8 hours)**

**Overview of solid state devices**

Characteristics of Ideal and Real switches - Static and Dynamic Characteristicsfor MOSFET and IGBT, Driver circuit and Snubbers for MOSFET and IGBT – Conduction and Switching loss - Power dissipation and selection of heat sink.

**Module 2** **(10 hours)**

**Phase controlled Rectifiers**

Single-phase converter - full converter and semi converter - analysis with RLE loads – input PF with continuous and ripple free load current - inversion mode – effect of source inductance – Effect of single phase rectifiers on neutral currents in three phase four wire systems.

Three-phase converter - Full converter & semi converter – analysis with RLE loads – continuous conduction only – inversion mode - effect of source inductance –line notching and distortion.

**Module 3** **(10 hours)**

**Inverters**

Single phase full Bridge Inverters –Analysis with RL load - Three phase bridge inverter - Analysis with delta and star connected RL loads – Common mode voltage; PWM principle - Sinusoidal pulse width modulation- Unipolar and Bipolar modulation, Effect of blanking time on voltage of PWM inverter, output filter design.

**Multilevel Inverters**

Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters

**Module 4** **(7 hours)**

**DC Choppers**

Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers, PWM control-Time ratio control – Current limit control, Source filter and its design, multiphase chopper.

**Module 5** **(6 hours)**

**AC voltage controllers**

Three phase AC Voltage Controllers-Principle, operation and analysis with R loads

**Current control of VSI**

Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control

**PWM rectifiers**

Single phase PWM rectifiers –Basic topologies and control

**Text Books**

Joseph Vithayathil, Power Electronics: Principles and Applications, Tata McGraw Hill 2010.

Mohan, Undeland, Robbins, Power Electronics; Converters, Applications and Design. - 3rd edition, John Wiley and Sons, 2003.

Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education, 2013.

**Reference Books**

Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.

L. Umanand, Power Electronics – Essentials & Applications, Wiley-India, 2009.

M H Rashid (Ed), Power Electronics Handbook: Devices, Circuits and Applications,Academic Press 2010.

José Rodríguez, *et al*, Multilevel Inverters: A Survey of Topologies, Controls, and Applications, IEEE Transactions on Industrial Electronics, vol. 49, no. 4, August 2002.

**Total Lecture Hours: 45**

**Course Contents and Lecture Schedule:**

| **No** | **Topic** | **No. of Lectures** |
|---|---|---|
| **1** | **Overview of solid state devices (8 hours)** | |
| 1.1 | Characteristics of Ideal and Real switches | 1 |
| 1.2 | Static and Dynamic Characteristics for MOSFET and IGBT | 2 |
| 1.3 | Driver circuit and Snubbers for MOSFET and IGBT | 2 |
| 1.4 | Conduction and Switching loss | 1 |
| 1.5 | Power dissipation and selection of heat sink | 2 |
| **2** | **Phase controlled Rectifiers (10 hours)** | |
| 2.1 | Single-phase converter - full converter and semi converter - analysis with RLE loads | 2 |
| 2.2 | Input PF with continuous and ripple free load current - inversion mode | 1 |
| 2.3 | Effect of source inductance. | 1 |
| 2.4 | Effect of single phase rectifiers on neutral currents in three phase four wire system | 1 |
| 2.5 | Three-phase converter - Full converter & semi converter – analysis with RLE loads - continuous conduction only | 2 |

| | | |
|---|---|---|
| 2.6 | Inversion mode - Effect of source inductance | 2 |
| 2.7 | line notching and distortion | 1 |
| **3** | **Inverters (10 Hours)** | |
| 3.1 | Single phase full Bridge Inverters – Analysis with RL load | 1 |
| 3.2 | Three phase bridge inverter - Analysis with delta and star connected RL loads – Common mode voltage | 2 |
| 3.3 | PWM principle - Sinusoidal pulse width modulation - Unipolar and Bipolar modulation | 2 |
| 3.4 | Effect of blanking time on voltage of PWM inverter, output filter design | 2 |
| | **Multilevel Inverters** | |
| 5.2 | Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters | 3 |
| **4** | **DC Choppers (7 Hours)** | |
| 4.1 | Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers | 3 |
| 4.2 | PWM control-Time ratio control – Current limit control | 2 |
| 4.3 | Source filter and its design | 1 |
| 4.4 | Multiphase chopper | 1 |
| **5** | **AC voltage controllers (6 Hours)** | |
| 5.1 | Three phase AC Voltage Controllers - Principle, operation and analysis with R loads | 2 |
| | **Current control of VSI** | |
| 5.3 | Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control | 2 |
| | **PWM rectifiers** | |
| 5.4 | Single phase PWM rectifiers –Basic topologies and control | 2 |

Concerns

1. Prerequisite
2. Credits and hours of the course
3. Knowledge levels

4. Design of driver circuit in QP
5. CO-PO mapping
6. Assessment pattern – marks

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| 22EEHR611.3 | OPERATION AND CONTROL OF POWER SYSTEMS | HONOURS | 3 | 1 | 0 | 4 |

**Preamble** : This course introduces analysis techniques for the operation and control of power systems. Load dispatch and scheduling of energy are discussed. Power system security and state estimation are introduced. This course serves as the most important prerequisite of many advanced courses in power systems.

**Prerequisite : Power Systems I**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Analyse various methods of generation scheduling. |
| **CO 2** | Formulate hydro-thermal scheduling problems. |
| **CO 3** | Evaluate power exchange in interconnected power systems. |
| **CO 4** | Analyse security issues in power system networks. |
| **CO 5** | Analyse various state estimation methods. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | 2 | | | | | | | | 2 |
| **CO 2** | 3 | 3 | | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | 2 | 2 | | | | | | | | 2 |
| **CO 5** | 3 | 3 | | | | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which students should answer any one question. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain economic dispatch and unit commitment (K1)
2. Problems on optimal load dispatch (K2, K3)

**Course Outcome 2 (CO2):**

1. Distinguish between the long term and short term scheduling. (K2)
2. Explain how scheduling of energy can be done with limited supply. (K2, K3)

**Course Outcome 3 (CO3):**

1. Discuss the advantages and disadvantages of power pools (K2).
2. Explain what do you mean by interchange evaluation with unit commitment (K2, K3).

**Course Outcome 4 (CO4):**

1. What is system security? Explain the major factors involved in system security (K2)
2. Explain the effects of generator outages in power systems. (K2, K3).

**Course Outcome 5 (CO5):**

1. Discuss in detail, what do you mean by network observability.(K1)
2. Explain any one method by which bad measurements can be detected. (K2).

**Model Question paper**

**QP CODE:**

PAGES: 2

Reg. No:_______________

Name:_______________

**TKM COLLEGE OF ENGINEERING**

**SIXTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEHR611.3**

**Course Name: OPERATION AND CONTROL OF POWER SYSTEMS**

Max. Marks: 100. Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain what do you mean by economic dispatch.
2. Discuss the different constraints in unit commitment.
3. Differentiate between long range and short term generation scheduling.
4. Write short notes on pumped storage hydro plants
5. Explain what do you mean by power pools.
6. Write short notes on energy banking.
7. Illustrate the importance of power system security
8. What do you mean by contingency analysis?
9. Elaborate on the importance of state estimation in power system.
10. What are the sources of errors in state estimation?

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. What do you mean by optimal load dispatch? Explain any one method by which optimal load dispatch can be done. (14)

12 a. With the help of a flowchart, explain the priority list method of unit commitment. (10)

b. Write notes on security constrained unit commitment. (4)

**Module 2**

13. a. Explain any one method by which short term hydrothermal co-ordination can be done. (7)

b. Explain how hydroelectric plants are modelled for scheduling problems. (7)

14. a. Explain how scheduling of energy can be done with limited supply. (7)

b. Explain any one method by which hydrothermal scheduling with storage limitation can be done. (7)

**Module 3**

15. a. Explain the advantages of economy interchange between interconnected utilities. (7)

b. Explain the different types of interchange contracts. (7)

16. a. Discuss the advantages and disadvantages of power pools (7)

b. Explain what do you mean by interchange evaluation with unit commitment. (7)

**Module 4**

17. With the help of a flowchart, explain contingency analysis using sensitivity factors. (14)

18. a.What is system security? Explain the major factors involved in system security (9)

b. Explain the effects of generator outages in power systems. (5)

**Module 5**

19. a) Explain how quantities which are not measured can be estimated. (7)

b) Discuss in detail, what do you mean by network observability. (7)

20. a) Explain any one method by which bad measurements can be detected. (10)

b)List out the advantages of state estimation in power systems. (4)

## Syllabus

**Module 1**

Introduction- Optimum load dispatch - First order gradient method base point and participation factors.

Economic dispatch versus unit commitment.

Unit Commitment Solution Methods - Priority-List Methods – Security Constrained Unit Commitment.

**Module 2**

Generation with limited supply-Take or pay fuel supply contract- Introduction to Hydro-thermal coordination-Long range and short range scheduling

Hydro-electric plant models-scheduling energy problems - types of scheduling problems- Scheduling energy - The Hydrothermal Scheduling Problem - Hydro scheduling with storage limitation - Introduction to Pumped storage hydro plants

**Module 3**

Inter change evaluation and power pools- Interchange contracts – Energy interchange between utilities - Interchange evaluation with unit commitment - Energy banking- power pools.

**Module 4**

Power system security- Factors Affecting Power System Security - Contingency Analysis: Detection of Network Problems - Generation Outages - Transmission Outages - An Overview of Security Analysis

**Module 5**

Introduction to State estimation in power system, Maximum Likelihood Weighted Least-Squares Estimation - State Estimation of an AC Network - Sources of Error in State Estimation - Detection and Identification of Bad Measurements - Estimation of Quantities Not Being Measured - Network Observability and Pseudo-measurements - The Use of Phasor Measurement Units (PMUs) - Application of Power Systems State Estimation - Importance of Data Verification and Validation

**Text books:**

1. Allen J. Wood, Bruce F. Wollenberg & Gerald B. Sheblé, "Power Generation, Operation, and Control", 3rd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey.

2. John Gainger & William Stevenson, "Power System Analysis", McGraw-Hill, Inc, , 1994.

**References:**

1. Ali Abur, Antonio Gómez Expósito, Power System State Estimation: Theory and Implementation, CRC Press, 2004.

**Course Contents and Lecture Schedule:**

| Sl. No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Load Dispatch (9 hours)** | |
| 1.1 | Review of economic load dispatch | 1 |
| 1.2 | Optimum load dispatch | 2 |
| 1.3 | First order gradient method base point and participation factors. | 2 |
| 1.4 | Economic dispatch versus unit commitment - Unit Commitment Solution Methods - Priority-List Methods | 2 |
| 1.5 | Security-Constrained Unit Commitment | 2 |
| **2** | **Generation Scheduling (9 hours)** | |
| 2.1 | Generation with limited supply-Take or pay fuel supply contract | 2 |
| 2.2 | Introduction to Hydro-thermal coordination-Long range and short range scheduling | 1 |
| 2.3 | Hydro-electric plant models | 1 |
| 2.4 | Scheduling energy problems - types of scheduling problems- Scheduling energy | 2 |
| 2.5 | The Hydrothermal Scheduling Problem | 2 |
| 2.6 | Introduction to Pumped storage hydro plants | 1 |
| **3** | **Interchange evaluation and power pools (9 Hours)** | |
| 3.1 | Interchange Contracts | 2 |
| 3.2 | Energy Interchange between Utilities | 2 |
| 3.3 | Interchange evaluation with unit commitment | 1 |
| 3.4 | Energy banking | 2 |
| 3.5 | Power pools | 2 |
| **4** | **Power system security (7 Hours)** | |
| 4.1 | Factors affecting Power System Security | 2 |
| 4.2 | Contingency Analysis | 1 |
| 4.3 | Detection of Network Problems | 1 |
| 4. 4 | Generation Outages | 1 |
| 4. 5 | Transmission Outages | 1 |
| 4. 6 | An overview of Security Analysis | 1 |

| | | |
|---|---|---|
| **5** | **State estimation in power system (9 Hours)** | |
| 5.1 | State estimation in power system - Maximum Likelihood Weighted Least-Squares Estimation | 2 |
| 5.2 | State Estimation of an AC Network - Sources of Error in State Estimation | 2 |
| 5.3 | Detection and Identification of Bad Measurements | 1 |
| 5.4 | Estimation of Quantities Not Being Measured | 1 |
| 5.5 | Network Observability and Pseudo-measurements | 1 |
| 5.6 | The Use of Phasor Measurement Units (PMUS) | 1 |
| 5.7 | Application of Power Systems State Estimation - Importance of Data Verification and Validation | 1 |

# SEMESTER VII

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET701** | **ADVANCED CONTROL SYSTEMS** | **PCC** | **2** | **1** | **0** | **3** |

**Preamble:** This course aims to provide a strong foundation on advanced control methods for modelling, time domain analysis, and stability analysis of linear and nonlinear systems. The course also includes the design of feedback controllers and observers.

**Prerequisite:** EET 305 Signals and Systems, EET 302 Linear Control Systems

**Course Outcomes:** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Develop the state variable representation of physical systems |
| **CO 2** | Analyse the performance of linear and nonlinear systems using state variable approach |
| **CO 3** | Design state feedback controller for a given system |
| **CO 4** | Explain the characteristics of nonlinear systems |
| **CO 5** | Apply the tools like describing function approach or phase plane approach for assessing the performance of nonlinear systems |
| **CO 6** | Apply Lyapunov method for the stability analysis of physical systems. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | - | - | - | - | - | - | - | - | - | 2 |
| **CO 2** | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 2 |
| **CO 3** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 2 |
| **CO 4** | 3 | 2 | - | - | - | - | - | - | - | - | - | 2 |
| **CO 5** | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 2 |
| **CO 6** | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 2 |

**Assessment Pattern:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 15 | 15 | 30 |
| Apply (K3) | 25 | 25 | 50 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B.
Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

**Course Level Assessment Questions:**

**Course Outcome 1 (CO1)**

1. Derive the state model of an armature controlled DC servo motor. (K2, PO1)
2. Obtain the phase variable representation for the system with G(s)= (K3, PO1, PO2)

$$T(s)=\frac{2s^2+s+3}{s^3+6s^2+11s+6}$$

3. Problems on deriving the state model of a given electrical circuit. (K2, PO1)
4. Problems on the conversion of Phase variable form to Canonical form. (K3, PO1, PO2)

**Course Outcome 2 (CO2):**

1. Obtain the time response y(t) of the homogeneous system:

$\dot{X}=\begin{bmatrix}-1 & 1\\ -2 & -3\end{bmatrix}x,\quad y=\begin{bmatrix}1 & 1\end{bmatrix}x$ and $x(0)^T=\begin{bmatrix}1 & 0\end{bmatrix}$ (K3, PO1, PO2)

2. Determine the transfer function for the system with the state model:

$\dot{X}=\begin{bmatrix}-2 & 1\\ -3 & -2\end{bmatrix}x+\begin{bmatrix}1\\ 1\end{bmatrix}u;\quad y=\begin{bmatrix}1 & 1\end{bmatrix}x$. (K3, PO1, PO2)

3. Determine the controllability of the following state model: (K3, PO1, PO2, PO3)

$$\dot{x}=\begin{bmatrix}1 & 0 & 0\\ 0 & 0 & 2\\ 0 & -1 & -5\end{bmatrix}x+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u$$

**Course Outcome 3(CO3):**

1. Design a state feedback controller for the following system such that the closed loop poles are placed at: -1 ± j2 and -12.

$$\dot{x}=\begin{bmatrix}0 & 1 & 0\\ 0 & -1 & 2\\ 0 & -1 & -3\end{bmatrix}x+\begin{bmatrix}0\\ 0\\ 1\end{bmatrix}u$$

(K3, PO1, PO2, PO3)

2. Design problems on State observer. (K3, PO1, PO2, PO3)

**Course Outcome 4 (CO4):**

1. Explain the linearization concept and assumptions made referred to Describing Function analysis. (K1, PO1)
2. With suitable characteristics explain the jump resonance phenomena. (K2, PO1, PO2)
3. Differentiate between linear and nonlinear systems referred to:
 i) frequency response, ii) sustained oscillations. (K2, PO1, PO2)
4. Identify and explain the type of singular points for the following two systems:

i) $\dot{X}=\begin{bmatrix}0 & 1\\ -2 & 3\end{bmatrix}X$ and ii) $\dot{X}=\begin{bmatrix}0 & 1\\ -1 & -2\end{bmatrix}X$. (K3, PO1, PO2)

**Course Outcome 5 (CO5):**

1. Problems related to the derivation of describing function of a common nonlinearity. (K2, PO1, PO2)
2. Problems related to application of describing function for analysing the stability of given closed loop system. (K3, PO1, PO2, PO3)

3. Obtain the phase trajectory of the system with $\ddot{y} + 6\dot{y} + 5y = 0$, for initial point $x(0)^T = [1 \;\; 0.6]$. Use Isocline method. Also, identify the type of singular point. (K3, PO1, PO2, PO3)

**Course Outcome 6 (CO6):**

1. Use Lyapunov Direct method to determine the value of K such that the given LTI system is stable.

$$\dot{X} = \begin{bmatrix} 0 & K \\ -2 & -1 \end{bmatrix} X$$

. (K3, PO1, PO2, PO3)

2. Determine the stability of the LTI system with state model: $\dot{X} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -5 \end{bmatrix} X$

(K3, PO1, PO2, PO3)

3. Test stability of the nonlinear system given below, using Lyapunov method.

$$\dot{X} = \begin{bmatrix} -4 & 0 \\ 3{x_2}^2 & -2 \end{bmatrix} X$$

(K3, PO1, PO2, PO3)

**Model Question Paper** PAGES: 3

QP CODE:

Reg.No:_____________
Name:_______________

**TKM COLLEGE OF ENGINEERING**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

Course Code**: 22EET701**

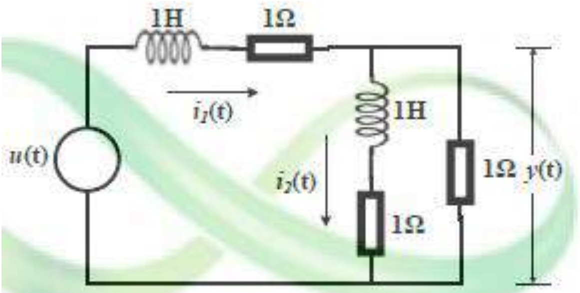
Course Name: **ADVANCED CONTROL SYSTEMS**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1 Selecting $i_1(t) = x_1(t)$ and $i_2(t) = x_2(t)$ as sate variables obtain state equation and output equation of the network shown.




2 for the system with the transfer function:

3 with state model:

4 Explain any four properties of state transition matrix.

5 Determine the controllability of the following state model: $\dot{x} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 1 \\ 0 & -1 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$

6 Explain the significance of PBH test for observabilty.

7 With suitable characteristics explain the jump resonance phenomena in nonlinear systems.

8 Obtain the describing function of deadzone non-linearity.

9 Determine given quadratic form is positive definite or not:
$V(x) = 10x_1^2 + 4x_2^2 + x_3^2 + 2x_1 x_2 - 2x_2 x_3 - 4x_1 x_3$

10 Use Lyapunov theorem to determine test stability of the nonlinear system given below.
$$\dot{X} = \begin{bmatrix} -4 & 0 \\ 3x_2^2 & -2 \end{bmatrix} X$$

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11 a) Obtain the phase variable representation for the system with transfer function:
$$T(s) = \frac{2s^2 - 3}{s^3 + 6s^2 + 11s + 6}$$
(7 Marks)

b) Derive the state model of an armature controlled DC servo motor. (7 Marks)

12 a) Determine the diagonal canonical representation for the system:

$$\dot{X} = \begin{bmatrix} -2 & 1 \\ -3 & -2 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u; \quad y = \begin{bmatrix} 1 & -1 \end{bmatrix} x.$$

(9 Marks)

b) Explain any four advantages of state model as compared to transfer function model. (5 Marks)

## Module 2

13 a) Obtain the unit step response y(t) of the system

$$\dot{X} = \begin{bmatrix} -1 & 0 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u, \quad y = \begin{bmatrix} 1 & 1 \end{bmatrix} x.$$

(10 Marks)

b) Show that eigen values of state models are unique. (4 Marks)

14 a) Determine the state transition matrix for the system with state model:

$$\dot{X} = \begin{bmatrix} -1 & 1 \\ 1 & -2 \end{bmatrix} x$$

(7 Marks)

b) How do you derive the z transfer function from the state model of a sampled data system? (7 Marks)

## Module 3

15 a) Consider a linear system described by the transfer function $\frac{Y(s)}{U(s)} = \frac{10}{s(s+1)(s+2)}$ Design a feedback controller with a state feedback so that the closed loop poles are placed at -2, -1±j1. (10 Marks)

b) Write short note on reduced order observer. (4 Marks)

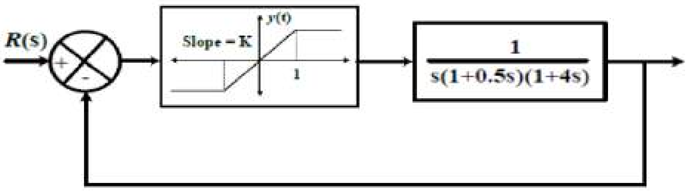
16 a) Consider a linear system described by $\dot{x} = \begin{bmatrix} 1 & 2 & 0 \\ 3 & -1 & 1 \\ 0 & 2 & -5 \end{bmatrix} x + \begin{bmatrix} 2 \\ 1 \\ 1 \end{bmatrix} u$

Design a state observer so that the closed loop poles are placed at -4, -3±j1. (9 Marks)

b) With suitable example explain the concept of duality referred to controllability. (5 Marks)

## Module 4

17 a) Determine the value of K for an occurrence of limit cycle. Also determine the amplitude, frequency and stability of limit cycle.




. (10 Marks)

b) With relevant characteristics explain any three nonlinearities in electrical systems. (4 Marks)

18 a) Obtain the describing function of relay with dead zone nonlinearity. (8 Marks)

b) Explain the linearization concept and assumptions made referred to Describing Function analysis. (6 Marks)

## Module 5

19 a) A linear second order system is described by the equation:

$\ddot{e} + 2\delta\omega n\dot{e} + \omega n^2 e = 0$, with $\delta = 0.25$, $\omega n$ = 1rad/sec, e(0)=1.0, and $\dot{e}(0) = 0$

Determine the singular point and state the stability by constructing the phase trajectory using the method of isoclines. (11 Marks)

b) Identify and explain the type of singular point for the following system:

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & 3 \end{bmatrix} X$$

(3 Marks)

20 a) Differentiate between stable and unstable limit cycles. (5 Marks)

b) Use Lyapunov Direct method to determine the value of K such that the given LTI system is stable.

$$\dot{X} = \begin{bmatrix} 0 & K \\ -2 & -1 \end{bmatrix} X$$

(9 Marks)

## Syllabus

**Module 1**

**State Space Representation of Systems (7 hours)**

Introduction to state space and state model concepts- State equation of linear continuous time systems, matrix representation- features- Examples of electrical circuits and dc servomotors.
Phase variable forms of state representation- Diagonal Canonical forms- Similarity transformations to diagonal canonical form.

**Module 2**

**State Space Analysis (9 hours)**

State transition matrix- Properties of state transition matrix- Computation of state transition matrix using Laplace transform and Cayley Hamilton method.
Derivation of transfer functions from state equations.
Solution of time invariant systems: Solution of time response of autonomous systems and forced systems.
State space analysis of Discrete Time control systems: Phase variable form and Diagonal canonical form representations- Pulse transfer function from state matrix- Computation of State Transition Matrix (problems from $2^{nd}$ order systems only).

**Module 3**

**State Feedback Controller Design (6 hours)**

Controllability & observability: Kalman's, Gilbert's and PBH tests.- Duality principle
State feedback controller design: State feed-back design via pole placement technique
State observers for LTI systems- types- Design of full order observer.

**Module 4**

**Nonlinear Systems (7 hours)**

Types and characteristics of nonlinear systems- Jump resonance, Limit cycles and Frequency entrainment
Describing function method: Analysis through harmonic linearization- Determination of describing function of nonlinearities.
Application of describing function for stability analysis of autonomous system with single nonlinearity (relay, dead zone and saturation only).

**Module 5**

**Phase Plane and Lyapunov Stability Analysis (8 hours)**

Phase plots: Concepts- Singular points – Classification of singular points.
Definition of stability- asymptotic stability and instability.
Construction of phase trajectories using Isocline method for linear and nonlinear systems.
Lyapunov stability analysis: Lyapunov function- Lyapunov methods to stability of nonlinear systems- Lyapunov methods to LTI continuous time systems.

**Text Books:**

1. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers, 2007
2. Ogata K., Modern Control Engineering, 5/e, Prentice Hall of India, 2010.
3. Gopal M, Modern Control System Theory, 2/e, New Age Publishers, 1984
4. Kuo B.C, Analysis and Synthesis of Sampled Data Systems, Prentice Hall Publications, 2012.

**References:**

1. Khalil H. K, Nonlinear Systems, 3/e, Prentice Hall, 2002

2. Gibson J.E. Nonlinear Automatic Control, Mc Graw Hill, 1963.

3. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill, 2012.

4. Slotine J. E and Weiping Li, Applied Nonlinear Control, Prentice-Hall, 1991,

5. Gopal M, Digital Control and State Variable Methods, 2/e, Tata McGraw Hill, 2003

6. Thomas Kailath, Linear Systems, Prentice-Hall, 1980.

7. Ogata K., Discrete Time Control Systems, 2/e, Pearson Education, Asia, 2015

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**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **State Space Representation of Systems** | **(7 hours)** |
| 1.1 | Introduction to state space and state model concepts- state equation of linear continuous time systems, matrix representation- features -Examples of electrical circuits and dc servomotors | 3 |
| 1.2 | Phase variable forms of state representation- features- controllable and observable companion forms | 2 |
| 1.3 | Diagonal canonical forms of state representation- Diagonal & Jordan forms- features- Similarity transformations to diagonal canonical form | 2 |
| **2** | **State Space Analysis** | **(9 hours)** |
| 2.1 | State transition matrix- Properties of state transition matrix- Computation of state transition matrix using Laplace transform- Cayley Hamilton method. | 2 |
| 2.2 | Derivation of transfer functions from state equations. | 1 |
| 2.3 | Solution of time invariant systems: Solution of time response of autonomous systems and forced systems | 3 |
| 2.4 | State space analysis of Discrete Time control systems: Phase variable form and Diagonal canonical form representations | 2 |
| 2.5 | Pulse transfer function from state matrix- Computation of State Transition Matrix- (problems from $2^{nd}$ order systems only) | 1 |
| **3** | **State Feedback Controller Design** | **(6 hours)** |
| 3.1 | Controllability & observability: Kalman's, Gilbert's and PBH tests- Duality property | 2 |
| 3.2 | State feedback controller design: State feed-back design via pole placement technique | 2 |
| 3.3 | State observers for LTI systems- Full order and reduced order observers- Design of full order observer design | 2 |
| **4** | **Nonlinear Systems** | **(7 hours)** |
| 4.1 | Types of nonlinear systems- characteristics of nonlinear systems- peculiar features like Jump resonance, Limit cycles and Frequency entrainment | 2 |
| 4.2 | Describing function Method: Analysis through harmonic linearisation | 1 |

| | | |
|---|---|---|
| 4.3 | Determination of describing function of nonlinearities | 2 |
| 4.4 | Application of describing function for stability analysis of autonomous system with single nonlinearity (relay, dead zone and saturation only). | 2 |
| **5** | **Phase Plane and Lyapunov Stability Analysis** | **(8 hours)** |
| 5.1 | Phase plots: Concepts- Singular points - Classification of singular points. | 1 |
| 5.2 | Construction of phase trajectories using Isocline method for linear and nonlinear systems | 2 |
| 5.3 | Definition of stability- asymptotic stability and instability | 1 |
| 5.4 | Lyapunov stability analysis: Lyapunov function- Lyapunov methods to stability of nonlinear systems | 2 |
| 5.5 | Lyapunov methods to LTI continuous time systems. | 2 |

**--------------- x -------------**

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEL705 | CONTROL SYSTEM LAB | PCC | 0 | 0 | 3 | 2 |

**Preamble:** This Laboratory Course provides a platform for modelling and analysis of linear and nonlinear systems with the help of hardware and software tools in the control framework.

**Prerequisite:** EET302 Linear Control Systems, EET305 Signals and Systems

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Demonstrate the knowledge of simulation tools for control system design. |
| **CO 2** | Develop the mathematical model of a given physical system by conducting appropriate experiments. |
| **CO 3** | Analyse the performance and stability of physical systems using classical and advanced control approaches. |
| **CO 4** | Design controllers for physical systems to meet the desired specifications. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 2 | 3 | 3 | | | 3 | 3 | 3 | | 3 |
| **CO 2** | 3 | 3 | 3 | 3 | 3 | | | 3 | 3 | 3 | | 3 |
| **CO 3** | 3 | 3 | 3 | 3 | 3 | | | 3 | 3 | 3 | | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 3 | | | 3 | 3 | 3 | | 3 |

**Course Level Assessment Questions**

**Assessment Pattern**

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 75 | 75 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 15 marks

Continuous Assessment : 30 marks

Internal Test : 30 marks

**End Semester Examination Pattern:** The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks

(b) Implementing the work/Conducting the experiment : 10 Marks

(c) Performance, result and inference (usage of equipments and troubleshooting) : 25 Marks

(d) Viva voce : 20 marks

(e) Record : 5 Marks

**General instructions:**

Practical examination to be conducted immediately after the second series test after completing 12 experiments out of the 18 experiments given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

**Reference Books**

1. Richard C. Dorf and Robert H. Bishop, Modern Control Systems,Eleventh Edition, Pearson Education 2009.

2. Katsuhiko Ogatta, Modern Control Engineering, Fourth Edition, Pearson Education,2002.

**List of Exercises/Experiments**: (Lab experiments may be given considering 12 sessions of 3 hours each.)

1. Simulation tools like MATLAB/ SCILAB or equivalent may be used.
2. All experiments done by the students in addition to 12 experiments may be treated as beyond syllabus experiments.

| Experiment No. | Name of the experiment |
|---|---|
| 1 | **Step response of a second order system.**<br><br>Objective: Design a second order system (eg: RLC network) to analyse the following:<br><br>A. The effect of damping factor (ξ: 0, <1,=1,>1) on the unit step response using simulation study (M-File and SIMULINK).<br><br>B. Verification of the delay time, rise time, peak overshoot and settling time with the theoretical values.<br><br>C. Performance analysis of hardware setup and comparison with the simulation results. |
| 2 | **Performance Analysis using Root-Locus Method.**<br><br>Objective: Plot the root locus of the given transfer function to analyse the following using simulation:<br><br>A. Verification of the critical gain, wo with the theoretical values<br><br>B. The effect of controller gain K on the stability<br><br>C. The sensitivity analysis by giving small perturbations in given poles and zeros<br><br>D. The effect of the addition of poles and zeros on the given system. |

**3 Stability Analysis by Frequency Response Methods.**

Objective: Plot the i) Bode plot and ii) Nyquist plot of the given transfer functions to analyse the following using simulation:

A. Determination of Gain Margin and Phase Margin

B. Verification of GM and PM with the theoretical values

C. The effect of controller gain K on the stability,

D. The effect of the addition of poles and zeros on the given system (especially the poles at origin).

**4 Realisation of lead compensator.**

Objective: Design, set up and analyse the gain and phase plots of a lead compensator by hardware experimentation using i) passive elements and ii) active components..

**5 Realisation of lag compensator.**

Objective: Design, set up and analyse the gain and phase plots of a lag compensator by hardware experimentation using i) passive elements and ii) active components..

**6 Design of compensator in frequency domain and time domain.**

Objective: Design a compensator for the given system to satisfy the given specifications

A. Time domain specifications using MATLAB

B. Frequency domain specifications using MATLAB

**7 State space model for analysis and design**

Objective: Study and analysis of state variable model of a given system (eg. DC Motor speed control/ Servo motor/etc) and design a controller by pole-placement technique using MATLAB based tool boxes.

A. Determine the open loop stability, controllability and observability

B. Analyse the effect of system parameters on eigen values and system performance.

C. Design a controller by pole-placement technique.

**8 PID Controller Design**

Objective: Design and analysis of a PID controller for a given system (eg. DC Motor speed control/ Servo motor/etc) using SIMULINK/ MATLAB based tool boxes

A. Design of PID controller to meet the given specifications

B. Study the effect of tuning of PID controller on the above system.

**9 Phase plane analysis of nonlinear autonomous systems**

Objective: Study and analysis of phase trajectory of a given nonlinear autonomous system using state space model in Simulation tools.

A. Determination and verification of the singular points,

B. Stability Analysis of the system at various singular points from phase portraits.

**10 Transfer Function of Armature and Field Controlled DC Motor**

Objective: Obtain the transfer function of the armature and field controlled DC motor by experiment.

**11 Synchro Transmitter and Receiver.**

Objective: Plot and study the different performance characteristics of Synchro transmitter-receiver units in Direct mode and Differential mode.

**12 Transfer function of Separately excited DC Generator.**

Objective: Obtain the open loop transfer function of a separately excited DC Generator by experiment.

**13 Transfer function of A.C. Servo motor.**

Objective: Obtain the open loop transfer function of AC Servo motor by experiment.

**14 Performance of a typical process control system**

Objective: Study of performance characteristics and response analysis of a typical temperature/ Flow/ Level control system.

**15 Closed loop performance of inverted pendulum.**

Objective: Study of performance characteristics of inverted pendulum by experiment.

A. Determine the various unknown parameters of an inverted pendulum experimentally,

B. Obtain and analyse the non-linear and linearised models,

C. Design and implement various state feedback controllers to analyse the performance of the system.

**16 Performance analysis of magnetic levitation system.**

Objective: Study of performance of magnetic levitation system by experiment.

A. Obtain and analyse the dynamics of a magnetic levitation system,

B. Design and implement various loop controllers to analyse the performance of this experimental system while tracking in presence/absence of disturbances.

**17 Closed loop performance of Twin rotor system**

Objective: Study of performance characteristics of Twin rotor system by experiment.

**18 Mass Spring Damper system**

Objective: Study of performance characteristics of Mass-Damper-Spring system by experiment.

A. Determine the various unknown parameters of a mass spring damper system experimentally to obtain transfer function/ state space models,

B. Design and implement various state feedback controllers to analyse the performance of the system while regulation and tracking

# SEMESTER VII
# (PROGRAM ELECTIVE II)

| 22EEE702.1 | ELECTRIC DRIVES | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PEC | 2 | 1 | 0 | 3 |

**Preamble:** To impart knowledge about the DC and AC motor drives and its applications

**Prerequisite:** EET306 Power Electronics, EET202 DC Machines and Transformers and EET307 Synchronous and Induction Machines.

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Describe the transient and steady state aspects electric drives |
| **CO 2** | Apply the appropriate configuration of controlled rectifiers for the speed control of DC motors |
| **CO 3** | Analyse the operation of chopper-fed DC motor drive in various quadrants |
| **CO 4** | Illustrate the various speed control techniques of induction motors |
| **CO 5** | Examine the vector control of induction motor drives |
| **CO 6** | Distinguish different speed control methods of synchronous motor drives |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | - | - | - | - | - | - | - | - | - | - |
| **CO 2** | 3 | 2 | - | 2 | | - | - | - | - | - | - | 1 |
| **CO 3** | 3 | 2 | - | 2 | | - | - | - | - | - | - | 1 |
| **CO 4** | 3 | 2 | - | 2 | | - | - | - | - | - | - | 1 |
| **CO 5** | 3 | 1 | - | 2 | | - | - | - | - | - | - | 1 |
| **CO 6** | 3 | 2 | - | 2 | | - | - | - | - | - | - | 1 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 20 | 20 | 40 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Assignment/Quiz/Course project | : 15 marks |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Derive the condition for steady state stability (K3,K4, PO1, PO4).

2. Draw the speed torque characteristics of traction drive (K1, PO1).

3. Problems based on fundamental torque equations and equivalent values of drive parameters (K3, K4 , PO2, PO4).

**Course Outcome 2 (CO2)**

1. Numerical problems based on rectifier controlled separately excited dc motor. (K3, K4, PO2, PO4).

2. Describe the function of a three phase inverter driving a dc motor (K2, PO1).

3. Draw the circuit diagram of dual converter and explain the operation (K1, PO1).

**Course Outcome 3(CO3):**

1. Explain Motoring and braking operation of chopper controlled DC motor (K2,PO1).

2. Numerical problems based on chopper controlled separately excited dc motor. (K3, K4, PO2, PO4).

3. With the block diagram illustrate the closed loop control of SEDC motor (K2, PO4).

**Course Outcome 4 (CO4):**

1. List different speed control methods for three phase induction motors (K1, PO1)

2. Discuss sine triangle PWM control of three phase induction motor drive (K2, PO4).

3. Numerical problems based on speed control of induction motor drives (K3,K4, PO2, PO4).

**Course Outcome 5 (CO5):**

1. Draw the block diagram of direct vector control of induction motor drives (K2, PO1).

2. Figure out the differences of scalar and vector control methods of three phase induction motor (K3, PO1).

3. Draw the decoupled diagram and phasor diagram of three phase induction motor (K2, PO1) .

**Course Outcome 6 (CO6):**

1. Explain v/f control of three phase synchronous motor drive (K2, PO1).

2. Enumerate different speed control methods of synchronous motor drives (K1, PO1).

3. With the diagram of load commutated CSI synchronous motor drive discuss the operation (K2, PO1).

**Model Question Paper** PAGES: 3

**QPCODE:**

Reg. No:____________

Name:______________

**TKM COLLEGE OF ENGINEERING**
**SEVENTH SEMESTER B. TECH DEGREE EXAMINATION**
**MONTH & YEAR**

Course Code**: 22EEE702.1**

Course Name: **ELECTRIC DRIVES**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**
**Answer all Questions.**
**Each question carries 3 Marks**

1 Draw the block diagram of an electric drive.

2 List 3 classifications of load torque with one example for each.

3 For a single phase fully-controlled rectifier fed separately excited DC motor, the armature current is assumed to be continuous and ripple free ($i_a = I_a$). Draw the source current waveform for a firing angle of 45˚.

4 Can a half-controlled rectifier fed separately excited DC drive operated in quadrant IV? Justify your answer.

5 Draw the circuit diagram of a two-quadrant (class C) chopper showing the two quadrants of operation.

6 With the help of the torque – speed characteristics of a DC series motor, explain why it is used for high-starting torque applications?

7 Constant torque loads are not suitable for AC voltage controller fed induction motor drive. Why?

8 Why V/f ratio is kept constant upto base speed and V constant above base speed in variable frequency control of an induction motor?

9 Differentiate between true synchronous mode and self-control mode of operation of a synchronous motor.

10 List any two advantages of vector control of 3-phase induction motors.

**PART B**
**Answer any one full question from each module.**
**Each question carries 14 Marks**

**Module 1**

11 a) What are the advantages of electric drives? (7)

| | | | |
|---|---|---|---|
| | b) | Explain the multi-quadrant operation of a motor driving a hoist load. | (7) |
| 12 | a) | Explain about steady state stability of equilibrium point in electric drive. | (7) |
| | b) | A drive has following parameters: - $J=10kg\text{-}m^2$, $T=100-0.1N$ and $T_l=0.05N$ where N is the speed in rpm. Initially the drive is operating in steady state. Now it is to be reversed. For this motor characteristics is changed to $T = -100-0.1N$. Calculate the time of reversal. | (7) |

**Module 2**

| | | | |
|---|---|---|---|
| 13 | a) | Explain the working of 3-phase fully-controlled separately excited DC drive with necessary waveforms. | (7) |
| | b) | A 220V, 1500rpm, 10A separately excited DC motor is fed from a single phase fully controlled rectifier with an ac source voltage of 230V, 50Hz. $R_a=2\Omega$. Conduction can be assumed to be continuous. Calculate the firing angles for rated motor torque and -1000rpm. | (7) |
| 14 | a) | Explain the discontinuous conduction mode of operation of a fully controlled rectifier fed separately excited DC motor with necessary waveforms. | (7) |
| | b) | Explain the working of a dual converter (circulating current type) fed separately excited DC motor. | (7) |

**Module 3**

| | | | |
|---|---|---|---|
| 15 | a) | Explain the operation of four quadrant chopper fed DC drives. | (7) |
| | b) | A chopper used to control the speed of a separately excited DC motor has supply voltage of 230V, $T_{on}$ = 15ms, $T_{off}$ = 5ms. Assuming continuous conduction of motor current, calculate the average load current when the motor speed is 3000rpm. Assume voltage constant $K_v$ = 0.5V/rad/sec and $R_a = 4\Omega$. | (7) |
| 16 | a) | Explain the chopper control of DC series motor. | (7) |
| | b) | Using a neat block diagram, explain the closed loop speed control for a separately excited DC motor. | (7) |

**Module 4**

| | | | |
|---|---|---|---|
| 17 | a) | Explain V/f control of 3-phase induction motor using necessary speed – torque characteristics. | (7) |
| | b) | A 440V, 3-phase, 50Hz, 6-pole, 945rpm, delta connected induction motor has following parameters referred to the stator: $R_s = 2\Omega$, $R_r' = 2\Omega$, $X_s = 3\Omega$, $X_r' = 4\Omega$. When driving a fan load at rated voltage it runs at rated speed. The motor speed is controlled by stator voltage control. Determine motor terminal voltage, current and torque at 800rpm. | (7) |
| 18 | a) | Explain the working of static rotor resistance control of 3-phase induction motor. Also derive the expression for the total rotor circuit resistance per phase. | (7) |
| | b) | Explain the static slip power recovery scheme using one uncontrolled bridge rectifier and one controlled bridge rectifier in the rotor circuit. | (7) |

**Module 5**

| | | | |
|---|---|---|---|
| 19 | a) | Describe the principle of operation of vector control. | (7) |
| | b) | Explain the variable frequency control of multiple synchronous motor. | (7) |
| 20 | a) | Explain Clerke and Park transformation with necessary equations. | (5) |
| | b) | Describe the working of a self-controlled synchronous motor drive employing load commutated thyristor inverter. | (9) |

**Syllabus (36 hours)**

**Module 1 (6 hours)**

Introduction to electric drives – block diagram – advantages of electric drives – dynamics of motor load system, fundamental torque equations, types of load – classification of load torque, four quadrant operation of drives, Equivalent values of drive parameters- effect of gearing - steady state stability.

**Module 2 (7 hours)**

Rectifier control of DC drives- separately excited DC motor drives using controlled rectifiers- single-phase fully controlled rectifier fed drives (discontinuous and continuous mode of operation), critical speed - single-phase semi converter fed drives (continuous mode of operation) - three-phase semi converter and fully controlled converter fed drives (continuous mode of operation) - dual converter control of DC motor - circulating current mode.

**Module 3 (6 hours)**

Chopper control of DC drives - two quadrant and four quadrant chopper drives - motoring and regenerative braking - chopper fed DC series motor drive - closed loop speed control for separately excited dc motor.

**Module 4 (10 hours)**

Three phase induction motor drives: Stator voltage control - Stator frequency control – v/f control - below and above base speed – Voltage Source Inverter (VSI) fed v/f control using sine-triangle PWM - static rotor resistance speed control employing chopper – static slip power recovery speed control scheme for speed control below synchronous speed.

**Module 5 (7 hours)**

Concept of space vector – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives – decoupling of flux and torque components - space vector diagram and block diagram [Ref.1].

Synchronous motor drives – v/f control – open loop control – self-controlled mode – load commutated CSI fed synchronous motor.

**Note:** Simulation assignments can be given using modern simulation tools like MATLAB, PSIM, PSpice, LTspice etc. from all modules of 2, 3, 4 and 5.

**Text Books**

1. G. K. Dubey, "Fundamentals of Electric Drives", Narosa publishers, second edition, 2001

**Reference Books.**

1. Bimal K.Bose, "Power Electronics and and Motor Drives", Academic press, An Imprint of Elsevier, 2006.

2. Vedam Subrahmanyam, "Electric Drives Concepts and Applications", MC Graw Hill Education, second edition, 2011,New Delhi.

3. Dr. P. S. Bimbhra, "Power Electronics", Khanna publishers, fifth edition, 2012.

4. Ned Mohan, Tore M Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons Inc.,3rd edition
5. Muhammad H.Rashid, "Power Electronics, Devices, Circuits and Applications", Pearson, 3rd edition, 2014
6. R Krishnan, "Electric Motor Drives: Modeling, Analysis, and Control", Prentice Hall, 2001.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Fundamentals of Electric drives (6 hours)** | |
| 1.1 | Introduction to electric drives- block diagram – advantages of electric drives | 1 |
| 1.2 | Dynamics of motor load system, fundamental torque equations, | 1 |
| 1.3 | four quadrant operation of drives | 1 |
| 1.4 | Types of load – classification of load torque | 1 |
| 1.5 | Equivalent values of drive parameters- effect of gearing - | 1 |
| 1.6 | Steady state stability | 1 |
| **2** | **Rectifier Control of DC drives (7 hours)** | |
| 2.1 | Rectifier controlled DC drives- separately excited DC motor drives using controlled rectifiers- single-phase fully controlled rectifier fed drives discontinuous mode of operation, | 2 |
| 2.2 | continuous mode of operation - critical speed | 1 |
| 2.3 | single-phase semi converter fed drives (continuous mode of operation) | 1 |
| 2.4 | three-phase semi converter controlled converter fed drives (continuous mode of operation) | 1 |
| 2.5 | Three phase fully controlled converter fed drives (continuous mode of operation) | 1 |
| 2.6 | Dual converter control of DC motor - circulating current mode | 1 |
| **3** | **Chopper control of DC drives (6 hours)** | |
| 3.1 | Two quadrant chopper DC drives - motoring and regenerative braking | 2 |
| 3.2 | Four quadrant chopper DC drives | 1 |
| 3.3 | Chopper fed DC series motor drive | 2 |
| 3.4 | Closed loop speed control for separately excited dc motor. | 1 |
| **4** | **Three phase induction motor drives (10 hours)** | |
| 4.1 | Stator voltage control - Stator frequency control | 1 |
| 4.2 | v/f control - below and above base speed | 2 |
| 4.3 | Voltage Source Inverter (VSI) fed v/f control using sine-triangle PWM | 2 |
| 4.4 | Static rotor resistance speed control employing chopper | 1 |

| | | |
|---|---|---|
| 4.5 | Static slip power recovery speed control scheme for speed control below synchronous speed. | 1 |
| 4.6 | Auto Sequential Commutated Current source Inverter (CSI) fed induction motor drives | 1 |
| 4.7 | Current regulated VSI using power semiconductor devices, operation and control scheme - comparison of CSI and VSI fed drives. | 2 |
| **5** | **Concept of space vector , Synchronous motor drives (7 hours)** | |
| 5.1 | Concept of space vector – Clarke and Park transformation – field orientation principle – Introduction to direct vector control of induction motor drives – decoupling of flux and torque components - space vector diagram and block diagram. | 4 |
| 5.2 | Synchronous motor drives – v/f control – open loop control | 1 |
| 5.3 | Self-controlled mode – load commutated CSI fed synchronous motor. | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEE702.2 | DIGITAL CONTROL SYSTEMS | PEC | 2 | 1 | 0 | 3 |

**Preamble** : This course aims to provide a strong foundation in discrete domain modelling, analysis and design of digital controllers to meet performance requirements.

**Prerequisite : EET201 Circuits and Networks, EET305 Signals and Systems, and EET302 Linear Control Systems**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Describe the various control blocks and components of digital control systems. |
| **CO 2** | Analyse sampled data systems in z-domain. |
| **CO 3** | Design a digital controller/ compensator in frequency domain. |
| **CO 4** | Design a digital controller/ compensator in time domain. |
| **CO 5** | Apply state variable concepts to design controller for linear discrete time system. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 2 |
| **CO 2** | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | 2 |
| **CO 3** | 3 | 3 | 3 | 3 | 2 | - | - | - | - | - | - | 3 |
| **CO 4** | 3 | 3 | 3 | 3 | 2 | - | - | - | - | - | - | 3 |
| **CO 5** | 3 | 3 | 3 | 3 | - | - | - | - | - | - | - | 3 |

**Assessment Pattern:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 15 | 15 | 30 |
| Apply (K3) | 25 | 25 | 50 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

**Part B** contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

**Course Level Assessment Questions:**

**Course Outcome 1 (CO1)**

10. Selection of sampling period and elements of discrete time systems (K2) (PO1, PO2).
11. Derivation of the transfer functions of discrete time systems (K3)(PO1, PO2, PO3, PO12).
12. Relations between continuous system poles and that in discrete domain (K2) (PO1, PO2).

**Course Outcome 2 (CO2):**

13. Derivation of pulse transfer function or response function of various system configurations (K3) (PO1, PO2, PO3, PO4, PO12).
14. Determination of time response of systems, error constant and steady state error (K2) (PO1, PO2).
15. Problems to analyse the response of systems (K3) (PO1, PO2, PO3, PO4, PO12).

**Course Outcome 3(CO3):**

10. Obtain the frequency response and design controller (K3) (PO1, PO2, PO3, PO4, PO5, PO12).
11. Design suitable compensator in frequency domain (K3) (PO1, PO2, PO3, PO4, PO5, PO12).
12. Problems related to compensator and controller design in frequency domain (K3) (PO1, PO2, PO3, PO4, PO5, PO12).

**Course Outcome 4 (CO4):**

13. Problems related to design controller from time response (K3) (PO1, PO2, PO3, PO4, PO5, PO12).
14. Design suitable compensator in time domain (K3) (PO1, PO2, PO3, PO4, PO5, PO12).
15. Problems related compensator and controller design in time domain (K3) (PO1, PO2, PO3, PO4, PO5, PO12).

**Course Outcome 5 (CO5):**

10. Problems related to modelling and analysis (stability, controllability and observability) of system in state space (K2) (PO1, PO2, PO3, PO4).
11. Design a state feedback controller and observer (K3) (PO1, PO2, PO3, PO4).
12. Problems to identify the response and solution of state equation (K2) (PO1, PO2, PO3, PO4).

**Model Question Paper** PAGES: 2

**QP CODE:**

Reg.No:____________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION**

**MONTH & YEAR**

Course Code**: 22EEE702.2**

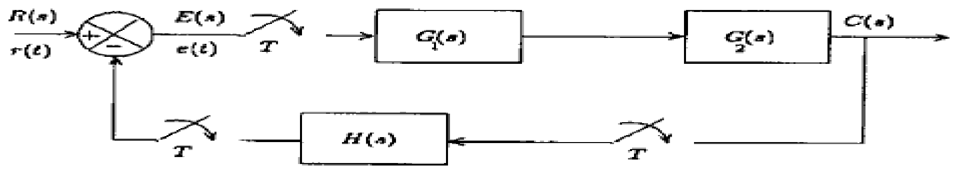
Course Name: **DIGITAL CONTROL SYSTEMS**

**Max. Marks: 100** **Duration: 3 Hours**

## PART A

**Answer all Questions. Each question carries 3 Marks**

1. Explain any four advantages of sampled data control systems.
2. Identify and justify a suitable sampling frequency for the continuous time system with transfer function $G(s) = \frac{100}{(s+1)(s+10)(s+100)}$
3. Obtain the pulse transfer function for the given system.




4. Distinguish between type and order of a system.
5. Explain the frequency domain specifications.
6. Realize the digital compensator with transfer function $D(z) = \frac{2.3798z-1.9387}{z-0.5589}$
7. Draw and explain the mapping between s- plane to z-plane for the constant frequency loci.
8. What is dead beat response?
9. Identify the discrete equivalent of the continuous time system $\dot{x} = Ax$ when the sampling period is $T$s

0. Define controllability and observability.

## PART B

**Answer any one full question from each module. Each question carries 14 Marks**

### Module 1

a) Derive the transfer function of a FoH circuit. **(6)**

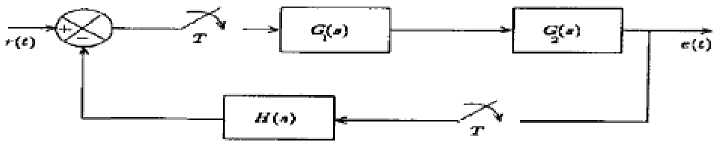
b) Determine the pulse transfer function of the system with transfer function $H(s) = \frac{3}{s(s+2)^2}$ if the sampling period is 0.1s. **(8)**

a) Derive the transfer function of a ZoH circuit. **(5)**

b) Realize the digital filter $D(z) = \frac{2z-0.6}{z+0.5}$ by the three methods of direct, standard and ladder programming. **(9)**

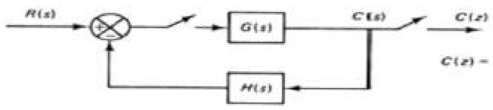
**Module 2**

Obtain the pulse transfer function for the unity feedback system with $G_1(s) = \frac{1}{s}$, $G_2(s) = \frac{1}{(s+2)}$ and assume T=0.1s and hence determine the step response of the system.



**(14)**

a) Obtain the unit impulse response C(n) of the following feedback DT system with $G(s) = \frac{1}{(s+3)}, . H(s) = \frac{1}{s}$,



Assume ideal sampling and T=1 ms. **(9)**

b) Explain the factors on which the steady state error constants depend on? **(5)**

**Module 3**

Design a suitable compensator for the unity feedback system with forward transfer function $G(z) = \frac{0.01758\,(z+0.8753)}{(z-1)\,(z-0.6703)}, T = 0.1s$, such that the phase margin of the system be atleast 45° at approximately 2 rad/sec and velocity error constant atleast 100s$^{-1}$.**(14)**

Consider the unity feedback system with forward transfer function $G(z) = \frac{K(0..01873z + 0.01752)}{z^2 - 1.8187z + 0.8187}$. Design a controller for the system such that the $w$-plane phase margin is 50°, gain margin is 10dB, and the static velocity error constant is 2 sec$^{-1}$. Assume a sampling period of 0.2sec. **(14)**

**Module 4**

Design a suitable digital compensator for the unity feedback system with open loop transfer function $G(s) = \frac{1}{s(s+4)}$ to meet the following specifications. Velocity error constant $K_v \geq 40$ sec$^{-1}$, Damping factor $\zeta = 0.5$, Natural frequency $\omega_n$ =4 rad/sec.

Assume a sampling period of 0.1s **(14)**

Design a controller, by the method of Ragazzini, for the unity feedback system with open loop transfer function $G(z) = \frac{0.018201\,(z+0.905)}{(z-1.105)\,(z-0.6703)}, T = 0.1s$ to meet the following specifications. Damping factor $\zeta = 0.5$, Natural frequency $\omega_n$ =2 rad/sec and zero steady state error for unit step input. **(14)**

**Module 5**

Design a suitable controller for the system by selecting suitable poles. $x(k+1) = \begin{bmatrix} 0.9128 & -0.008826 & 0.1574 \\ 0.09194 & 1.114 & -0.1662 \\ 0.07429 & -0.08753 & 0.6855 \end{bmatrix} x(k) + \begin{bmatrix} 0.104 \\ -0.00411 \\ 0.08707 \end{bmatrix} u(k),\ y(k) = [0 \quad 1 \quad 0] x(k)$ Formulate the control law that can perfectly track a step command. Since the output is directly available for measurement, design a reduced order observer to realise the controller. **(14)**

Compute the unit step response of the system represented by $x(k+1) = \begin{bmatrix} 0.9048 & 0 \\ 0.08611 & 0.8187 \end{bmatrix} x(k) + \begin{bmatrix} 0.09516 \\ 0.09516 \end{bmatrix} u(k),\ y(k) = [1 \ \ 1] x(k)$ assume the initial state $x(0) = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$. **(14)**

# Syllabus

**Module 1**

**Basics of Digital Control (6 hours)**

Basic digital control system- Mathematical modelling - sampling and reconstruction - Zero order and First order hold circuits - realisation of digital filters. Relation between transfer function and pulse transfer function - Mapping between s-domain and z-domain.

**Module 2**

**Response Computation (7 hours)**

Pulse transfer function of different configurations of systems- Modified z-transform-Time Response of discrete time system. Order and Type of a system Steady state error and Static error constants.

**Module 3**

**Design of controller/Compensator in frequency domain (7 hours)**

Bilinear transformation and sketching of frequency response - Digital P/PI/PID controller design based on frequency response - Digital compensator based on frequency response. Introduction to design and simulation using MATLAB (for demo/ assignment only and not to be included for examination).

**Module 4**

**Design of controller/Compensator based on time response (7 hours)**

Design of lag, lead and lag-lead compensator using root locus - Design of controllers and compensators by the method of Ragazzini- Dead beat response and deadbeat controller design.

**Module 5**

**Modern control approach to digital control (10 hours)**

Introduction to state space - state space modelling of discrete time SISO system - Computation of solution of state equation and state transition matrix.

Controllability, observability and stabilizability of discrete time systems- Loss of controllability and observability due to sampling. Digital controller and observer design - state feedback – pole placement - full order observer - reduced order observer.

**Text Book:**


1. C. L. Philips, H. T. Nagle, Digital Control Systems, Prentice-Hall, Englewood Cliffs, New Jersey, 1995.
2. M. Gopal, Digital Control and State Variable Methods, Tata McGraw-Hill, 1997
3. Ogata K., Discrete-Time Control Systems, Pearson Education, Asia.


**References:**


1. Benjamin C. Kuo, Digital Control Systems, 2/e, Saunders College Publishing, Philadelphia, 1992.
2. Constantine H. Houpis and Gary B. Lamont, Digital Control Systems Theory, Hardware Software, McGraw Hill Book Company, 1985.
3. Isermann R., Digital Control Systems, Fundamentals, Deterministic Control, V. I, 2/e, Springer Verlag, 1989.

4. Liegh J. R., Applied Digital Control, Rinchart & Winston Inc., New Delhi.
5. Åström, Karl J., and Björn Wittenmark,. Computer-controlled systems: theory and design. Courier Corporation, 2013.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Basics of Digital Control** | **(6 hours)** |
| 1.1 | Basic digital control system- Examples - mathematical model - choice of sampling and reconstruction-ZOH and FOH | 2 |
| 1.2 | Realisation of digital filters. | 2 |
| 1.3 | Relation between s and z - Mapping between s-domain and z-domain | 2 |
| **2** | **Response Computation** | **(7 hours)** |
| 2.1 | Pulse transfer function- Different configurations for the design | 2 |
| 2.2 | Time Response of discrete time system. | 2 |
| 2.3 | Steady state performance and error constants. | 3 |
| **3** | **Design of controller/Compensator in frequency domain** | **(7 hours)** |
| 3.1 | Digital P/PD/PI controller design | 2 |
| 3.2 | Digital PID controller design | 1 |
| 3.3 | Design of lag and lead compensator, | 2 |
| 3.4 | Design of lag-lead compensator. | 1 |
| 3.5 | Demo with MATLAB | 1 |
| **4** | **Design of controller/Compensator based on time response** | **(7 hours)** |
| 4.1 | Design of lag and lead compensator. | 2 |
| 4.2 | Design of lag-lead compensator. | 1 |
| 4.3 | Design based on method of Ragazzini. | 2 |
| 4.4 | Dead beat response design and deadbeat controller design. | 2 |
| **5** | **Modern control approach to digital control** | **(10 hours)** |
| 5.1 | Introduction to state space- | 1 |
| 5.2 | Computation of solution of state equation and state transition matrix. (examination questions can be limited to second order systems) | 2 |
| 5.3 | Controllability, Observability, and stabilizability of systems | 2 |
| 5.4 | Loss of controllability and observability due to sampling. | 1 |
| 5.5 | State feedback controller based on pole placement. | 2 |
| 5.6 | Observer design based on pole placement. | 2 |

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| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEE702.3** | **Modern Operating System** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble:** Understanding of concepts of OS, through process/threads, system call interface, inter process communication, deadlock, scheduling, address space , main memory, virtual memory and file systems.

**Prerequisite: NIL**

**Course Outcomes :** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Describe the key concepts of modern operating systems |
| **CO 2** | Apply the concepts of scheduling, resource management and process synchronization for process management. |
| **CO 3** | Evaluate the implementation of various memory management techniques. |
| **CO 4** | Illustrate different file management and directory management methods. |
| **CO 5** | Evaluate Disc scheduling algorithms |
| **CO 6** | Explain RAID structures |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | | | | | | | | | | |
| **CO 2** | 2 | 2 | | | | | | | | | | 2 |
| **CO 3** | 2 | 2 | | | | | | | | | | 2 |
| **CO 4** | 2 | | | | | | | | | | | |
| **CO 5** | 2 | 2 | | | | | | | | | | |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 15 | 15 | 30 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 15 | 15 | 30 |
| Analyse (K4) | | | |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Assignment/Quiz/Course project | : 15 marks |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. What is an operating system?(K1, PO1)
2. What are operating system services?(k2, PO1)
3. Explain time sharing operating system?(K1, PO1)
4. Explain OS structure?(K2, PO1, PO2)

**Course Outcome 2 (CO2):**

1. Define the process? (K1, PO1)
2. What is meant by the state of the process?(K1,PO2)
3. What are the types of schedulers?(K1, PO2)
4. Consider the following five processes, with the length of the CPU burst time given in

   milliseconds. Process Burst time P1 10 P2 29 P3 3 P4 7 P5 12 Consider the First come

   First serve (FCFS), Non Pre-emptive Shortest Job First (SJF), Round Robin(RR) (quantum=10ms) scheduling algorithms. Illustrate the scheduling using Gantt charts. (K3, PO1,PO2)
5. Define race condition.(K2, PO2)
6. What are the requirements that a solution to the critical section problem must satisfy?(K2, PO1, PO2)

**Course Outcome 3 (CO3):**

1. Define Swapping(K1,PO2)
2. What is Demand Paging?(K2,PO1,PO2)
3. Explain about the following page replacement algorithms a)FIFO b)OPR, c)LRU
4. Differentiate local and global page replacement algorithms. Differentiate local and global page replacement algorithm(K3, PO1,PO2)

**Course Outcome 4 (CO4):**

1. What is a File?(K1, PO1)
2. What are the various File Operations?(K1, PO1)
3. What are the different Accessing Methods of a File?(K2, PO2)
4. What are the Allocation Methods of a Disk Space?(K2, PO2)

**Course Outcome 5 (CO5):**

1. Explain different Disk scheduling algorithms SCAN,CSCAN.CLOOK(K3, PO1,PO2)
2. Explain disk structure in detail( K2, PO1)
3. What are goals for good disk scheduling algorithm(K1, PO1)
4. Define seek time, Rotational latency and disk bandwidth(K1, PO1)

**Course Outcome 6 (CO6):**

1. What is RAID Technology(K1, PO1)
2. What data is stored on the second hard drive with RAID 1?(K2,PO2
3. Explain RAID level 10(K2, PO1, PO2)

**Model Question paper**

**TKM COLLEGE OF ENGINEERING**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION,**
**MONTH & YEAR**

**Course Code: 22EEE702.3**

**Course Name:**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A (3 x 10 = 30 Marks)**

Answer all Questions. Each question carries 3 Marks

Explain the concept of MultiProgramming and Multiprocessing

Enlist different kinds of computing environments

Compare and contrast user level threads & kernel level threads? Illustrate various multi-threading models.

What are the conditions for deadlock?

Differentiate between External fragmentation and Internal fragmentation

What is thrashing

Enlist five file attributes? What you mean by extended file attributes

Distinguish between sequential access file & direct access file. Give example on each

Define seek time, Rotational latency and disk bandwidth

. Differentiate between viruses and worms , Give one example for each

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

**Module 1**

11. (a)Explain the role of OS as Extended Machine (7)

(b) Explain User Operating-System Interface in detail (7)

OR

12. (a)Differentiate between grid computing & Cloud computing. Give examples for each.(6)
(b)What are the functions of the process management module of the OS? What is PCB, Explain its structure (8)

**Module 2**

13. Consider the following five processes, with the length of the CPU burst time given in milliseconds. Process Burst time P1 10 P2 29 P3 3 P4 7 P5 12 Consider the First come First serve (FCFS), Non Preemptive Shortest Job First (SJF), Round Robin(RR) (quantum=10ms) scheduling algorithms. Illustrate the scheduling using Gantt chart. Also find average waiting time and turnaround time for each algorithm (14)

**OR**

14. (a) What is race condition? List the condition to be satisfied to ensure mutual exclusion in critical section (7)

(b)Explain semaphores. (7)

**Module 3**

15. (a)What is contiguous memory allocation?(7)

(b)Explain the different methods and strategies of contiguous memory allocation(7)

**OR**

16. (a)Explain paging scheme for memory management, discuss the paging hardware and Paging (5)

(b)Explain about the following page replacement algorithms a)FIFO b)OPR, c)LRU (9)

**Module 4**

17. (a)What are the operations that can be performed on files (7)

(b) Explain Indexed file allocation with proper illustration (7)

**OR**

18. (a)What is meant by directory structure (6)

(b)what is free space management? Illustrate bit vector free space management technique (8)

**Module 5**

19. (a)What are goals for good disk scheduling algorithm(4)

(b) Consider a disk with 300 tracks and the queue has random requests from different processes in the order: 60, 39, 23, 90, 170, 150, 38, 194, 295. Initially the arm is at 100. Find the Average Seek length using FIFO, SSTF, SCAN and C- SCAN algorithms (10)

**OR**

20. (a)Explain different RAID Level in details with proper illustration(8)

(b) Explain programme threats and system threats with proper examples (6)

## Syllabus

**Module** 1: Introduction-Definition– Operating System Structure- Operating System Operations, Process Management- Memory Management- Storage Management- Protection and Security- User and Operating-System Interface-System Calls- Types of System Calls Computing Environments- Open-Source Operating Systems.
Process Management- Process Concept- Operations on Processes-Threads Overview- Multithreading Models

**Module 2** - CPU Scheduling- Basic Concepts- Scheduling Criteria- Scheduling Algorithms- First come first served scheduling - Shortest job first - Shortest remaining time next- Round robin scheduling - Priority scheduling.
**Inter-process communication** - race condition - critical sections -Mutual exclusion with busy waiting - sleep and wakeup - Semaphores, Mutexes
Introduction to Deadlocks

**Module 3:** Memory Management-Swapping- Contiguous Memory Allocation- Virtual memory - Paging - Page tables – TLBs - Page replacement algorithms - Optimal page replacement algorithm - - First-in first-out algorithm - Second chance page replacement algorithm - Clock algorithm - Least recently used algorithm - the working set page replacement algorithm -Belady's anomaly, local verses global policies

**Module 4:** File Management- File-System Interface- File Concept- Access Methods - Directory and Disk Structure - File-System Mounting - File Sharing- Protection- File-System Implementation- File-System Structure- - Directory Implementation- Allocation Methods Free-Space Management - Efficiency and Performance

**Module 5:** Mass Storage Structure- Disk Scheduling- RAID Structure - - Protection and Security- Protection- Goals of Protection- Principles of Protection- Domain of Protection- Access Matrix Implementation of Access Matrix- Access Control- Revocation of Access Rights Security- The Security Problem -Program Threats- System and Network Threats

### Text Book

1. Abraham Silberschatz, Greg Gagne, Peter B. GalvinAuthor, Operating System Concepts, 10th Edition "Title", Publisher, 9th$^{th}$ edition, Wiley publishers

### Reference Books

1. William Stallings "Operating Systems: Internals and Design Principles, 7$^{th}$ edition, prentice Hall

2. Andrew S. Tanenbaum; Modern Operating systems ,4th edition, Person publications

### Course Content and Lecture Schedule

| No | Topic | No. of Lectures |
|---|---|---|
| | **Module 1 (9 hrs)** | |
| 1.1 | Introduction-Definition– Operating System Structure | 1 |
| 1.2 | Operating System Operations, Process Management and Memory Management | 1 |
| 1.3 | Storage Management- Protection and Security | 1 |
| 1.4 | User and Operating-System Interface | 1 |
| 1.5 | System Calls, Types of System Calls | 1 |
| 1.6 | Computing Environments- Open-Source Operating Systems | 1 |
| 1.7 | Process Management- Process Concept | 1 |
| 1.8 | Operations on Processes | 1 |
| 1.9 | Threads Overview- Multithreading Models | 1 |
| | **Module 2 (8 hrs)** | |
| 2.1 | CPU Scheduling- Basic Concepts- Scheduling Criteria | 1 |
| 2.2 | Scheduling Algorithms- First come first served scheduling- problems | 1 |
| 2.3 | Shortest job first - Shortest remaining time next- problems | 1 |
| 2.4 | Round robin scheduling - Priority scheduling.- problems | 1 |
| 2.5 | Inter-process communication - race condition - critical sections | 1 |
| 2.6 | critical sections and Mutual exclusion with busy waiting | 1 |
| 2.7 | Sleep and wakeup Semaphores, Mutexes | 1 |
| 2.8 | Deadlock- introduction only | 1 |
| | **Module 3 (7 hrs)** | |
| 3.1 | Memory Management-Swapping- Contiguous Memory Allocation | 1 |
| 3.2 | Virtual memory – Paging | 1 |
| 3.3 | Page tables – TLBs | 1 |
| 3.4 | Page replacement algorithms- Optimal page replacement algorithm - FIFO | 1 |
| 3.5 | Least recently used algorithm | 1 |
| 3.6 | Second chance page replacement algorithm - Clock algorithm | 1 |
| 3.7 | the working set page replacement algorithm -Beladys anomaly, local verses global policies | 1 |
| | **Module 4 (7 hrs)** | |
| 4.1 | File Management- File-System Interface- File Concept- Access Methods | 1 |
| 4.2 | Directory and Disk Structure | 1 |
| 4.3 | File-System Mounting - File Sharing- Protection- F | 1 |
| 4.4 | File-System Implementation- File-System Structure- | 1 |
| 4.5 | Directory Implementation- | 1 |
| 4.6 | Allocation Methods Free-Space Management | 1 |
| 4.7 | Efficiency and Performance | 1 |
| | **Module 5 (5 hrs)** | |
| 5.1 | Disk Scheduling- | 1 |

| | | |
|---|---|---|
| 5.2 | RAID Structure | 1 |
| 5.3 | Protection- Goals of Protection- Principles of Protection- Domain of Protection | 1 |
| 5.4 | Access Matrix Implementation of Access Matrix- Access Control- Revocation of Access Rights Security- | 1 |
| 5.5 | The Security Problem -Program Threats- System and Network Threats | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEE702.4** | **DATA STRUCTURES** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble** : This course aims at moulding the learner to understand the various data structures, their organization and operations. The course helps the learners to assess the applicability of different data structures and associated algorithms for solving real world problems efficiently. This course introduces abstract concepts for data organization and manipulation using data structures such as stacks, queues, linked lists, binary trees and graphs for designing their own data structures to solve practical application problems.

**Prerequisite** : **EST 102 Programming in C**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Analyze the time and space efficiency of the data structure(K3) |
| **CO 2** | Describe how arrays, records, linked structures, stacks and queues are used by algorithms (K1) |
| **CO 3** | Compare and contrast the benefits of dynamic and static data structures implementations(K3) |
| **CO 4** | Explain different memory management techniques and their significance (K3) |
| **CO 5** | Develop algorithms incorporating trees and graphs (K3) |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | | | | | | | | | | |
| **CO 2** | 3 | 2 | | | | | | | | | | |
| **CO 3** | 3 | 2 | | | | | | | | | | |
| **CO 4** | 3 | 2 | | | | | | | | | | |
| **CO 5** | 3 | 2 | | | | | | | | | | |
| **CO 6** | 3 | 2 | | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 25 | 25 | 50 |
| Apply (K3) | 15 | 15 | 30 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Assignment/Quiz/Course project | : 15 marks |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Derive the big O notation for f(n) = n2+2n+5 (K2,PO1)
2. What do you understand by complexity of an algorithm? Write worst case and best case
3. Find complexity of linear search.(K2,PO1)
4. Write an algorithm for matrix multiplication and calculate its time complexity. (K3,PO2)

**Course Outcome 2 (CO2)**

1. Write an algorithm/pseudo code to add a new element in a particular position of an array(K3,PO2)
2. Explain about the use and representation of header node in linked list (K1,PO1)
3. How a linked list can be used to represent the polynomial 5x4y6+24x3y4-17x2y3+15xy2+45.(K3,P02)
4. What is a circular queue? How it is different from normal queue? (K1,PO1)

**Course Outcome 3(CO3):**

1. Compare and contrast singly linked list and doubly linked list ((K2,PO1)
2. Write a program that implement stack (its operations) using i) Arrays ii) Linked list(Pointers) and compare performance(K3,PO2)
3. Compare array and linked list implementation of a general list.(K2,P02)
4. What are the disadvantages of representing a linear queue using array? How are they overcome (K1,PO1)

**Course Outcome 4 (CO4):**

1. Free memory blocks of size 60K, 25K, 12K, 20K, 35K, 45K and 40K are available in this order. Show the memory allocation for a sequence of job requests of size 22K, 10K, 42K, and 31K (in this order) in First Fit, Best Fit and Worst Fit allocation strategies (K3,PO2)
2. Explain how memory de-allocation is done in memory management (K1,PO1)
3. Compare various memory management techniques (K2,PO1)

**Course Outcome 5 (CO5):**

1. List the properties of a binary search tree. (K1,P01)

2. Create a Binary search Tree with node representing the following sequence 14, 15, 4, 18, 9, 16, 20, 17, 3, 7, 5, 2 and perform inorder, preorder and postorder traversals on the above tree and print the output. .(K3,P02)
3. Develop an algorithm to add an element into a binary search tree (K3,P02)
4. Give any two representations of graph. Give algorithm for DFS. Demonstrate DFS using suitable example. (K2,P01)

**Model Question Paper**

QP CODE:

PAGES : 3

Reg No: _______________

Name: _________________

**TKM COLLEGE OF ENGINEERING**
**THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEE702.4**

**Course Name: DATA STRUCTURES**

**Max.Marks:100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Compare Structured Approach and Object Oriented Approach of Programming.

Calculate the frequency count of the statement x = x+1; in the following code segment

```
for (i = 0; i< n; i++)
for (j = 0; j< n; j*=2)
x = x + 1;
```

Write an Algorithm to reverse a string using Stack.

Explain the disadvantages of representing a Linear Queue using Array.

Write any three Applications of Linked List.

Explain DEQUEUE

Write a non recursive algorithm/ Pseudocode for pre-order traversal in a binary tree.

What is a binary search tree (BST)? Give an example of a BST with five nodes.

Give two different types of representation for graphs.

10. Compare Prim's and Kruskal's Algorithm

**PART B**

) Explain space complexity and time complexity of an Algorithm. Write an Algorithm/pseudo code for linear search and mention the best case and worst case time complexity of Linear Search algorithm? (10)

b) Explain Modular Programming with Suitable Example (4)

OR

12.a) Explain System Lifecycle in detail. (10)

b) Explain an algorithm? How is its complexity analysed? (4)

) Write algorithms to insert and delete elements from a double ended Queue. Demonstrate with examples (10)

) Compare and Contrast a Circular Queue with a normal Queue (4)

OR

14.a) Write an Algorithm to evaluate Postfix operation. (8)

) Convert the following infix expression into prefix expression (A-B/C) * (D*E-F) .Show the stack contents for each step. (6)

15.a) Write algorithms to perform the following operations on a doubly linked list.

(i) Insert a node with data ‘y’ after a node whose data is ‘x’.

(ii) Delete a node whose data is ‘s’ .

(iii) Insert a node with data ‘a’ as the 1st node of the list. (10)

b) Write an algorithm to count the number of occurrences of a character in a linked list ( each node contains only one character). (4)

OR

16.a) Assume that a Stack is represented using Linked List. Write Algorithms for the following operations.

a) PUSH

b) POP (10)

b) Compare a Circular Linked List and a Doubly Linked List. (4)

17. a) Explain how memory de-allocation is done in memory management. (8)

b) Discuss the advantages and Disadvantages of First-fit,Best-fit and Worst-fit Allocation schemes. (6)

OR

18.a) Write an algorithm/Psudocode to perform the following operations on Binary . Search tree.

a) Insert an element k

b) Search for an element k (10)

b) Write an iterative algorithm for in-order traversal of a Binary Tree (4)

Explain the various ways in which a graph can be represented bringing out the advantages and disadvantages of each representation (10)

b) Write an algorithm to perform bubble sort on a collection of ‘n’ numbers. (4)

OR

20.a) Give algorithms for DFS and BFS of a graph and explain with examples. (8)

b) How graphs can be represented in a Computer? (6)

## Syllabus

**Module 1**

Basic Concepts of Data Structures

Introduction to programming methodologies – structured approach, object oriented approach, stepwise refinement techniques, Algorithms, Performance Analysis, Space Complexity, Time Complexity, Asymptotic Notation, Complexity Calculation of Simple Algorithms

**Module 2**

Arrays

Introduction to data structures: Stacks, Queues-Circular Queues, Priority Queues, Double Ended Queues, Evaluation of Expressions, Applications of stacks and queues

**Module 3**

Linked List

Singly Linked List-Operations on Linked List. Doubly Linked List, Circular Linked List, Stacks and Queues using Linked List, Polynomial representation using Linked List

**Module 4**

Memory Management and Trees

Memory Management - Memory allocation and de-allocation-First-fit, Best-fit and Worst-fit allocation schemes

Trees, Binary Trees-Tree Operations, Binary Tree Representation, Tree Traversals, Binary Search Trees- Binary Search Tree Operations

**Module 5**

Graphs

Graphs : Definitions, Representation of Graphs, Topological Sort, Depth First Search and Breadth First Search on Graphs, Shortest-path algorithms, Minimum spanning tree, Prim's and Kruskal's algorithms, Applications of graphs

**Text Book**

1. Fundamentals of Data structures in C, 2nd Edition, E.Horowitz, S.Sahni and Susan Anderson-Freed, University Press (India),2008.

**Reference Books**

1. Classic Data Structures, Samanta D., Prentice Hall India, 2/e,,2009.

2. Data Structures: A Pseudocode Approach with C, 2/e, Richard F. Gilberg, Behrouz A. Forouzan, Cengage Learning 2005.
3. Data Structures and Algorithms, Aho A. V., J. E. Hopcroft and J. D. Ullman Pearson Publication. 2nd Edition
5. Introduction to Data Structures with Applications, Tremblay J. P. and P. G. Sorenson,Tata McGraw Hill 1995
4. Advanced Data Structures, Peter Brass ,Cambridge University Press,2008
5. Theory and Problems of Data Structures, Lipschuts S., Schaum's Series 1996
6. 8A Structured Approach to Programming, . Hugges J. K. and J. I. Michtm, PHI. 1987

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction** | **5** |
| 1.1 | Introduction to programming methodologies – structured approach, object oriented approach, stepwise refinement techniques\ | 1 |
| 1.2 | Algorithms , Performance Analysis | 1 |
| 1.3 | Space Complexity, Time Complexity | 1 |
| 1.4 | Asymptotic Notation (Big O Notation) | 1 |
| 1.5 | Complexity Calculation of Simple Algorithms | 1 |
| **2** | **Arrays** | **7** |
| 2.1 | Stacks | 1 |
| 2.2 | Queues, Circular Queues | 1 |
| 2.3 | Priority Queues | 1 |
| 2.4 | Double Ended Queues | 1 |
| 2.5 | Conversion and Evaluation of Expressions | 1 |
| 2.6 | Applications of stacks and queues | 2 |
| **3** | **Linked List** | **8** |
| 3.1 | Singly Linked List | 1 |
| 3.2 | Doubly Linked List | 1 |

| | | |
|---|---|---|
| 3.3 | Circular Linked List | 1 |
| 3.4 | Stacks using Linked List | 1 |
| 3.5 | Queues using Linked List | 1 |
| 3.6 | Polynomial representation using Linked List | 2 |
| **4** | **Memory Management and Trees** | **8** |
| 4.1 | Memory allocation and de-allocation | 1 |
| 4.2 | First-fit, Best-fit and Worst-fit allocation schemes | 2 |
| 4.3 | Binary Trees- Tree Operations | 1 |
| 4.4 | Binary Tree Representation, Tree Traversals | 2 |
| 4.5 | Binary Search Trees- Binary Search Tree Operations | 2 |
| 5 | **Graphs** | **7** |
| 5.1 | Graphs  Definitions, Representation of Graphs | 1 |
| 5.2 | Topological sort, Depth First Search and Breadth First Search on Graphs, | 2 |
| 5.3 | Shortest-path algorithms, | 1 |
| 5.4 | Minimum spanning tree | 1 |
| 5.5 | Prim’s and Kruskal’s algorithms, Applications of graphs | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEE702.5** | **DIGITAL SIGNAL PROCESSING** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble** : This course introduces the discrete Fourier transform (DFT) and its computation using direct method and fast Fourier transform (FFT). Techniques for designing infinite impulse response (IIR) and finite impulse response (FIR) filters from given specifications are also introduced. Various structures for realization of IIR and FIR filters are discussed. Detailed analysis of finite word-length effects in fixed point DSP systems is included. Architecture of a digital signal processor is also discussed.

**Prerequisite** : **EET305 - Signals and Systems**

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Compute Discrete Fourier transform and Fast Fourier transform . |
| **CO 2** | Discuss the various structures for realization of IIR and FIR discrete-time systems. |
| **CO 3** | Design IIR (Butterworth and Chebyshev) digital filters using impulse invariant and bilinear transformation methods. |
| **CO 4** | Design FIR filters using frequency sampling method and window function method. |
| **CO 5** | Compare fixed point and floating point arithmetic used in digital signal processors and discuss the finite word length effects. |
| **CO 6** | Explain the architecture of digital signal processors and the applications of DSP. |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | - | 2 | 2 | - | - | - | - | - | - | 2 |
| **CO 2** | 3 | 2 | - | 2 | 2 | - | - | - | - | - | - | 2 |
| **CO 3** | 3 | 2 | - | 2 | 2 | - | - | - | - | - | - | 2 |
| **CO 4** | 3 | 2 | - | 2 | 2 | - | - | - | - | - | - | 2 |
| **CO 5** | 3 | 2 | - | - | 2 | - | - | - | - | - | - | 2 |
| **CO 6** | 3 | - | 2 | - | 2 | 2 | - | - | - | - | - | 3 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 10 | 10 | 10 |
| Understand (K2) | 10 | 10 | 30 |
| Apply (K3) | 30 | 30 | 60 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1)**

1. State and prove various properties of DFT - (K1, PO1,PO2,PO12)
2. Determine the linear convolution using DFT – (K2,PO1,PO2,PO4,PO5,PO12)
3. Determine the linear convolution using overlap-add and overlap-save method – (K3,PO1,PO2,PO4,PO5)
4. Compute DFT using DIT FFT and DIF FFT – (K2,PO1,PO2,PO4,PO5)

**Course Outcome 2 (CO2)**

1. Determine the structures for direct form, cascade, parallel, transposed and lattice-ladder realisations of IIR systems –( K2,PO1,PO2,PO4,PO5,PO12)
2. Determine the structures for direct form, cascade, lattice ,and linear phase realizations of FIR systems – (K2,PO1,PO2,PO4,PO5)

**Course Outcome 3(CO3)**

1. Design IIR digital LP/HP/BP/BS filter using Butterworth and Chebyshev methods – (K3,PO1,PO2,PO4,PO5)
2. Transform H(s) to H(z) using impulse invariant technique and bilinear transformation – (K2,PO1,PO2,PO4,PO5,PO12)

**Course Outcome 4 (CO4)**

1. Design FIR digital LP/HP/BP/BS filter using frequency sampling method – (K3,PO1,PO2,PO4,PO5,PO12)
2. Design FIR digital LP/HP/BP/BS filter using window function – (K3,PO1,PO2,PO4,PO5)

**Course Outcome 5 (CO5)**

1. Differentiate between fixed-point arithmetic and floating point arithmetic - (K2,PO1,PO2,PO12)
2. Explain various finite word length effects in fixed point DSP processors.- (K2,PO1,PO2)
3. Problems to determine steady state output noise power and round-off noise power – (K3,PO1,PO2)
4. Explain limit cycle oscillations and methods for its elimination  - (K2,PO1,PO2)

**Course Outcome 6 (CO6)**

1. Explain Harvard architecture –( K1,PO1,PO5,PO12)
2. Describe the architecture of a fixed-point DSP processor – (K1,PO1,PO5)
3. List various applications of digital signal processor – (K3,PO1,PO3,PO6)

**Model Question Paper** PAGES: 3

**QPCODE:**

Reg. No:___________

Name:_____________

**TKM COLLEGE OF ENGINEERING**
**SEVENTH SEMESTER B. TECH DEGREE EXAMINATION**
**MONTH & YEAR**

Course Code**: 22EEE702.5**

Course Name: **DIGITAL SIGNAL PROCESSING**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**
**Answer all Questions.**
**Each question carries 3 Marks**

1 List any 3 properties of DFT.

2 The first 5 points of the 8-point DFT of a real valued sequence are $X(k)=\{0.25, 0.125-j0.3, 0, 0.125-j0.05, 0\}$ . Determine the remaining 3 points.

3 Obtain direct form 1 realization for a digital IIR system described by the system function, $H(z)=\dfrac{z+0.2}{z^2+0.5z+1}$.

4 Obtain realization with minimum number of multipliers for the system function $H(z)=\dfrac{1}{2}+z^{-1}+\dfrac{1}{2}z^{-2}$.

5 Explain warping effect in bilinear transformation.

6 Determine the order of a Chebyshev analog lowpass filter with a maximum passband attenuation of 2.5dB at $\Omega_p$ = 20 rad/sec and the stopband attenuation of 30dB at $\Omega_s$ = 50 rad/sec.

7 What are the desirable characteristics of a window function used for truncating the infinite impulse response?

8 Represent the numbers i) +4.5 and ii) -4.5 in IEEE 754 single-precision floating point format.

9 List any 3 finite-word length effects in a fixed point digital signal processor.

10 Draw the block diagram of a basic Harvard architecture in digital signal processor.

## PART B

**Answer any one full question from each module.**
**Each question carries 14 Marks**

### Module 1

11 a) Find the 4-point DFT of the sequence, $x(n)=\{1,-1,1,-1\}$. Also, using time shift property, find the DFT of the sequence, $y(n)=x((n-2))_4$. (7)

b) Two finite duration sequences are $h(n)=\{1,0,1\}$ and $x(n)=\{-1,2,-1,0,1,3,-2,1,-3,-2,-1,0,-2\}$. Use overlap-save method, to find $y(n)=x(n)*h(n)$. (7)

**OR**

12 Compute IDFT of the sequence $X(k)=\{7,-0.707-j0.707,-j,0.707-j0.707,1,0.707+j0.707,j,-0.707+j.707\}$ using DIT FFT. (14)

### Module 2

13 a) Realize the system function in cascade form $H(z)=\dfrac{1+\frac{1}{3}z^{-1}}{1-\frac{3}{4}z^{-1}+\frac{1}{8}z^{-2}}$. (6)

b) Determine the direct form 2 and transposed direct form structure for the given system $y(n)=\dfrac{1}{2}y(n-1)-\dfrac{1}{4}y(n-2)+x(n)+x(n-1)$. (8)

**OR**

14 a) Obtain the direct form realization of linear phase FIR system given by (7)

$$H(z)=1+\frac{3}{4}z^{-1}+\frac{17}{8}z^{-2}+\frac{3}{4}z^{-3}+z^{-4}$$

b) Determine the coefficients $k_m$ of the lattice filter corresponding to FIR filter described by the system function $H(z)=1+2z^{-1}+\frac{1}{3}z^{-2}$. Also, draw the corresponding second order lattice structure (7)

### Module 3

15 a) Find H(z) using impulse invariant transformation. $H(s)=\dfrac{1}{s^2+\sqrt{2}s+1}$; $T=1\text{sec}$. (7)

b) A Butterworth lowpass filter has to meet the following specifications. (7)
Passband gain = -3dB at $f_p$ = 500Hz
Stopband attenuation greater than or equal to 40dB at $f_s$ = 1000Hz
Determine the order of the Butterworth filter to meet the above

specifications. Also, find the cut off frequency.

**OR**

16 Design a Chebyshev digital lowpass filter with a maximum passband attenuation of 2dB at 100Hz and minimum stopband attenuation of 20dB at 500Hz. Sampling rate is 4000 samples/sec. Use bilinear transformation. (14)

**Module 4**

17 a) Design a linear phase lowpass FIR filter with N = 7 and a cut-off frequency $0.3\pi$ radian using the frequency sampling method. (7)

b) A linear phase FIR filter has frequency response $H(\omega) = \cos\frac{\omega}{2} + \frac{1}{2}\cos\frac{3\omega}{2}$ (7)

Determine the impulse response h(n).

**OR**

18 A band stop filter is to be designed with the following desired frequency response (14)

$$H_d(e^{j\omega}) = \begin{cases} e^{-j\omega\alpha} & -\omega_{c1} \le \omega \le \omega_{c1} \quad \omega_{c2} \le |\omega| \le \pi \\ 0 & \text{otherwise} \end{cases}$$

Design with N = 7, $\omega_{c1} = \pi/4$ rad/sec, $\omega_{c2} = 3\pi/4$ rad/sec using rectangular window.

**Module 5**

19 a) Compare between fixed point and floating point digital signal processors. (6)

b) The output of an ADC is applied to a digital filter with system function $H(z) = \frac{0.5z}{(z-0.5)}$. Find the output noise power from digital filter when input signal is quantized to have 8 bits. (8)

**OR**

20 a) Draw and explain the architecture of any fixed-point DSP processor. (8)

b) Explain the techniques used to prevent overflow in fixed-point DSP operations. (6)

## Syllabus

**Module 1 - DISCRETE-FOURIER TRANSFORM**

Review of signals and systems - Frequency domain sampling - Discrete Fourier transform (DFT) – inverse DFT (IDFT) - properties of DFT – linearity, periodicity, symmetry, time reversal, circular time shift, circular frequency shift, circular convolution, complex conjugate property – Filtering of long data sequences – over-lap save method, over-lap add method – Fast Fourier transform (FFT) – advantages over direct computation of DFT - radix -2 decimation-in-time FFT (DITFFT) algorithm, Radix-2 decimation-in-frequency FFT (DIFFFT) algorithm.

**Module 2 - REALIZATION OF IIR AND FIR SYSTEMS**

Introduction to FIR and IIR systems - Realization of IIR systems – direct form 1, direct form 2, cascade form, parallel form, lattice structure for all-pole system, lattice-ladder structure – conversion of lattice to direct form and vice-versa - signal flow graphs and transposed structures – Realization of FIR systems – direct form, cascade form, lattice structure, linear phase realization.

**Module 3 - IIR FILTER DESIGN**

Conversion of analog transfer function to digital transfer function – impulse invarient transformation and bilinear transformation – warping effect

Design of IIR filters – low-pass, high-pass, band-pass, band-stop filters – Butterworth and Chebyshev filter – frequency transformation in analog domain - design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation.

**Module 4 - FIR FILTER DESIGN AND REPRESENTATION OF NUMBERS**

Impulse response of ideal low pass filter – linear phase FIR filter – frequency response of linear phase FIR filter – Design of FIR filter using window functions (LP, HP, BP, BS filters) – Rectangular, Bartlett, Hanning, Hamming and Blackmann only – FIR filter design based on frequency sampling approach (LP, HP, BP, BS filters)

Representation of numbers – fixed point representation – sign-magnitude, one's complement, two's complement – floating point representation – IEEE 754 32-bit single precision floating point representation

**Module 5 - FINITE WORD LENGTH EFFECTS AND DIGITAL SIGNAL PROCESSORS**

**Finite word length effects** in digital Filters – input quantization – quantisation noise power – steady-state output noise power – coefficient quantisation – overflow – techniques to prevent overflow - product quantization error – rounding and truncation – round-off noise power – limit cycle oscillations – zero input limit cycle oscillations – overflow limit cycle oscillations – signal scaling.

**Digital signal processor architecture** based on Harvard architecture (block diagram) – Harvard architecture, pipelining, dedicated hardware multiplier/accumulator, special instructions dedicated to DSP, replication, on-chip memory cache, extended parallelism (Reference [2]) - comparison of fixed-point and floating-point processor – applications of DSP

**Text Books**

1. John G. Proakis & Dimitris G.Manolakis, "Digital Signal Processing Principles, Algorithms & Applications", Pearson

**Reference Books**

1. Emmanuel Ifeachor & Barrie W Jervis, "Digital Signal Processing", Pearson, 13th edition, 2013
2. P. Ramesh Babu, "Digital Signal Processing", Scitech Publications (India) Pvt Ltd, 2nd edition, 2003
3. Li Tan, "Digital Signal Processing, Fundamentals & Applications", Academic Press, Ist edition, 2008
4. D. Ganesh Rao & Vineeta P Gejji, "Digital Signal Processing, A Simplified Approach", Sanguine Technical Publishers, 2nd edition, 2008

**Course Contents and Lecture Schedule**

| Sl. No | Topic | No. of Lectures |
|---|---|---|
| **1** | **DISCRETE-FOURIER TRANSFORM (7 hours)** | |
| 1.1 | Review of signals, systems and discrete-time Fourier transform (DTFT), Frequency domain sampling, discrete-Fourier transform (DFT), twiddle factor, inverse DFT, properties of DFT - linearity, periodicity, symmetry, time reversal, circular time shift, circular frequency shift, circular convolution, complex conjugate property | 3 hours |
| 1.2 | Linear filtering using DFT, linear filtering of long data sequences, overlap-save method, overlap-add method | 1 hour |
| 1.3 | Fast Fourier transform (FFT) – comparison with direct computation of DFT - radix -2 decimation-in-time FFT (DITFFT) algorithm – bit reversal - Radix-2 decimation-in-frequency FFT (DIFFFT) algorithm | 3 hours |
| **2** | **REALIZATION OF IIR AND FIR SYSTEMS (7 hours)** | |
| 2.1 | Introduction to FIR and IIR systems - comparison - Realization of IIR systems – direct form 1, direct form 2, cascade form, parallel form | 3 hours |
| 2.2 | Lattice structure for all-pole system - lattice-ladder structure – conversion of lattice to direct form and vice-versa signal flow graphs and transposed structures | 2 hours |
| 2.3 | Realization of FIR systems – direct form, cascade form, lattice structure, linear phase realization. | 2 hours |
| **3** | **IIR FILTER DESIGN (7 hours)** | |
| 3.1 | Conversion of analog transfer function to digital transfer function – impulse invarient transformation and bilinear transformation – warping effect | 2 hours |
| 3.2 | Design of IIR filters – characteristics of ideal and practical low-pass, high-pass, band-pass, band-stop filters – design of Butterworth filter – normalised analog filter - frequency transformation in analog domain - design of LP, | 3 hours |

| | | |
|---|---|---|
| | HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation. | |
| 3.3 | Design of Chebyshev filter – design of LP, HP, BP, BS IIR digital filters using impulse invariance and bilinear transformation | 2 hours |
| **4** | **FIR FILTER DESIGN AND REPRESENTATION OF NUMBERS (7 hours)** | |
| 4.1 | Impulse response of ideal low pass filter – linear phase FIR filter – frequency response of linear phase FIR filter – Design of FIR filter using window function (LP, HP, BP, BS filters) – Rectangular, Bartlett, Hanning, Hamming and Blackmann only | 3 hours |
| 4.2 | FIR filter design based on frequency sampling approach (LP, HP, BP, BS filters) | 2 hours |
| 4.3 | Representation of numbers – fixed point representation – sign-magnitude, one's complement, two's complement – floating point representation – IEEE 754 32-bit single precision floating point representation | 2 hours |
| **5** | **FINITE WORD LENGTH EFFECTS AND DIGITAL SIGNAL PROCESSORS (7 hours)** | |
| 5.1 | Finite word length effects in digital Filters – input quantization – quantisation noise power – steady-state output noise power | 2 hours |
| 5.2 | Coefficient quantisation – overflow – techniques to prevent overflow - product quantization error – rounding and truncation – round-off noise power | 1 hour |
| 5.3 | Limit cycle oscillations – zero input limit cycle oscillations – overflow limit cycle oscillations – signal scaling. | 1 hour |
| 5.4 | Digital signal processor architecture based on Harvard architecture (block diagram) – Harvard architecture, pipelining, dedicated hardware multiplier/accumulator, special instructions dedicated to DSP, replication, on-chip memory cache, extended parallelism (Reference [1]) | 2 hours |
| 5.5 | Comparison of fixed-point and floating-point processor – applications of digital signal processor | 1 hour |

***Note: Preferable list of computer based assignments***

| **Assignments using signal processing tool of MATLAB/SCILAB etc** | |
|---|---|
| 1 | Determine 4-point/8-point DFT/IDFT of any sequence by direct computation |
| 2 | Compute 4-point/8-point DFT/IDFT using DIT FFT and DIF FFT algorithms. |
| 3 | Find the linear convolution and circular convolution of two sequences. |
| 4 | Find the linear convolution using overlap-add and overlap-save methods. |
| 5 | Determine 2 stage/3 stage lattice ladder coefficients if the system function of IIR direct form is given. |
| 6 | Obtain coefficients of IIR direct form from lattice ladder form. |
| 7 | Transform an analog filter into digital filter using impulse invariant technique/bilinear transformation. |
| 8 | Calculate the order and cut-off frequency of a low pass Butterworth filter |

| | |
|---|---|
| 9 | Obtain the frequency response and filter coefficients of a LP/HP/BP/BS IIR Butterworth filter |
| 10 | Obtain the frequency response and filter coefficients of a LP/HP/BP/BS IIR Chebyshev filter |
| 11 | Compute LP/HP/BP/BS FIR filter coefficients using rectangular/Bartlett/Hamming/Hanning/Blackmann window |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEE702.6** | **ILLUMINATION TECHNOLOGY** | PEC | 2 | 1 | 0 | 3 |

Preamble: The basic objective of this course is to deliver the fundamental concepts of illumination engineering in the analysis and design of architectural lighting systems.

Prerequisite: Nil

**Course Outcomes: After the completion of the course the student will be able to**

| | |
|---|---|
| CO 1 | Explain the fundamental concepts of natural and artificial lighting schemes |
| CO 2 | Design efficient indoor lighting systems |
| CO 3 | Design efficient outdoor lighting systems |
| CO 4 | Describe aesthetic and emergency lighting systems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 2 | | | | | | | | | | |
| CO 2 | 2 | 2 | 3 | | | | 1 | | | | | 1 |
| CO 3 | 2 | 2 | 3 | | | | 1 | | | | | 1 |
| CO 4 | 2 | 2 | | | 3 | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 15 | 15 | 30 |
| Understand | 15 | 15 | 30 |
| Apply | 20 | 20 | 40 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

Course Outcome 1 (CO1):

1. Explain the quality of a good lighting (K2 PO1)
2. Select the factors affecting the quality of artificial lighting (K2 PO2)
3. Define MHCP, MSCP. (K1 PO1)

Course Outcome 2 (CO2)

1. Define Maintenance Factor.(K1 PO1)
2. Problems related to design of indoor lighting systems.(K2 PO2 PO3 PO7)
3. What are the special features that must be taken care of while illuminating staircase. (K2 PO2 PO12)

Course Outcome 3(CO3):

1. Select the main factors for designing street/road lighting? .(K2 PO2 PO3 PO12)
2. Problems related to design of Flood Lighting system?(K2 PO2 PO3 PO7)
3. With a neat diagram give the application of Track Fixtures.(K2 PO2 PO3)

Course Outcome 4 (CO4):

1. Explain at least Five features of monument lighting.(K2 PO1 PO2)
2. What are the different factors to be considered while designing aesthetic illumination of bridges and statues? .(K2 PO1 PO2 PO5)
3. Selection of luminaries for different areas in hospitals? .(K2 PO1 PO2 PO5)

**Model Question paper**

QP CODE: PAGES:

Reg No:_______________

Name :_______________

**TKM COLLEGE OF ENGINEERING**
**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION,**
**MONTH & YEAR**

**Course Code: 22EEE702.6**
**Course Name:** ILLUMINATION TECHNOLOGY

**Max. Marks: 100** **Duration: 3 Hours**

**PART A** (10X3=30marks)

**Answer all Questions. Each question carries 3 Marks**

1. What are the different schemes of artificial lighting?
2. Explain with neat diagram the different types of artificial lighting system used.
3. Explain how photometric bench is used for measuring candle power of a test lamp
4. Explain how illumination can be calculated for Line source and Surface source.
5. Illustrate at least five fixtures used for outdoor lighting?
6. Define Space to Mounting height ratio
7. How are the projectors in flood lighting classified according to the beam?
8. What are different methods available for aiming the lamp in flood lighting?
9. List out the requirements of a good Sport lighting.
10. List out and explain at least five features of auditorium lighting

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module-1**

11(a) What is the impact of stroboscopic effect on visual comfort in an artificial lighting scheme? How the effect can be reduced

11(b) Explain with neat diagram the different types of artificial lighting system used.

12(a) Explain Colour rendering and stroboscopic effect

12(b) What is a glare? How it is classified.

## Module-2

13(a) Four lamps 15m apart are arranged to illuminate a corridor. Each lamp is mounted at a height of 8m above the floor level. Each lamp gives 450 Cd in all directions below the horizontal. Find the illumination at the midway between 2nd and 3rd lamp

13(b) Illustrate with a neat diagram the concept of polar curve in illumination technology

14(a) State the Laws of Illumination

14(b) Explain with neat figures a.) Inverse square law b.) Lambert's Cosine law

## Module-3

15(a) Specify the need of DLOR and ULOR in artificial architectural lighting. List out three factors on which DLOR and ULOR depends

15(b) Illustrate at least five fixtures used for interior lighting?

16(a) Define

1. Coefficient of utilisation
2. Depreciation factor

16(b) A drawing hall in an engineering college is to be illuminated with a lighting installation. The hall is 30m × 20m × 8m (high). The mounting height is 5m and the required level of illumination is 144 lm/m2. Using metal filament lamps, estimate the size and number of single lamp luminaries and draw their spacing layout. Assume: Utilization factor = 0.6, MF = 0.75; Space/Height = 1. Lumens/ Watt for 300-W lamp = 13, Lumens/Watt for 500-W lamp = 16

## Module-4

17a) How are the projectors in flood lighting classified according to the beam?

17 b) Describe the area of application of each type of flood light.

18(a) Illustrate at least five fixtures used for outdoor lighting?

18(b) Explain the various types of lamps used in street lighting.

## Module-5

19a) What are different factors to be considered while designing aesthetic illumination of bridges and statues?

19 b) What is the importance of modelling and shadows in the case of sports field lighting?

20 a) Describe any five characteristics of statue lighting

20(b) During the Onam week celebration organised by the Dept. of Tourism, it is a customary to illuminate the Kerala Secretariat Building and the arterial road in the capital city in different colours. As an illumination engineer what are the different factors which must be considered for

i) Illuminating the Secretariat building
ii) The roads way aesthetic lighting
iii) A Statue in front of Secretariat building

**Syllabus**

Module 1

Introduction of Light: Types of illumination, Day lighting, Artificial light sources- artificial lighting and total lighting, Quality of good lighting, Factors affecting the Physical processes- Incandescent and Halogen lamps, Fluorescent lamps, LPSV and HPSV lamps, mercury vapour lamps, metal halide lamps, LED lamps- modern trends. Supplementary lighting-shadow, glare, reflection, Colour rendering and stroboscopic effect, Methods of artificial lighting, Lighting systems-direct, indirect, semi direct, semi indirect, Lighting scheme, General and localised, Different types of Luminaires

Module 2

Measurement of Light: Definition of luminous flux, Luminous intensity, Lumen, Candle power, Illumination, M.H.C.P, M.S.C.P, M.H.S.C.P, Lamp efficiency, Brightness or luminance, Laws of illumination, Inverse square law and Lambert's Cosine law, Illumination at horizontal and vertical plane from point source, Concept of polar curve, Calculation of luminance and illumination in case of linear source, round source and flat source. Measuring apparatus- Goniophotometer, Integrating sphere, lux meter.

Module 3

Design of Interior Lighting: Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilisation and factors affecting it, Illumination required for various work planes, Types of fixtures and relative terms used for interior illumination such as DLOR and ULOR, Selection of lamp and luminance, Selection of utilisation factor, reflection factor and maintenance factor, Determination of Lamp Lumen output taking into account voltage and temperature variations, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaire, Calculation of space to mounting height ratio, Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting and industrial building.

Module 4

Design of Outdoor Lighting: Street Lighting - Types of street and their level of illumination required, Terms related to street lighting, Types of fixtures used and their suitable application, Various arrangements in street lighting, Requirements of good street lighting, Selection of lamp and luminaire, Calculation of illumination level available on road. Tunnel Lighting, Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.

Flood Lighting: Terms related to flood lighting, Types of fixtures and their suitable applications, Selection of lamp and projector, recommended method for aiming of lamp, Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.

Module 5

Special Features of Aesthetic Lighting: Monument and statue lighting, Sports lighting, Hospital lighting, Auditorium lighting

General Aspects of emergency lighting. Lighting controllers – dimmers, motion and occupancy sensors, photo sensors and timers. Lighting system design using software (eg: DIALux and Relux).

Note: Case study of indoor and outdoor lighting design using software may be given as assignment.

Text Books

1. D.C. Pritchard Lighting, Routledge, 2016
2. Jack L. Lindsey, Applied Illumination Engineering, PHI, 1991

References:

1. John Matthews Introduction to the Design and Analysis of Building Electrical Systems, Springer, 1993
2. M.A. Cayless, Lamps and Lighting , Routledge, 1996
3. Craig DiLouie, Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications, CRC Press, 2005.
4. Lighting Engineering Applied calculations R. H. Simons and A. R. Bean, Routledge; 1st edition, 2020

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | Introduction of Light (7 hours) | |
| 1.1 | Types of illumination, Day lighting. | 1 |
| 1.2 | Artificial light sources-Physical processes- Incandescent and Halogen lamps, Fluorescent lamps, LPSV and HPSV lamps, mercury vapour lamps, metal halide lamps, LED lamps- modern trends. | 2 |
| 1.3 | Supplementary artificial lighting and total lighting, Quality of good lighting, Factors affecting the lighting-shadow, glare, reflection, Colour rendering and stroboscopic effect. | 2 |
| 1.4 | Methods of artificial lighting, Lighting systems-direct, indirect, semi direct, semi indirect, Lighting scheme, General and localised, Different types of Luminaires. | 2 |
| 2 | Measurement of Light. (7 hours) | |

| | | |
|---|---|---|
| 2.1 | Definition of luminous flux, Luminous intensity, Lumen, Candle power, Illumination, M.H.C.P, M.S.C.P, M.H.S.C.P, Lamp efficiency, Brightness or luminance. | 2 |
| 2.2 | Laws of illumination, Inverse square law and Lambert’s Cosine law, Illumination at horizontal and vertical plane from point source. | 2 |
| 2.3 | Concept of polar curve, Calculation of luminance and illumination in case of linear source, round source and flat source. | 2 |
| 2.4 | Measuring apparatus- Goniophotometer, Integrating sphere, lux meter. | 1 |
| 3 | Design of Interior Lighting (8 Hours) | |
| 3.1 | Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilisation and factors affecting it, Illumination required for various work planes. | 2 |
| 3.2 | Types of fixtures and relative terms used for interior illumination such as DLOR and ULOR, Selection of lamp and luminance, Selection of utilisation factor, reflection factor and maintenance factor. | 2 |
| 3.3 | Determination of Lamp Lumen output taking into account voltage and temperature variations, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaire, Calculation of space to mounting height ratio. | 2 |
| 3.4 | Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting and industrial building. | 2 |
| 4 | Design of Outdoor Lighting (10 Hours) | |
| 4.1 | Street Lighting - Types of street and their level of illumination required, Terms related to street and street lighting, Types of fixtures used and their suitable application. | 2 |
| 4.2 | Various arrangements in street lighting, Requirements of good street lighting, Selection of lamp and luminaire, Calculation of illumination level available on road. Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio. | 2 |
| 4.3 | Tunnel Lighting, Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio. | 2 |

| | | |
|---|---|---|
| 4.4 | Flood Lighting: Terms related to flood lighting, Types of fixtures and their suitable applications, Selection of lamp and projector, Recommended method for aiming of lamp. | 2 |
| 4.5 | Flood Lighting: Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio. | 2 |
| 5 | Special Features of Aesthetic and Emergency lighting (6 Hours) | |
| 5.1 | Monument and statue lighting, Sports lighting | 2 |
| 5.2 | Hospital lighting, Auditorium lighting | 1 |
| 5.3 | General Aspects of emergency lighting, Lighting controllers – dimmers, motion and occupancy sensors, photo sensors and timers | 2 |
| 5.4 | Lighting system design using software | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEE702.7 | DIGITAL PROTECTION OF POWER SYSTEM | PEC | 3 | 0 | 0 | 3 |

**Preamble:** The basic objective of this course is to deliver fundamental concepts to design various electronic circuits to implement various relaying functions. The relays such as Static Relays, Microprocessor based protective relays, Digital relay Travelling wave-based protection and adaptive relaying is comprehensively covered in this course. It should be also useful to practicing engineers and the research community.

**Prerequisite :** 1) EET 301 Power Systems I

2) EET 304 Power Systems II

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Identify the relay protection scheme suitable for over current, differential and distance protection. |
| **CO 2** | Develop the protection scheme for bus bars, transformers, generators, motors and distribution systems using appropriate protective relays. |
| **CO 3** | Illustrate the operation of a numerical relay in his/her own way. |
| **CO 4** | Explain signal processing methods and algorithms in digital protection. |
| **CO 5** | Infer emerging protection schemes in power systems. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | - | - | - | - | - | - | - | - | - | - |
| **CO 2** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - |
| **CO 3** | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - |
| **CO 4** | 3 | 2 | 3 | - | - | - | - | - | - | - | - | - |
| **CO 5** | 3 | 3 | - | 2 | - | - | - | - | - | - | - | - |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 30 |
| Understand | 20 | 20 | 40 |
| Apply | 20 | 20 | 30 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

Continuous Internal Evaluation Pattern:

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Assignment/Quiz/Course project | : 15 marks |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Discuss how saturation affects the accuracy of C.T.s. (K2)
2. Why I.D.M.T. relays are widely used for over current protection (K2))
3. Develop a criteria for the selection off distance relays.(K3)

**Course Outcome 2 (CO2)**

1. In what way distance protection is superior to over current protection for the protection of transmission lines.(K2)
2. Discuss the working principle of frame leakage protection.(K2)
3. Explain the differential scheme for bus zone protection.(K1)

**Course Outcome 3(CO3):**

1. Explain the principle of operation of numerical relays. (K1)
2. What is the function of the sample and hold circuit.(K2)
3. Explain the sliding window concept.(K2)

**Course Outcome 4 (CO4):**

1. Explain the concept of Finite Impulse Response filters,(K2)
2. Explain sinusoidal wave based algorithms. (K1)
3. Explain Least squares based algorithm. (K1)

**Course Outcome 5 (CO5):**

1. Compare the different decision making schemes in protective relays.(K2)
2. Explain the concept of synchronized sampling. (K2)
3. What are the basic components of a phasor measurement unit.(K1)

**Model Question paper**

QP CODE: **PAGES:4**

Reg.No:______________

Name:______________

TKM COLLEGE OF ENGINEERING

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: 22EEE702.7

**Course Name : DIGITAL PROTECTION OF POWER SYSTEMS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

Answer all Questions. Each question carries 3 Marks

**1.** Explain the basic principle and characteristics of impedance relays.

**2.** Explain current setting and time setting.

**3.** Explain the effect of power swings on the performance of distance relays.

**4.** What are the features of directional protection schemes for distribution system.

**5.** Give a comparison of numerical relays with static relays.

**6.** What are the basic components of numerical relays. Explain

**7.** Why digital filtering is required in a digital relay. Explain.

**8.** What are the useful properties of finite impulse filter.

**9.** What are the advantages of adaptive relaying

**10.** Give the definition of wide-area protection

**PART B (14 x 5 = 70 Marks)**

Answer any one full question from each module. Each question carries 14 Marks

**Module 1**

11.a) Explain the time current characteristics of inverse, very inverse and extremely inverse over current relays. Discuss their area of applications 7

b) What are the requirements of C.T. s used for protection. 7

12.a) Explain the types of construction used for P.T.s. 7

b) Explain the basic principle and characteristics of reactance and mho relays. 7

**Module 2**

13.a) With the help of a schematic diagram explain the carrier current protection scheme. 7

b) With the help of a neat diagram explain the working of harmonic restraint relay. 7

14.a) Explain the Phase comparison line protection scheme. 7

b) Explain the loss of excitation protection for a generator. 7

**Module 3**

15.a) With the help of a block diagram explain the basic components of a digital relay. 8

b) Explain the communication in protective relays (IEC 61850) 6

16.a) Briefly explain the information handling with substation automation system. 7

b) Explain the signal conditioning subsystem in numerical relays. 7

**Module 4**

17.a) Explain the full cycle window algorithm. 8

b) Give a comparison between infinite impulse filter and finite impulse filter. 6

18.a) Give the basic formulation of sample and first derivative method in sinusoidal wave based algorithm.
8

b) Explain how the impedance to the fault is found by using Least square method. 6

**Module 5**

19.a) Explain the methods of deterministic decision making and decision making with multiple criteria in protective relays.
8

b) Explain the architectures of wide-area protection 6

20.a) Explain the concept of Adaptive relaying and its applications. 8

b) Explain the Adaptive Differential protective scheme. 6

## Syllabus

## Module 1 (8 hours)

**Introduction:** Need for protective systems, Zones of protection, Current transformers and voltage transformers (Electromagnetic and Capacitive voltage transformers), Principle of operation of magneto optic CT/ PT, effect on relaying philosophy.

**Relays:** Over current relays - time-current characteristics of over current relays: definite time over current relays, inverse Definite Minimum time - directional over current relays, current setting and time setting - Numerical Problems - Differential relays: Operating and restraining characteristics, types of differential relays, Distance relays: impedance relays, reactance relays, mho relays, quadrilateral relays, elliptical relays (basic principles and characteristics only).

## Module 2 (8 hours)

**Protection of Transmission Line Systems:** Schemes of distance protection, Differential line protection, Phase comparison line protection, Use of line carrier and communication links, Effect of power swings on the performance of distance relays.

**Protection of Bus-bar, Transformer and Generator & Motor Systems*:*** Types of faults, differential protection: High impedance and low impedance differential protection schemes, harmonic restraint relay, Restricted Earth Fault Protection, frame leakage protection, stator and rotor protection against various types of faults.

**Pilot relaying schemes:** Pilot wire protection, carrier current protection (Basic Principles and schematic).

**Protection Scheme for Distribution Systems:** Protection criteria for distribution system, Features of directional and non-directional protection schemes for distribution system,

Fundamentals of travelling wave protection scheme.

## Module 3 (8 hours)

**Introduction to Digital (Numerical) Relays**- Basic Components of numerical Relays with block diagram, Processing Unit, Human machine Interface, Principle of operation- Comparison of numerical relays with electromechanical and static relays, Advantages of numerical relays - communication in protective relays (IEC 61850), Information handling with substation automation system (SAS)

Signal Conditioning Subsystems: Surge Protection Circuits, Anti-aliasing filter, Conversion Subsystem, The Sampling Theorem, aliasing, Sample and Hold Circuit, Concept of analog to digital and digital to analog conversion, Idea of sliding window concept, Fourier, Discrete and fast Fourier transforms

## Module 4 (6 hours)

Signal processing techniques: Sinusoidal wave based algorithms, Fourier Analysis based algorithms (half cycle and full cycle), Least squares based algorithm.

Digital filters – Fundamentals of Infinite Impulse Response Filters, Finite Impulse Response filters, Filters with sine and cosine windows

## Module 5 (6 hours)

Decision making in Protective Relays – Deterministic decision making, Statistical Hypothesis testing, Decision making with multiple criteria, Adaptive decision schemes.

Wide Area Protection and Measurement: Phasor Measurement Units, concept of synchronized sampling, Definition of wide-area protection, Architectures of wide-area protection, concept of Adaptive relaying, advantages of adaptive relaying and its application, Adaptive Differential protective scheme.

Assignment - Simulation of protection schemes using SIMULINK

**References**


1. A. T. Johns and S. K. Salman, "Digital Protection for Power Systems," Peter Peregrinus Ltd, UK, 1995.
2. Waldemar Rebizant, Digital Signal Processing in Power System Protection and Control – Springer Publication
3. J. L. Blackburn, "Applied Protective Relaying," Westinghouse Electric Corporation, New York, 1982.
4. A. G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems," Research study press Ltd, John Wiley & Sons, Taunton, UK, 1988.
5. S.P Patra, S.K Bl,lsu and S. Choudhary, "Power System Protection", Oxford IBH Pub.
6. S. Ravindernath and M. Chander, "Power System Protection and Switchgear", Wiley Eastern Ltd.
7. Badri Ram and Vishwakarma, Power System Protection and Switchgear, A McGraw Hill.
8. Digital Signal Processing in Power System Protection and Control by Waldemar Rebizant, Janusz Szafran ,Andrzej Wiszniewski - Springer publication


**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction to protective relays (8 hours)** | |
| 1.1 | Introduction: Need for protective systems, Zones of protection, Current transformers and voltage transformers (Electromagnetic and Capacitive voltage transformers), Principle of operation of magneto optic CT/ PT, effect on relaying philosophy. | 2 |

| | | |
|---|---|---|
| 1.2 | Relays: Over current relays-time-current characteristics of over current relays: definite time over current relays, inverse Definite Minimum time -directional over current relays, current setting and time setting- Numerical Problems | 2 |
| 1.3 | Differential relays: Operating and restraining characteristics, types of differential relays, | 1 |
| 1.4 | Distance relays: impedance relays, reactance relays, mho relays, quadrilateral relays, elliptical relays (basic principles and characteristics only). | 3 |
| 2 | **Protection of Transmission, Distribution, Bus-bar, Transformer, Generator & Motor Systems (8 hours)** | |
| 2.1 | **Protection of Transmission Line Systems:** Schemes of distance protection, Differential line protection, Phase comparison line protection, Use of line carrier and communication links, Effect of power swings on the performance of distance relays. | 2 |
| 2.2 | **Protection of Bus-bar, Transformer and Generator & Motor Systems*:*** Types of faults, differential protection: High impedance and low impedance differential protection schemes, harmonic restraint relay, Restricted Earth Fault Protection, frame leakage protection, stator and rotor protection against various types of faults. | 3 |
| 2.3 | **Pilot relaying schemes:** Pilot wire protection, carrier current protection (Basic Principles and schematic) . | 1 |
| 2.4 | **Protection Scheme for Distribution Systems:** Protection criteria for distribution system, Features of directional and non-directional protection schemes for distribution system,<br><br>Fundamentals of travelling wave protection scheme. | 2 |
| 3 | **Introduction to Digital (Numerical) Relays (8 hours)** | |
| 3.1 | Basic Components of numerical Relays with block diagram, Processing Unit, Human machine Interface, Principle of operation- Comparison of numerical relays with electromechanical and static relays, Advantages of numerical relays | 3 |
| 3.2 | Communication in protective relays (IEC 61850), Information handling with substation automation system (SAS) | 1 |
| 3.3 | Signal Conditioning Subsystems: Surge Protection Circuits, Anti-aliasing filter, Conversion Subsystem, The Sampling Theorem, aliasing, Sample and Hold Circuit, Concept of analog to digital and digital to analog conversion | 3 |
| 3.4 | Idea of sliding window concept, Fourier, Discrete and fast Fourier transforms | 1 |

| | | |
|---|---|---|
| 4 | **Signal processing techniques (6 hours)** | |
| 4.1 | Signal processing techniques: Sinusoidal wave based algorithms, Fourier Analysis based algorithms (half cycle and full cycle), Least squares based algorithm | 3 |
| 4.2 | Digital filters – Fundamentals of Infinite Impulse Response Filters, Finite Impulse Response filters, Filters with sine and cosine windows | 3 |
| 5 | **Decision making in Protective Relays (6 hours)** | |
| 5.1 | Decision making in Protective Relays – Deterministic decision making, Statistical Hypothesis testing, Decision making with multiple criteria, Adaptive decision schemes. | 2 |
| 5.2 | Wide Area Protection and Measurement: Phasor Measurement Units, concept of synchronized sampling, Definition of wide-area protection, Architectures of wide-area protection | 2 |
| 5.3 | concept of Adaptive relaying, advantages of adaptive relaying and its application, Adaptive Differential protective scheme. | 2 |

# SEMESTER VII
# (OPEN ELECTIVES)

| 22EEO703.1 | CONTROL SYSTEMS ENGINEERING | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | OEC | 2 | 1 | 0 | 3 |

**Preamble:**

Control Engineering is not limited to any engineering discipline, but is equally applicable to mechanical, chemical, electrical, aeronautical engineering. The most characteristic quality of control engineering is the opportunity to control machines, industrial and economic process for the benefit of society. This course aims to provide a strong foundation on classical control theory. In this course modelling, time domain analysis, frequency domain analysis and stability analysis of linear systems based on transfer function approach will be discussed.

**Prerequisite:**

Knowledge of Laplace transforms.

**Course Outcomes:** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Identify the elements of control system. |
| **CO 2** | Develop transfer function models of systems. |
| **CO 3** | Analyse the relation between pole locations with the transient response of first and second order systems. |
| **CO 4** | Determine the stability of LTI systems. |
| **CO 5** | Apply the concept of Root locus to assess the performance of linear systems. |
| **CO 6** | Determine the frequency domain specifications from Bode plot, Polar plot and Nyquist plot. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 2** | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 3** | 3 | 2 | - | - | 2 | - | - | - | - | - | - | 1 |
| **CO 4** | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 5** | 3 | 2 | - | - | 2 | - | - | - | - | - | - | 1 |
| **CO 6** | 3 | 2 | - | | 2 | - | - | - | - | - | - | 1 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 20 | 20 | 40 |
| Apply | 20 | 20 | 40 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| **150** | **50** | **100** | **3 hours** |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions:**

**Course Outcome 1 (CO1)**

1. Explain with an example how does he feedback element affects the performance of a closed loop system.(K3,PO1, PO2 and PO12)
2. What is the function of controller and sensor in a closed loop system? (K2, PO1)
3. What are the modifications required to convert an open loop system to a closed loop system?(K1, PO1, PO12)

**Course Outcome 2 (CO2)**

1. Problems related to derivation of transfer function of mechanical systems. (K3,PO1 and PO12)
2. Define transfer function and derive the transfer function of an RC network. (K3, PO1, PO2 and PO12)

3. Write short notes on Force- voltage and Force – current analogy? (K1, PO1, PO12)

**Course Outcome 3 (CO3)**

1. What is the effect of location of roots on S-plane on the transient response of a system? (K1, PO1, PO12)
2. What is the change in transient response of a second order system due to the addition of poles? Illustrate with an example. (K1, PO1, PO2, PO12)
3. What is the significance of settling time in control system? (K1, PO1, PO12)

**Course Outcome 4 (CO4)**

1. Problems related to application of Routh's stability criterion for analysing the stability of a given system. (K3, PO1, PO2, PO12)
2. Plot the impulse response of a second order system for different location of poles on S-plane. (K3, PO1, PO2, PO12)
3. How can we relate asymptotic stability to location of roots of characteristic equation? K2, PO1, PO2, PO12)

**Course Outcome 5 (CO5)**

1. Determine the value of K such that the closed loop system with $G(s)H(s) = \frac{K}{s\,(s+1)\,(s+4)}$ is oscillatory, using Root locus. (K3, PO1, PO2, PO12)
2. Construct the Root locus for the closed loop system with $G(s)H(s) = \frac{K}{s\,(s^2 + 2\,s + 2)}$ and determine the value of K to achieve a damping factor of 0.5. (K3, PO1, PO2, PO12)
3. Problems on root locus for systems with positive feedback. (K3, PO1, PO2, PO12)

**Course Outcome 6 (CO6)**

1. Problems related to assess the stability of the given system using Bode plot. (K3, PO1, PO2, PO3, PO12)
2. Problems related to Polar plot. (K3, PO1, PO2, PO12)
3. Explain Nyquist stability criterion. (K2, PO1, PO2, PO12)

**Model Question Paper** PAGES: 2

**QPCODE:**

Reg. No:____________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION**

**MONTH & YEAR**

Course Code**: 22EEO703.1**

Course Name: **CONTROL SYSTEMS ENGINEERING**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

Write short notes on Force- voltage and Force – current analogy?

Explain Mason's gain formula?

Define damping ratio.

Derive and sketch the time response of a first order system.

What are dynamic error coefficients? What are their merits?

Define BIBO Stability. What is the requirement of BIBO Stability?

How to determine break away and break in point in root locus plot?

What is the significance of dominant pole?

Write a short note on the correlation between time and frequency response

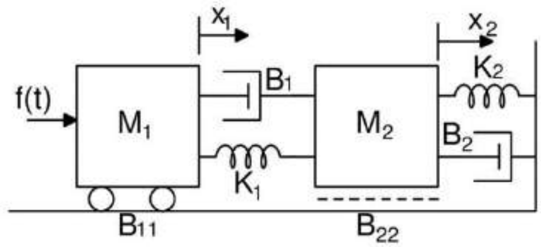
Explain Nyquist stability criterion

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

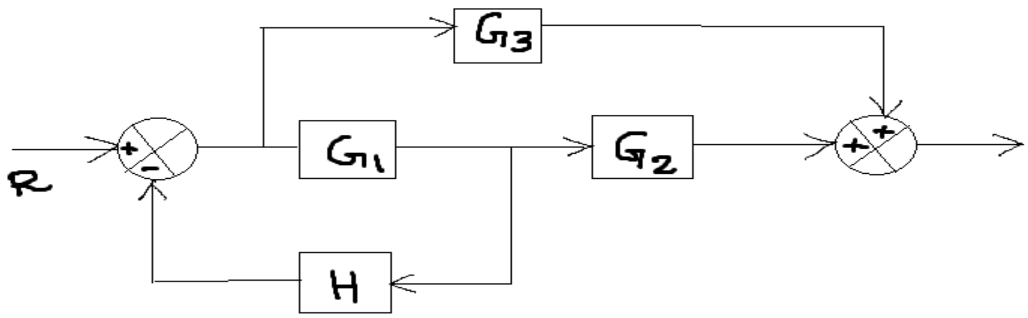
**Module 1**

9. a. Derive the transfer function for the mechanical system shown in figure. 10



b. Distinguish between open loop system and closed loop system 4

10. a. Reduce the block diagram shown in figure 10




b. Define transfer function and derive the transfer function of an RC network 4

**Module 2**

11 a. Sketch the time response of a general second order underdamped system and explain the specifications 6

b. The damping ratio of a system is 0.6 and the natural frequency of oscillation is 8 rad/sec. Determine the rise time, peak overshoot and peak time 8

12a. Distinguish between type and order of a system 5

b. The open loop transfer function of a unity feedback system is

$$G(s) = 20/s(s + 10)$$

What is the nature of response of closed loop system for unit step input? 9

**Module 3**

**13 a.** Plot the impulse response of a second order system for different location of poles on S-plane. 9

b. What is the effect of location of roots on S-plane on the transient response of a system? 5

14 a. A unity feedback system has a open loop transfer function of 7

$$G(s) = 10/(s + 1)(s + 2)$$

Determine steady state error for unit step input

b. Using Routh criterion determine the value of K for which the unity feedback closed loop system with $G(s) = \frac{K}{s(s^2 + 20s + 8)}$ is stable. **7**

**Module 4**

15 a. What is the relation between stability and coefficient of characteristic polynomial? 2

b. Explain the methods to find the crossing points of Root locus in imaginary axis. 4

c. Sketch the root locus for the unity feedback system whose open loop transfer function is given by: 8

$$G(s) = \frac{K}{s(s+4)(S^2+4S+20)}$$

16. Draw the root locus for a unity feedback system having forward path transfer function,

$$G(s) = \frac{K}{s(s+1)(s+5)}$$ 8

(a)Determine value of K which gives continuous oscillations and the frequency of oscillation.

(b)Determine the value of K corresponding to a dominant closed loop pole with damping ratio 0.7 6

**Module 5**

17. Consider a unity feedback system having an open loop transfer function

$$G(s) = k/s(1+0.2s)(1+0.05s)$$

(a) Sketch the polar plot 8

(b) Determine the value of K so that

(i) Gain margin is 18 db

(ii) Phase margin is $60^o$ 6

18. (a)The open loop transfer function of a system is given by

$$G(s) = k/s(1+0.2s)(1+0.5s)$$

Sketch the Bode plot 8

(b)From the Bode plot determine the value of K so that

(i) Gain margin of the system is 6 db

(ii) Phase margin of the system is $25^o$ 6

## Syllabus

**Module 1**

**Feedback Control Systems (10 hours)**

Open loop-and closed loop control systems: Transfer function of LTI systems-Mechanical and Electromechanical systems – Force voltage and force current analogy - block diagram representation - block diagram reduction - signal flow graph - Mason's gain formula - characteristic equation..

**Module 2**

**Performance Analysis of Control Systems (5 hours)**

Time domain analysis of control systems: Transient and steady state responses - time domain specifications - first and second order systems - step responses of first and second order systems.

**Module 3**

**Error Analysis and Stability (6 hours)**

Error analysis: Steady state error analysis and error constants -Dynamic error coefficients.
Stability Analysis: Concept of BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems - Routh's stability criterion-

**Module 4**

**Root Locus Technique (6 hours)**

Root locus technique: Construction of Root locus- stability analysis- effect of addition of poles and zeroes.

**Module 5**

**Frequency Domain Analysis (9 hours)**

Frequency domain specifications- correlation between time domain and frequency domain responses.
Polar plot: Concepts of gain margin and phase margin- stability analysis
Bode Plot: Construction- Concepts of gain margin and phase margin.
Nyquist stability criterion (criterion only)

**Text books**

14. Nagarath I. J. and Gopal M., Control System Engineering, 5/e, New Age Publishers
15. Ogata K, Modern Control Engineering, 5/e, Prentice Hall of India.
16. Nise N. S, Control Systems Engineering, 6/e, Wiley Eastern
17. Dorf R. C. and Bishop R. H, Modern Control Systems, 12/e, Pearson Education

**Reference Books**

10. Kuo B. C, Automatic Control Systems, 7/e, Prentice Hall of India

11. Desai M. D., Control System Components, Prentice Hall of India, 2008
12. Gopal M., Control Systems Principles and Design, 4/e, Tata McGraw Hill.
13. Imthias Ahamed T. P, Control Systems, Phasor Books, 2016

**Course Contents and Lecture Schedule:**

| Module | Topic coverage | No. of Lectures |
|---|---|---|
| **1** | **Feedback Control Systems (10 hours)** | |
| 1.1 | Terminology and basic structure of Open loop and Closed loop control systems- Examples of Automatic control systems (block diagram representations only). | 2 |
| 1.2 | Transfer function approach to feed back contr.ol systems- Mechanical and Electromechanical systems | 2 |
| 1.3 | Force –voltage , force –current analogy. | 2 |
| 1.4 | Block Diagram Reduction Techniques. | 2 |
| 1.5 | Signal flow graph- Mason’s gain formula, Characteristic Equation. | 2 |
| **2** | **Performance Analysis of Control Systems (5 hours)** | |
| 2.1 | Time domain analysis of control systems:<br>Transient and steady state responses- Impulse and Step responses of first and second order systems Time domain specifications. | 4 |
| 2.2 | Time domain specifications. | 1 |
| **3** | **Error analysis and Stability(6 hours)** | |
| 3.1 | Error analysis:<br>Steady state error analysis - static error coefficient of Type 0, 1, 2 systems. Dynamic error coefficients. | 2 |
| 3.2 | Stability Analysis:<br>Concept of stability-BIBO stability and Asymptotic stability- Time response for various pole locations- stability of feedback systems. | 2 |
| 3.3 | Application of Routh's stability criterion to control system analysis- Relative stability. | 2 |
| **4** | **Root Locus Technique (6 hours)** | |
| 4.1 | Root locus technique:<br>General rules for constructing Root loci – stability from root loci - | 5 |
| 4.2 | Effect of addition of poles and zeros on Root locus | 1 |
| **5** | **Frequency domain analysis (9 hours)** | |
| 5.1 | Frequency domain specifications- correlation between time domain and frequency domain responses. | 2 |

| | | |
|---|---|---|
| 5.2 | Polar plot: Concepts of gain margin and phase margin- stability analysis. | 2 |
| 5.3 | Bode Plot: Construction of Bode plots- gain margin and phase margin- Stability analysis based on Bode plot . | 4 |
| 5.4 | Nyquist stability criterion | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEO703.2 | INTRODUCTION TO POWER PROCESSING | OEC | 2 | 1 | 0 | 3 |

**Preamble** **:** The recent advances in power electronics has resulted in the development of various industrial and household devices/equipment that employ power processing. It is important for engineering professionals to understand the fundamental principles behind such devices/systems. This course provides an overview of various essential elements of power electronics used for power processing, and their principle of operation. Power electronics deals with the processing and control of 'raw' electrical power from an electrical source. The power levels handled can vary from a few watts to several hundreds of megawatts. It is an enabling technology with a very wide range of applications. The course contents enable the students to understand the principles of power electronics and provide an introduction to various applications such as industrial drives, renewable energy, power supplies and electrical /hybrid vehicles.

**Prerequisite** **: EST 130 Basics of Electrical and Electronics Engineering**

**Course Outcomes :** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Explain different elements of power electronics. |
| **CO 2** | Explain various power electronic converters. |
| **CO 3** | Describe the basic principles of ac and dc motor drives. |
| **CO 4** | Describe the structure of power processing systems in power supplies, renewable energy conversion and EVs. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | | | | | | | | | | |
| **CO 2** | 2 | | | | | | | | | | | |
| **CO 3** | 2 | | | | | | | | 2 | | | |
| **CO 4** | 2 | | | | | | 2 | | 2 | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 20 | 20 | 40 |
| Understand | 30 | 30 | 60 |
| Apply | | | |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 subdivisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the principle of operation of MOSFET. (K2, PO1)
2. What is the difference between thyristors and controllable switches? (K1, PO1)
3. Why are IGBTs becoming popular in their applications to controlled converters ?
4. Enumerate some applications of IGBTs. (K1, PO1)

5. What are the applications of power electronic systems? (K1, PO1)

**Course Outcome 2 (CO2)**

1. With a neat circuit and waveforms, explain the working of a boost DC-DC converter.(K2, PO1)
2. With the help of waveform explain sinusoidal pulse width modulation used in single phase inverter. (K2, PO1)
3. Explain the working of a single-phase half bridge square wave inverter with pure R load. Draw the output voltage and output current waveforms.(K2, PO1)
4. Illustrate how a thyristor based 1-phase fully controlled rectifier can be used to convert ac into variable dc. Draw the waveforms of output voltage and output current for both R and RL load at $\alpha$= 30 degree.(K2, PO1)

**Course Outcome 3(CO3):**

1. Give the classification of DC motors based on their field winding excitation with neat diagrams.(K2, PO9)
2. What is meant by armature reaction? What are its effects on main field flux? (K1, PO9)
3. Explain V/F control of induction motor drives. (K2, PO9)
4. Explain why we use starters for starting a DC motor. (K2, PO9)

**Course Outcome 4 (CO4):**

1. Explain a standalone solar PV system with a block diagram. (K2, PO7, PO9)
2. Explain the components of a linear power supply. (K2, PO7, PO9)
3. Distinguish between HEV and PHEV. (K2, PO7, PO9)
4. Explain the powertrain in an EV. (K2, PO7, PO9)

**Model Question paper**

**QP CODE:**

**PAGES:**

**Reg. No:______________**

**Name:______________**

**TKM COLLEGE OF ENGINEERING**

**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION,**

**MONTH & YEAR**

**Course Code: 22EEO703.2**

**Course Name: INTRODUCTION TO POWER PROCESSING**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks.**

1. Explain the principle of operation of SCR.
2. What are wide bandgap devices? What are its advantages?
3. With a neat circuit explain the working of single phase fully controlled SCR based bridge rectifiers with R load.
4. With neat circuit, explain the working of a boost DC-DC converter
5. Differentiate between voltage source inverter and current source inverter.
6. With the help of waveform explain sinusoidal pulse width modulation used in single phase inverter.
7. What is meant by armature reaction?
8. Explain why we use starters for starting a DC motor.
9. What is the difference between on grid and off grid Solar PV installations?
10. Give three advantages of electric vehicles over the conventional IC engine driven vehicles.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

## Module 1

11(a) What are the advantages, disadvantages and applications of power electronic systems? (10)

(b) Compare a diode and a thyristor. (4)

12 (a) Describe the working of IGBT. How does latch-up occur in an IGBT? Why are IGBTs becoming popular in their applications to controlled converters? Enumerate some applications of IGBTs. (10)

(b) With a neat block diagram, explain a typical power electronic system. (4)

## Module 2

13 (a) Illustrate how a thyristor based 1-phase fully controlled rectifier can be used to convert ac into variable dc. Draw the waveforms of output voltage and output current for RL load at $\alpha$= 30 degree. (10)

(b) Discuss the significance of a freewheeling diode. (4)

14 (a) Explain with a circuit diagram and necessary waveforms, the working of a buck regulator for continuous current mode. (10)

(b) Explain the phenomenon of inductive kick. (4)

## Module 3

15 (a) Explain the working of a single-phase half bridge square wave inverter with pure R load. Draw the output voltage and output current waveforms. (10)

(b) What is its main drawback? Explain how this drawback is overcome. (4)

16 (a) What is an ac voltage controller? List some of its industrial applications. Enumerate its merits and demerits. (7)

(b) Describe the operation of a single phase ac voltage controller with R load with necessary waveforms. (7)

Module 4

17. (a)With a neat schematic explain the components of an electric drive system (7)

(b)Explain the four-quadrant operation of a dc motor (7)

18 (a) List various control strategies used in induction motor drives (4)

(b) ExplainV/F control of induction motor drives. (10)

## Module 5

19. (a) Explain the operation of a grid connected solar PV system with a neat block schematic (7)

(b) Explain the components of a linear power supply. (7)

20. (a) Distinguish between HEV and PHEV (4)

(b) Explain different energy storage systems used in Electric Vehicles (10)

## Syllabus

**Module 1**

Introduction to power processing, elements of power electronics, power semiconductor devices. Uncontrolled, Semicontrolled and Fully controlled switches: Diode, SCR, MOSFETs and IGBTs-principle of operation. Advantages of wide bandgap devices-SiC, GaN.

**Module 2**

Basic power conversion circuits- converter circuits: Controlled rectifiers: Single- phase fully controlled SCR based bridge rectifier with R and RL load (continuous mode only). Principle of operation and waveforms (No analysis required).

DC-DC Converters (Non-isolated) : Buck, Boost and Buck-Boost converter. Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required).

**Module 3**

Single phase half and full bridge Inverter: Square-wave operation with R load. Types of PWM - single pulse, multiple pulse and sinusoidal PWM. Total Harmonic Distortion(THD).

Three phase voltage source inverter with R load- 120 and 180 degree conduction mode - waveforms

Single phase AC voltage controller with R load- waveforms.

**Module 4**

Applications: 1. *Motor drives*:

Introduction to electric motor drive- Block diagram

4-quadrant operation of a separately excited dc motor (circuit diagram and waveforms only).

Induction motor drives: Principle of operation- v/f control

**Module 5**

Applications 2: *Renewable energy*- solar PV installations-off grid and on grid systems: Principle of operation - Block diagram.

Applications 3: *Power supplies* - Principle of operation of linear and switched mode power supply-requirements of power supplies- Isolation, protection and regulation.

Applications 4: *Electric vehicles* - Introduction to HEV, PHEV and BEV-Block schematic of power train. Introduction to energy storage in EVs - Li Batteries, Hydrogen Fuel Cell.

**Reference Books**

1. Ned Mohan, Tore m Undeland, William P Robbins, “Power electronics converters applications and design”, John Wiley and Sons, 2003.
2. Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education, 2009.
3. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 2012.
4. Dubey G. K. “Fundamentals of Electrical drives” Narosa Publishing House, 1995.
5. Andrzej M. Trzynadlowski, Introduction to Modern Power Electronics, 3rd Edition, Wiley, 2015.
6. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
7. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001.
8. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
9. Non conventional energy sources, NPTEL lecture by Prof.Prathap Haridoss, IIT Chennai.
10. Abad, Gonzalo, ed. Power electronics and electric drives for traction applications. USA: Wiley, 2017.

**Course Contents and Lecture Schedule**

| No. | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction to power processing (6 hours)** | |
| 1.1 | Introduction to power electronics and its objectives, Advantages, disadvantages, applications, typical power electronic system | 1 |
| 1.2 | Elements of power electronics, power semiconductor devices. | 1 |
| 1.3 | Symbol and principle of operation of diode and SCR | 1 |
| 1.4 | Symbol and principle of operation of MOSFET | 1 |
| 1.5 | Symbol and principle of operation of IGBT | 1 |
| 1.6 | Advantages of wide bandgap devices- SiC, GaN | 1 |
| **2** | **Basic power conversion circuits (6 hours)** | |
| 2.1 | Converter circuits | 1 |

| | | |
|---|---|---|
| 2.2 | Single- phase fully controlled SCR based bridge rectifier with R (continuous mode only), Principle of operation and waveforms (No analysis required) | 1 |
| 2.3 | Single- phase fully controlled SCR based bridge rectifier with RL load (continuous mode only), Principle of operation and waveforms (No analysis required) | 1 |
| 2.4 | DC-DC Converters (Non-isolated) : Buck converter.<br><br>Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required). | 1 |
| 2.5 | Boost converter.<br><br>Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required). | 1 |
| 2.6 | Buck-Boost converter.<br><br>Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required). | 1 |
| 3 | **Inverter circuits, AC voltage controllers (8 hours)** | |
| 3.1 | Voltage source inverters | 1 |
| 3.2 | Single phase half and full bridge Inverter-Square-wave operation with R load | 1 |
| 3.3 | Types of PWM - single pulse, multiple pulse and sinusoidal PWM<br><br>Total Harmonic Distortion (THD) | 2 |
| 3.4 | Three phase voltage source inverter with R load- 120 degree conduction mode - waveforms | 1 |
| 3.5 | Three phase voltage source inverter with R load- 180 degree conduction mode - waveforms | 2 |

| | | |
|---|---|---|
| 3.6 | Single phase AC voltage controller with R load- waveforms. | 1 |
| 4 | **Applications of power processing in Drives (9 hours)** | |
| 4.1 | Introduction to electric drives, components of electric drive, advantages of electric drives. | 2 |
| 4.2 | DC motor – principle of operation – back emf – necessity of motor starter-classification, | 2 |
| 4.3 | Four quadrant operation of separately excited DC Motor | 2 |
| | Three phase induction motor-squirrel cage and slip ring induction motor, Working principle-synchronous speed, slip | 2 |
| 4.4 | Induction Motor Drives, V/F control | 1 |
| 5 | **Applications of power processing in renewable energy generation, power supplies and EVs (6 hours)** | |
| 5.1 | Solar PV installations-Off grid and On grid | 2 |
| 5.2 | Linear and Switch Mode Power Supplies, Functional Block Diagram and operation | 2 |
| 5.3 | Introduction to Electric Vehicle, Various Types, Types of Energy Storage | 2 |

| 22EEO 703.3 | RENEWABLE ENERGY SYSTEMS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | OEC | 2 | 1 | 0 | 3 |

**Preamble:** Objective of this course is to inculcate in students an awareness of new and renewable energy sources.

**Prerequisite: Students who have taken EET383 MINOR are not eligible to take this course.**

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Choose the appropriate energy source depending on the available resources. |
| **CO 2** | Explain the concepts of solar thermal and solar electric systems. |
| **CO 3** | Illustrate the operating principles of wind, and ocean energy conversion systems. |
| **CO 4** | Outline the features of biomass and small hydro energy resources |
| **CO 5** | Describe the concepts of fuel cell and hydrogen energy technologies |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | | | | 1 | 2 | | | | | |
| **CO 2** | 3 | | | | | | | | | | | |
| **CO 3** | 3 | | | | | 1 | 1 | | | | | |
| **CO 4** | 3 | | | | | 1 | 1 | | | | | |
| **CO 5** | 3 | | | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 25 | 25 | 50 |
| Understand | 20 | 20 | 40 |
| Apply | 5 | 5 | 10 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Assignment/Quiz/Course project | : 15 marks |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 subdivisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Write short notes on the advantages and disadvantages of any three types of non conventional energy sources.( K1, PO1)

2. What are the points to be considered while constructing a house for energy efficiency? (K2, PO1, PO6, PO7)

**Course Outcome 2 (CO2)**

1. Explain construction of solar flat plate collector with a neat diagram. (K2, PO1)

2. Draw the block diagram of a solar thermal electric plant and explain its working. (K1, PO1)

3. Discuss the effect of temperature and insolation on the characteristics of solar cell. Draw the P-V characteristics of Solar cell under varying temperature and irradiation level. (K3, PO1)

**Course Outcome 3 (CO3):**

1. Derive the expression for power in the wind turbine. (K1, PO1, PO6, PO7)

2. Classify tidal power plants and brief explain any two of them. (K1, PO1, PO6, PO7)

3. With the help of a block diagram explain the working of a hybrid OTEC. (K2, PO1, PO6, PO7)

**Course Outcome 4 (CO4):**

1. What are the factors that affect biogas generation? (K1, PO1, PO6, PO7)

2. Compare the construction and performance of floating drum type and fixed dome type biogas plants with the help of neat sketches. (K2, PO1, PO6, PO7)

3. Discuss the selection criteria of turbines for a small hydro project. (K1, PO1, PO6, PO7)

**Course Outcome 5 (CO5):**

1. What is small hydro power? How is it classified? Obtain an expression for the power that can be generated from a small hydro power station. (K1, PO1)

2. Explain the hydrogen energy system with necessary diagram. (K2, PO1)

3. What do you mean by the conversion efficiency of a fuel cell? (K1, PO1)

**Model Question Paper**

**Total Pages:2**

Reg No.:_______________ Name:__________________________

**TKM COLLEGE OF ENGINEERING**

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

**Course Code: 22EEO703.3**

**Course Name: RENEWABLE ENERGY SYSTEMS**

Max. Marks: 100 Duration: 3 Hours

**PART A**

***Answer all questions, each carries 3 marks.***

1 Differentiate between flat plate collectors and solar concentrators.

2 Discuss advantages and limitations of conventional energy sources.

3 With the help of a block diagram explain the working of a hybrid OTEC.

4 List out the advantages and disadvantages of a tidal power plant.

5 Discuss the different types of wind turbine rotors used to extract wind power.

6 The Danish offshore wind farm has a name plate capacity of 209.3 MW. As of January 2017 it has produced 6416 GWh since its commissioning 7.3 years ago. Determine the capacity factor of above wind farm.

7 What are the factors that affect biogas generation

8 Discuss the process of biomass to ethanol conversion

9 What are the components of micro hydel power plant.

10 Enumerate the design and selection of different types of turbines used for small hydro plants

**PART B**

**Answer any one full question from each module. Each question carries 14 marks**

**Module 1**

9 a) With the aid of a neat diagram, explain the working of a central tower collector type solar thermal electric plant (9)

b) Define (i) Open Circuit Voltage (ii) Short circuit Current (iii) Fill factor and (iv) Efficiency of the solar cell (5)

10 a) Compare the components and working of a standalone and grid connected PV system (5)

b) How energy resources are classified. Compare conventional and non conventional sources of energy resources (9)

**Module 2**

11 What are the site selection criteria for OTEC? Draw the block diagram and explain the working of Anderson cycle based OTEC system. Explain how biofouling affects efficiency of energy conversion and how can it be minimised? (14)

12 Explain the principle of operation of a tidal power plant. How it is classified? Draw the layout of a double basin tidal power plant and label all the components.Explain the function of each component (14)

**Module 3**

13 a) Prove that the maximum wind turbine output can be achieved when $V_d = \frac{1}{3}V_u$ $V_d = \frac{1}{3}V_u$, where $V_d$ $V_d$ and $V_u V_u$ are down-stream and up-stream wind velocity respectively (10)

b) What is pitch control of wind turbine? Explain. (4)

14 a) Determine the power output of a wind turbine whose blades are 12m in diameter and when the wind speed is 6m/s, the air density is about 1.2kg/m$^3$ and the maximum power coefficient of the wind turbine is 0.35. (5)

b) Explain the parts, their function and working of a wind power plant. What are the site selection criteria of a wind power plant? (9)

**Module 4**

| | | | |
|---|---|---|---|
| 15 | a) | With a neat schematic diagram , explain the biomass gasification based electric power generation system | (5) |
| | b) | Explain the how urban waste is converted into useful energy | (9) |
| 16 | a) | Compare the construction and performance of floating drum type and fixed dome type biogas plants with the help of neat sketches | (10) |
| | b) | Explain the importance of biomass programme in India | (4) |

**Module 5**

| | | | |
|---|---|---|---|
| 15 | a) | Explain the operation of a phosphoric acid fuel cell with the help of a suitable diagram | (7) |
| | b) | What are the different methods used for the production and storage of hydrogen | (7) |
| 16 | a) | Draw the layout of a mini hydro project and explain its working | (7) |
| | b) | Describe the working and constructional features of PEM fuel cell | (7) |

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## Syllabus

**Module 1**

Introduction, Classification of Energy Resources- Conventional Energy Resources - Availability and their limitations- Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison.

SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. – Flat plate collectors. Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector).

SOLAR ELECTRIC SYSTEMS- Solar Thermal Electric Power Generation – Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, .construction. Solar PV Systems – stand-alone and grid connected- Applications .

**Module 2**

ENERGY FROM OCEAN- Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system- Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle. Site-selection criteria- Biofouling- Advantages & Limitations of OTEC.

TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification-single basin- double basin types –Limitations -Environmental impacts.

**Module 3**

WIND ENERGY- Introduction- Basic principles of Wind Energy Conversion Systems (WECS) wind speed measurement-Classification of WECS- types of rotors. wind power equation -Betz limit. Electrical Power Output and Capacity Factor of WECS- Advantages and Disadvantages of WECS -site selection criteria.

**Module 4**

BIOMASS ENERGY- Introduction- Biomass fuels-Biomass conversion technologies -Urban waste to Energy Conversion- Biomass Gasification- Biomass to Ethanol Production- Biogas production from waste biomass- factors affecting biogas generation-types of biogas plants – KVIC and Janata model-Biomass program in India.

**Module 5**

SMALL HYDRO POWER- Classification as micro, mini and small hydro projects - Basic concepts and types of turbines- selection considerations.

EMERGING TECHNOLOGIES: Fuel Cell-principle of operation –classification- conversion efficiency and losses - applications .Hydrogen energy -hydrogen production -electrolysis -thermo chemical methods -hydrogen storage and utilization.

**Text Books**


1. G. D. Rai, “ Non Conventional Energy Sources”, Khanna Publishers, 2010.
2. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999


**Reference Books**


1. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002
2. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
3. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
4. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
5. Tiwari G. N., Solar Energy- Fundamentals, Design, Modelling and Applications, CRC Press, 2002.
6. A.A.M. Saigh (Ed): Solar Energy Engineering, Academic Press, 1977
7. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001..
8. Boyle G. (ed.), Renewable Energy - Power for Sustainable Future, Oxford University Press, 1996
9. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
10. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 197
11. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978 62.
12. Khan B.H, Non Conventional Energy resources Tata McGraw Hill, 2009.


**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures (35 hours) |
|---|---|---|
| **1** | **Introduction (7 hours)** | |
| 1.1 | Classification of Energy Resources- Conventional Energy - Resources - Availability and their limitations | 1 |
| 1.2 | Non-Conventional Energy Resources – Classification, Advantages, Limitations, Comparison. | 1 |
| 1.3 | SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. | 1 |
| 1.4 | Flat plate collectors. Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) | 1 |

| | | |
|---|---|---|
| 1.5 | SOLAR ELECTRIC SYSTEMS- Solar Thermal Electric Power Generation | 1 |
| 1.6 | Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, construction. | 1 |
| 1.7 | Solar PV Systems – stand-alone and grid connected- Applications | 1 |
| **2** | **ENERGY FROM OCEAN (7 hours)** | |
| 2.1 | Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system- | 1 |
| 2.2 | Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) | 1 |
| 2.3 | Hybrid cycle. Site-selection criteria | 1 |
| 2.4 | Biofouling- Advantages & Limitations of OTEC | 1 |
| 2.5 | TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- | 1 |
| 2.6 | Classification-single basin- double basin types –Limitations and environmental impacts | 2 |
| **3** | **WIND ENERGY (7 hours)** | |
| 3.1 | Introduction- Basic principles of Wind Energy Conversion Systems (WECS) | 1 |
| 3.2 | Wind speed measurement | 1 |
| 3.3 | Classification of WECS- types of rotors | 2 |
| 3.4 | Wind power equation -Betz limit | 1 |
| 3.5 | Electrical Power Output and Capacity Factor of WECS | 1 |
| 3.6 | Advantages and Disadvantages of WECS -site selection criteria | 1 |
| **4** | **BIOMASS ENERGY (6 hours)** | |
| 4.1 | Urban waste to Energy Conversion | 1 |
| 4.2 | Biomass Gasification- Biomass to Ethanol Production | 1 |
| 4.3 | Biogas production from waste biomass | 2 |
| 4.4 | Types of biogas plants – KVIC and Janata model | 1 |
| 4.5 | Biomass program in India. | 1 |
| **5** | **SMALL HYDRO POWER (8 hours)** | |
| 5.1 | Classification as micro, mini and small hydro projects | 1 |
| 5.2 | Basic concepts and types of turbines- selection considerations. | 2 |
| 5.3 | EMERGING TECHNOLOGIES: Fuel Cell-principle of operation | 1 |
| 5.4 | Classification- conversion efficiency and losses - applications | 1 |

| | | |
|---|---|---|
| 5.5 | Hydrogen energy -hydrogen production | 1 |
| 5.6 | Electrolysis -thermo chemical methods | 1 |
| 5.7 | Hydrogen storage and utilization. | 1 |

| 22EEO7 03.4 | Electric Vehicles | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| | | OEC | 2 | 1 | 0 | 3 |

Preamble: This course introduces basic knowledge about electric vehicles. Basic knowledge about the drives used in EV and HEV, battery management system , energy sources and communication networks are also discussed.

**Prerequisite: NIL.**

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the basic concept of electric and hybrid electric vehicle |
| **CO 2** | Choose proper energy storage systems for vehicle applications |
| **CO 3** | Identify various communication protocols and technologies used in vehicle networks |

Mapping of course outcomes with program outcomes

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** | **PO 11** | **PO 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | **2** | | | | | 1 | 1 | | | | | 1 |
| **CO 2** | **2** | | | | | 1 | 1 | | | | | 1 |
| **CO 3** | **2** | | | | | 1 | 1 | | | | | 1 |

Assessment Pattern

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand | 25 | 25 | 50 |
| Apply | 15 | 15 | 30 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Assignment/Quiz/Course project | : 15 marks |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. List various vehicle performance indices. (K1, PO1, PO6, PO7)

2. List various hybrid electric vehicle topologies.(K1, PO1)

3. Highlight the importance of control of electric motor drives in electric and hybrid electric vehicle powertrains. (K2, PO1, PO6, PO7)

**Course Outcome 2 (CO2)**

1. State the different characteristics of the energy storage system used in electric and hybrid electric vehicles .(K2, PO1, PO6, PO7)

2. Describe how the battery size can be reduced in electric and hybrid electric vehicles. (K2, PO1, PO6, PO7)

3. Illustrate the different methods used for increasing the battery life in electric and hybrid electric vehicles. (K2, PO1, PO6, PO7)

**Course Outcome 3 (CO3):**

1. List the general objectives of energy management strategies employed in electric and hybrid electric vehicles. (K1, PO1, PO6, PO7)

2. Identify various communication protocols used in electric and hybrid electric vehicles. (K1, PO1, PO6)

3. Illustrate how fuel economy is maintained in hybrid electric vehicles. (K2, PO1, PO6, PO7)

**Model Question paper**

**QP CODE:**

PAGES: 3

Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION,**
**MONTH & YEAR**

**Course Code: 22EEO703.4**

**Course Name: Electric Vehicles**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. List the reasons that led to the evolution of hybrid electric vehicles.
2. List the characteristics of the transmission system in a vehicle.
3. Mention one instance, when the internal combustion engine shall take up extra torque in the drivetrain of a parallel hybrid while being driven.
4. List major components in the drivetrain of an electric vehicle.
5. Discuss the advantage and disadvantage of using DC motors in the drivetrain of electric and hybrid electric vehicles.
6. List any three motors that can be used in the drivetrain of electric and hybrid electric vehicles.
7. Explain the C-rating of a battery
8. Explain the basic fuel cell structure with the help of a neat diagram
9. What are the seven layers of Open System Interconnection (OSI)?
10. What is meant by CAN transfer protocol

**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. Explain the history of electric and hybrid electric vehicles. 14

12. Explain the essential characteristics in the power sources intended to be used in electric and hybrid electric vehicles. 14

**Module 2**

13. a. Highlight various factors that influence the component sizing in the power trains of hybrid electric vehicles. 7

b. Illustrate how an internal combustion engine is always operated in its maximum operating efficiency region in a hybrid electric vehicle. 7

14. a. Highlight the limitations posed by the battery during the power flow control in electric drive-train topologies. 8

b. Suggest various methods to minimize the battery size and maximize battery life during the power flow control in electric drive-train topologies. 6

**Module 3**

15. a. List the desired characteristics of motors used in the drive trains of electric and hybrid electric vehicles. 7

b. Demonstrate the control of separately excited DC motors in electric vehicles. 7

16. a. Explain the block diagram of electric drive system used in electric vehicles. 7

b. Demonstrate the Field Oriented Control of Induction Motors in the powertrain of electric vehicles. 7

**Module 4**

17. Explain about Lithium ion batteries with the help of necessary diagram. Write the chemical reactions involved in it. 14

18. What are the various battery parameters? Briefly explain 14

**Module 5**

19. Compare various energy management strategies in electric vehicles. 1
4

20. Discuss about a typical CAN layout in a hybrid electric vehicle with the help of block diagram 14

.

## Syllabus

**Module 1 (6 hrs)**

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance

**Module II (8 hrs)**

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, Introduction to electric components used in hybrid electric vehicles

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.

**Module III (8 hrs)**

Block diagram of electric drive system, Introduction to electric motors used in hybrid and electric vehicles: configuration and control of separately excited DC motors, Induction Motors (block diagram representation of FOC).

**Module IV (7 hrs)**

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage, Fuel Cell based energy storage, Hybridization of different energy storage devices, Introduction to Super capacitor and Hydrogen energy storage.

**Module V (7 hrs)**

Communications, supporting subsystems: In vehicle networks- CAN

Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies

**References**

1 Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

2. NPTEL (notes) – Electrical Engineering – Introduction to Hybrid and Electric Vehicles

3 K Sundareswaran, Elementary Concepts of Power Electronic Drives: CRC Press, Taylor & Francis Group

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction to Hybrid Electric Vehicles (6)** | |
| 1.1 | History of hybrid and electric vehicles, | 1 |
| 1.2 | Social and environmental importance of hybrid and electric vehicles | 1 |
| 1.3 | Basics of vehicle performance | 1 |
| 1.4 | Vehicle power source characterization, transmission characteristics | 1 |
| 1.5 | Mathematical models to describe vehicle performance | 1 |
| 1.6 | Dynamics of electric motion | 1 |
| 2 | **Hybrid Electric Drive -trains and Electric drive trains (8)** | |
| 2.1 | Basic concept of hybrid traction | 1 |
| 2.2 | Introduction to various hybrid drive-train topologies | 1 |
| 2.3 | Power flow control in hybrid drive-train topologies | 2 |
| 2.4 | Basic concept of electric traction | 1 |
| 2.5 | Introduction to various electric drive-train topologies, | 1 |

| | | |
|---|---|---|
| 2.6 | Power flow control in electric drive-train topologies | 2 |
| 3 | **Electric drive system in electric and hybrid electric vehicles (8)** | |
| 3.1 | DC motors and induction motors | 2 |
| 3.2 | Introduction to Electric drive system | 2 |
| 3.3 | Separately excited DC motor speed control | 1 |
| 3.4 | V/f control of induction motor drive | 1 |
| 3.5 | Introduction to vector control ( block diagram representation only) | 2 |
| 4 | **Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles (7)** | |
| 4.1 | Battery based energy storage | 3 |
| 4.2 | Fuel Cell based energy storage | 2 |
| 4.3 | Hybridization of different energy storage devices | 1 |
| | Introduction to Super capacitor and Hydrogen energy storage | 1 |
| 5 | Communications, supporting subsystems and energy management strategies (7) | |
| 5.1 | Communications networks | 2 |

| | | |
|---|---|---|
| 5.2 | Introduction to energy management strategies used in hybrid and electric vehicles | 1 |
| 5.3 | Classification of different energy management strategies | 2 |
| 5.4 | Comparison of different energy management strategies | 2 |

| 22EEO703.5 | Energy Management | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| | | OEC | 2 | 1 | 0 | 3 |

**Preamble:**

This course introduces basic knowledge about energy management and audit. Energy management opportunities in electrical and mechanical systems are discussed. Economic analysis of different energy conservation measures is also described.

**Prerequisite:** Basics of Mechanical Engineering and Basics of Electrical Engineering.

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | **Explain the significance and procedure for energy management and audit.** |
| **CO 2** | **Discuss the energy efficiency and management of electrical loads.** |
| **CO 3** | **Discuss the energy efficiency in boilers and furnaces.** |
| **CO 4** | **Explain the energy management opportunities in HVAC systems** |
| **CO 5** | **Compute the economic feasibility of the energy conservation measures.** |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | **2** | | | | | 1 | 1 | | 2 | 1 | | 1 |
| **CO 2** | **2** | | | | | 1 | 1 | | | | | |
| **CO 3** | **2** | | | | | 1 | 1 | | | | | |
| **CO 4** | **2** | | | | | 1 | 1 | | | | | |
| **CO 5** | **2** | | | | | 1 | 1 | | | | | 1 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 25 | 25 | 50 |
| Understand | 15 | 15 | 30 |
| Apply | 10 | 10 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Assignment/Quiz/Course project | : 15 marks |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Define energy management. (K1, PO1, PO6, PO7)

2. List the different phases involved in energy management planning.(K1)

3. State the need for energy audit. (K2, PO1, PO9, PO10, PO12)

**Course Outcome 2 (CO2)**

1. State the different methods which can be adopted to reduce energy consumption in lighting.(K2, PO1, PO6, PO7)

2. Describe how energy consumption can be reduced by energy efficient motors.(K2, PO1, PO6, PO7)

3. Illustrate the different methods used for controlling peak demand.(K2, PO1, PO6, PO7)

**Course Outcome 3 (CO3):**

1. List the energy conservation opportunities in boiler.(K1, PO1)

2. Define Steam trapping.(K1, PO1)

3. Demonstrate how fuel economy measures can be done in furnaces.(K2, PO1, PO6, PO7 )

**Course Outcome 4 (CO4):**

1. Define Coefficient of performance(K1, PO1)

2. Demonstrate how waste heat recovery can be done.(K2, PO1, PO6, PO7)

3. Describe how energy consumption can be reduced by cogeneration.(K2,PO1, PO6, PO7 )

**Course Outcome 5 (CO5):**

1. State the need for economic analysis of energy projects.(K2, PO6, PO7, PO12)

2. Define payback period.(K1, PO12)

3. Demonstrate how life cycle costing approach can be used for comparing energy projects.(K3, PO6, PO7, PO12)

**Model Question paper**

**QP CODE:**

PAGES: 3

Reg. No:______________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**THIRD SEMESTER B.TECH DEGREE EXAMINATION,**

**MONTH & YEAR**

**Course Code: 22EEO703.5**

**Course Name: ENERGY MANAGEMENT**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain what do you mean by energy audit report.
2. Write notes on building management system.
3. Compare the efficacy of different light sources.
4. Write notes on types of industrial loads.
5. Discuss any two opportunities for energy savings in steam distribution.
6. Explain how boiler efficiency can be assessed using direct method.
7. Explain the working of a waste heat recovery system.
8. Write notes on computer aided energy management.
9. What are the advantages and disadvantages of pay back period method.
10. What do you mean by time value of money?

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

## Module 1

| | | |
|---|---|---|
| 11. a. | With the help of case studies, explain any four energy management principles. | 8 |
| b. | Explain the different phases of energy management planning. | 6 |
| 12. a. | Explain in detail the different steps involved in a detailed energy audit. | 7 |
| b. | Discuss the different instruments used for energy audit. | 7 |

## Module 2

| | | |
|---|---|---|
| 13. a. | With the help of case studies, explain any four methods to reduce energy consumption in lighting. | 8 |
| b. | Explain how energy efficient motors help in reducing energy consumption. | 6 |
| 14. a. | With the help of case studies, explain any four methods to reduce energy consumption in motors. | 8 |
| b. | Explain the different methods used for peak demand control. | 6 |

## Module 3

| | | |
|---|---|---|
| 15. a. | Explain any four energy conservation opportunities in furnaces. | 7 |
| b. | What is meant by a steam trap? Explain the operation of the thermostatic steam trap. | 7 |
| 16. a. | Discuss the different energy conservation opportunities in boilers. | 7 |
| b. | Explain in detail, the reasons for low furnace efficiency. | 7 |

## Module 4

| | | |
|---|---|---|
| 17. a. | Explain any five energy saving opportunities in heating, ventilating and air conditioning systems. | 7 |
| b. | Explain the working of different types of cogeneration systems. | 7 |
| 18. a. | Explain the impact of evaporator and condenser temperature on the power consumption of a refrigerator. | 7 |
| b. | Explain the working of any two waste heat recovery devices. | 7 |

## Module 5

19. a. Calculate the energy saving and payback period which can be achieved by replacing a 11 kW, existing motor with an EEM. The capital investment required for EEM is Rs. 40,000/-. Cost of energy/kWh is Rs. 5. The loading is 70% of the rated value for both motors. Efficiency of the existing motor is 81% and that of EEM is 84.7%. 8

b. Compare internal rate of return method with present value method for the selection of energy projects. 6

20. a. Explain how the average rate of return method can be used for the selection of energy projects. 6

b. Compare the following motors based on life cycle costing approach. 8

| | **Motor A** | **Motor B** |
|---|---|---|
| Output rating | 10 kW | 10 kW |
| Conversion efficiency | 80% | 90% |
| Initial cost | Rs. 50000 | Rs. 75000 |
| Replacement life | 5 yrs | 20 yrs |
| Salvage value | Rs. 2500 | Rs. 3000 |
| Annual maintenance and overhead costs | Rs. 1000 | Rs. 1000 |
| Electricity cost | Rs. 5 per kWh | |
| Operating schedule | 8 hrs/day, 22 days/ month | |

## Syllabus

**Module 1 (7 hours)**

**Energy Management - General Principles and Planning:**

General principles of energy management and energy management planning

**Energy Audit:** Definition, need, types and methodologies. Instruments for energy audit, Energy audit report - Power quality audit

Energy conservation in buildings: ECBC code (basic aspects), Building Management System (BMS).

**Module 2 (8 hours)**

**Energy management in Electricity Utilization:**

Energy management opportunities in Lighting and Motors, Electrolytic Process and Electric heating.

Types of industrial loads.

Peak demand controls and methodologies

**Module 3 (8 hours)**

**Energy management in boilers and furnaces:**

Types of boilers, Combustion in boilers, Performances evaluation, Feed water treatment, Blow down, Energy conservation opportunities in boiler.

Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Identifying opportunities for energy savings.

Classification, General fuel economy measures in furnaces, Excess air, Heat Distribution, Temperature control, Draft control.

**Module 4 (6 hours)**

**Energy management in HVAC systems:**

HVAC system: Coefficient of performance, Capacity, Factors affecting Refrigeration and Air conditioning system performance and savings opportunities.

Classification and Advantages of Waste Heat Recovery system, analysis of waste heat recovery for Energy saving opportunities

Cogeneration-Types and Schemes, Optimal operation of cogeneration plants- Case study.

Computer aided energy management

**Module 5 (6 hours)**

**Energy Economics:**

Economic analysis methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, life cycle costing approach, Case studies.

**Reference Books**


1. Albert Thumann, William J. Younger, Handbook of Energy Audits, CRC Press, 2003.

2. Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.

3. Craig B. Smith, Energy management principles, Pergamon Press. 4. D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook, CRC Press, 2007

5. G.G. Rajan, Optimizing energy efficiencies in industry -, Tata McGraw Hill, Pub. Co., 2001.

6. IEEE recommended practice for energy management in industrial and commercial facilities,

7. IEEE std 739 - 1995 (Bronze book).

8. M Jayaraju and Premlet, Introduction to Energy Conservation and Management, Phasor Books, 2008

9. Paul O'Callaghan, Energy management, McGraw Hill Book Co.

10. Wayne C. Turner, Energy management Hand Book - - The Fairmount Press, Inc., 1997.


**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Energy Management - General Principles and Planning; Energy audit (7 hours)** | |
| 1.1 | Energy management; General principles of energy management | 2 |
| 1.2 | Energy management planning | 1 |
| 1.3 | **Energy audit:** Definition, need, types and methodologies. | 2 |
| 1.4 | Instruments for energy audit, Energy audit report<br>Power quality audit | 2 |
| 2 | **Energy management in Electricity Utilization (8 hours)** | |
| 2.1 | Energy management opportunities in Lighting. | 2 |
| 2.2 | Energy management opportunities in Motors. | 2 |
| 2.3 | Electrolytic Process and Electric heating. | 2 |
| 2.4 | Types of Industrial Loads.<br>Peak Demand controls and Methodologies | 2 |
| 3 | **Energy management in boilers and furnaces (8 hours)** | |
| 3.1 | Types of boilers, Combustion in boilers, Performances evaluation, Feed water treatment, Blow down, Energy conservation opportunities in boiler. | 2 |
| 3.2 | Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping | 2 |
| 3.3 | Condensate and flash steam recovery system, Identifying opportunities for energy savings. | 2 |

| | | |
|---|---|---|
| 3.4 | Classification, General fuel economy measures in furnaces, Excess air, Heat Distribution, Temperature control, Draft control, Waste heat recovery. | 2 |
| 4 | **Energy management in HVAC systems (6 hours)** | |
| 4.1 | HVAC system: Coefficient of performance, Capacity | 1 |
| 4.2 | Factors affecting Refrigeration and Air conditioning system performance and savings opportunities. | 1 |
| 4.3 | Classification and Advantages of Waste Heat Recovery system, analysis of waste heat recovery for Energy saving opportunities | 2 |
| 4.4 | Cogeneration-Types and Schemes, Optimal operation of cogeneration plants | 2 |
| 5 | **Energy Economics (6 hours)** | |
| 5.1 | Economic analysis methods | 1 |
| 5.2 | Cash flow model, time value of money, evaluation of proposals | 1 |
| 5.3 | Pay-back method, average rate of return method, internal rate of return method | 2 |
| 5. 4 | Present value method, life cycle costing approach, Case studies. | 2 |

# SEMESTER VIII

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EET801** | **ELECTRICAL SYSTEM DESIGN AND ESTIMATION** | **PCC** | **2** | **1** | **0** | **3** |

**Preamble:** Electrical System Design would provide general awareness on IS Product standards / Codes of Practice, The Electricity Act 2003, CEA Regulations and Rules, NEC etc. related to Domestic, Industrial and Commercial Installations. It will also help in the design of Main and Sub Switchboards and distribution system for a medium class domestic and industrial electrical installations. Design of lighting system and selection of luminaries. Selection of Underground cables, Standby generators, lifts and with all involved auxiliaries. Design and selection of power distribution system with power and motor loads for a medium industry. Electrical system design for High-rise buildings with rising main/ cable distribution to upper floors including fire pumps. Design of indoor and outdoor 11kV substations including selection of switching and protective devices for an HT consumer. Essential safety requirements for the electrical installations for Recreational buildings.

**Prerequisite : Basics of electrical power systems, circuit analysis and fault level calculations.**

**Course Outcomes :** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Explain the rules and regulations in the design of components for medium and high voltage installations. |
| **CO 2** | Design lighting schemes for indoor and outdoor applications. |
| **CO 3** | Design low/medium voltage domestic and industrial electrical installations. |
| **CO 4** | Design, testing and commissioning of 11 kV transformer substation. |
| **CO 5** | Design electrical installations in high rise buildings. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | 2 | - | - | 1 | - | 2 | - | - | - | - |
| **CO 2** | 3 | 2 | 3 | - | - | 1 | 1 | 1 | - | - | - | 1 |
| **CO 3** | 3 | 1 | 3 | - | - | 1 | - | 1 | - | - | - | 1 |
| **CO 4** | 3 | 1 | 3 | - | - | 1 | - | 1 | - | - | 1 | 1 |
| **CO 5** | 3 | 1 | 3 | - | - | 1 | 1 | 1 | - | - | - | 1 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 15 | 15 | 30 |
| Apply (K3) | 25 | 25 | 50 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Case study/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Mention the Scope of The Electricity Act 2003 (K1, K2, PO1)

2. Precautions to be followed for electric safety against loss of life and materials (K3, PO2, PO3, PO6)

3. Mention the Scope of IS 732 (K2, PO8)

**Course Outcome 2 (CO2)**

1. How are the luminaries selected based on the area of application? (K2, PO3, PO3, PO6)

2. What is CRI? (K1, PO1)

3. Parameters taken into consideration while designing street lighting and flood lighting (K3, PO2, PO3, PO7, PO8, PO12)

**Course Outcome 3 (CO3):**

1. Characteristics of MCBs (K1, PO1, PO3)

2. Grading between MCBs (K2, PO2, PO6, PO8)

3. Electrical Schematic and physical layout drawings of switch boards, DBs, lighting fittings, fans etc.(K3, PO2, PO6, PO8, P12)

**Course Outcome 4 (CO4):**

1. Selection of transformer substation. (K1, K2, PO1, PO3)

2. Protective switchgear selection and design of earthing. (K3, PO2, PO6, PO8, PO11)

3. Pre-commission tests to be conducted (K3, PO6, PO12)

**Course Outcome 5 (CO5):**

1. Selection of different electrical components/systems for multi-storeyed buildings (K1, K2, PO1)

2. Fire protection in high rise buildings (K1, K2, PO2, PO6, PO8)

3. The energy conservation techniques (K2, K3, PO2, PO6)

4. PV solar system design (K3, PO3, PO6, PO7, PO12)

5. Functioning of AMF system (K2, PO1)

**Model Question Paper**

PAGES: 3

**QP CODE:**

Reg. No:____________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**FIFTH SEMESTER B. TECH DEGREE EXAMINATION**

**MONTH & YEAR**

Course Code**: 22EET801**

Course Name: **ELECTRICAL SYSTEM DESIGN AND ESTIMATION**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1 Describe the scope of NEC with regard to electrical system design.

2 What are the 3 phase AC system voltages as per NEC and their permissible limits.

3 Explain the specific design considerations in the design of a good lighting scheme.

4 List the different types of lamps suitable for street lighting and give their merits and demerits.

5 What is load survey and explain its importance in electrical system design.

6 Explain the salient aspects considered for the selection of LV/MV cables.

7 Explain the working principle of MCB/MCCB and compare MCB and MCCB.

8 List out the pre-commissioning tests of 11kV indoor substation of an HT consumer and explain any one method.

9 Explain the terms Continuous, Prime and Standby power ratings as applied to a Diesel Generator set.

10 Explain the principle of operation of an AMF panel in an electrical system. What is its necessity in an industry?

## PART B

**Answer any one full question from each module. Each question carries 14 Marks**

### Module 1

What is standardization, how does NEC assist for the electrical system design. (5)

Explain the relevance of the following IS codes: IS 732, IS 3043. (5)

Briefly explain the electrical services in buildings. (4)

Enumerate any five safety measures incorporated in system design. (5)

Draw the standard graphical symbols as given in NEC for:

i) circuit breaker ii) star-delta starter

iii) fuse disconnector iv) autotransformer v) energy meter (5)

Explain the scope of the Electricity Act 2003. (4)

What are the requirements to be satisfied for good road lighting? How are sources selected for road lighting?
(7)

An office room of size 9X15m is to be illuminated by 2x18W LED luminaire. The lamps are being mounted at a height of 3m from the work plane. The average illumination required is 240 lux. Calculate the number of lamps required to be fitted, assuming a CU of 0.75 and a LLF of 0.8. Assume the ceiling height of the room as 5m. Draw the layout of the luminaire arrangement. The lumen output of 2x18W LED may be taken as 4000 lumens. (7)

Briefly explain the working of an LED lamp with circuit diagram. (7)

Design a road way lighting scheme and determine the spacing between the poles using the given lamps. Which alternative you will choose, from the point of energy conservation?

Width of the road way = 12 m

Illumination required = 15lux

Mounting height of poles = 9 m

| Types of Lamps | CU | LLF |
|---|---|---|

Arm length = 2m

| | | |
|---|---|---|
| HPSV - 150 W, 16000 lumen | 0.65 | 0.7 |
| LPSV - 150 W, 25500 lumen | 0.5 | 0.9 |

The lamps are placed on one side of the road. Assume any missing data. (7)

## Module 3

List the pre-commissioning tests for domestic installation and with the help of schematic diagram explain any one test in detail. (4)

Determine the total connected load, number of sub circuits and type of supply for a domestic building with the following rooms: One-bedroom with attached toilet, hall and kitchen (1BHK). Draw the schematic diagram showing the ratings of MCBs and sub circuits. Design shall be based on the NEC guide lines. Assume all required data. (10)

Briey explain the working of ELCB with a neat connection diagram. (4)

## Module 4

Explain the criteria for the design of bus-bar system of a Motor Control Centre (MCC). (4)

An industry consists of the following loads:

a. 7.5 kW, 3 phase cage induction motor – 1 No.
b. 11.2 kW, 3 phase cage induction motor – 2 Nos.
c. 22.5 kW, 3 phase cage induction motor – 1 No.
d. Power sockets – 15Nos.
e. Lighting loads - 40 Nos of 2 x 18 W LED lamps
f. Exhaust fans 100 W - 4 Nos.

Design the electrical system for the industry, if the industry is located in a village, and also determine:

i. Type of industry,
ii. Transformer capacity required and type of substation, and
iii. Draw the single line schematic diagram showing the details of cable size, starters and switch gears. Use a switch board with MCCB/SFU incomer and MCCB/SFU/MCB as outgoing and MCB type distribution board for lighting. (10)

Explain the design procedures of the MSB of an industry with predominantly motor loads. (4)

**Module 5**

Draw the schematic diagram of a 400 A rising main arrangement for a five-storied building also give the rating of floor wise feeders and switchgears. (6)

Briefly explain the sizing of solar PV system for a domestic installation with a daily usage of 5 units. (8)

Draw the electric schematic diagram of a 320 kVA standby DG set with an AMF panel. Explain the essential potential and metering arrangements required in the generator control panel. (6)

Briefly explain the sizing of the battery bank of an off grid solar PV system to cater 3 kWh per day for a domestic installation. (8)

## Syllabus

### Module 1

### IS Product Standards and Codes of practice, The Electricity Act 2003 and NEC 2011 (6 hours):

General awareness of IS Codes - IS 732 - IS 3043 –IS 2026- IS 3646-part 1&2 - IS 5216 part 1&2 - Electricity supply code-2014 (Relevance of each code in electrical installation applications only).

The Electricity Act 2003- General introduction- Distribution of Electricity (Part VI)- Central Electricity Authority (Part IX)- Regulatory Commissions (Part IX).

National Electric Code (NEC 2011) - Scope – Wiring installation (Section 9)- Short circuit calculations (Section 10).

Graphical symbols and signs as per NEC for electrical installations.

Classification of voltages-standards and specifications, tolerances for voltage and frequency.

### Module 2

### Lighting Schemes and calculations (6 hours):

Lighting design calculations - Definitions of luminous flux, Lumen, Luminous intensity/illuminance (Lux), Illumination calculations, factors affecting Coefficients of Utilisation (CoU) - and Light Loss Factor (LLF).

Benefits of LED lamps over the yesteryear luminaires – Efficacy of present-day LED lamps- Design of illumination systems – Average lumen method - Space to mounting height ratio- Design of lighting systems for a medium area seminar hall using LED luminaires

Exterior lighting design- point to point method - road lighting and public area lighting- Space to mounting height ratio - selection of luminaires- Metal Halide- High & Low pressure Sodium– LED lamps.

### Module 3

### Domestic Installation (10 hours)

General aspects as per NEC and IS 732 related to the design of domestic dwellings availing single phase supply (LV) and three phase supply (MV) for a connected load less than 15kW.

Load Survey- common power ratings of domestic gadgets- connected load-diversity factor-selection of number of sub circuits (lighting and power)-selection of MCB distribution boards to provide over load, short circuit and earth leakage protection.

Principle of operation of MCB, MCB Isolator, ELCB/RCCB and RCBO. Selection of CBs for protection and grading between major and minor sections.

Selection of wiring cables, conduits as per NEC and IS 732.

Design of electrical schematic and physical layout drawings for low and medium class domestic installation. Preparation of schedule of works and bill of quantities (cost estimation excluded).

Pre-commissioning tests- Insulation resistance measurement, continuity test, polarity test, and earth resistance measurement as applicable to domestic installations.

**Module 4**
**Industrial Power and Lighting Installations (9 hours):**

Industrial installations –classifications- Design of electrical distribution systems with main switch board, sub switch boards and distribution boards with ACBs, MCCBs and MCBs as the case may be, for feeding power (mainly motors) and lighting loads of small and medium industries.

Selection of armoured power cables (AYFY, A2XFY, YWY) – calculation of ampacity, voltage drop, short circuit withstand capacity etc.

Design of MSB & SSB including Motor Control Centre (MCC) for motor controls - selection of bus bars and switchgears.

Selection of 11kV indoor and outdoor transformer substations upto 630kVA - selection of switchgears and protective devices –Preparation of schedule of works and bill of quantities (cost estimation excluded).

Short circuit calculations and earthing design for the HV and LV sides of an 11 kV substation of capacity up to 630 kVA.

Pre-commissioning tests of 11kV indoor/outdoor substation of an HT consumer.

**Module 5**
**High Rise building, Solar PV system, Standby generators and Energy conservation (8 hours):**

Electrical installations of high-rise buildings: Distribution systems – rising main, cable system - Installation of lifts, standby generators, fire pumps - electric schematic drawing.

Selection of standby Diesel Generator set (DG set) –power rating - Continuous, Prime and Standby power ratings- installation and essential protections-Introduction to Automatic Mains failure (AMF) systems.

Energy Conservation Techniques in electrical power distribution - Automatic Power Factor Correction (APFC) panel – Principle of operation and advantages.

Introduction to Solar PV Systems, off-grid and on-grid systems, Solar panel efficiencies-design of a PV system for domestic application-Selection of battery for off-grid domestic systems.

**Data Book (Use for Examination Hall)**

1. Data Book Published by the University

**Reference Books**


1. National Electrical Code 2011, Bureau of Indian Standards.
2. National Lighting Code 2010, Bureau of Indian Standards.
3. National Building Code of INDIA 2016 - Bureau of Indian Standards.

4. M. K. Giridharan, Electrical Systems Design, I K International Publishers, New Delhi, 2nd edition, 2016.
5. U.A.Bakshi, V.U.Bakshi Electrical Technology, Technical publications, Pune.
6. Narang K.L., A Text Book of Electrical Engineering Drawing, Tech India Publications.
7. J. B. Gupta, A Course in Electrical Installation Estimating and Costing, S.K. Kataria & Sons; Reprint 2013 edition (2013).
8. K. B. Raina, S. K. Bhattacharya, Electrical Design Estimating Costing, NEW AGE; Reprint edition (2010).

**Website**

1. www.price.kerala.gov.in (Reference for module 3 and 4)

**Course Contents and Lecture Schedule:**

| Module | Topic coverage | No. of Lectures |
|---|---|---|
| **1** | **IS Codes, Ats, Rules and NEC (6 hours):** | |
| 1.1 | General awareness of IS Codes - IS 732 - IS 3043 –IS 2026- IS 3646-part 1&2 - IS 5216 part 1&2 - Electricity supply code-2014 (Relevance of each code in electrical installation applications only).<br><br>The Electricity Act 2003- General introduction- Distribution of Electricity (Part VI)- Central Electricity Authority (Part IX)- Regulatory Commissions (Part IX). | 2 |
| 1.2 | National Electric Code (NEC 2011) - Scope – Wiring installation (Section 9)- Short circuit calculations (Section 10). | 2 |
| 1.3 | Graphical symbols and signs as per NEC for electrical installations.<br><br>Classification of voltages-standards and specifications, tolerances for voltage and frequency. | 2 |
| **2** | **Lighting Schemes and calculations (6 hours):** | |
| 2.1 | Lighting design calculations - Definitions of luminous flux, Lumen, Luminous intensity/illuminance (Lux), Illumination calculations, factors affecting Coefficients of Utilisation (CoU) - and Light Loss Factor (LLF). | 2 |
| 2.2 | Benefits of LED lamps over the yesteryear luminaires – Efficacy of present-day LED lamps-Design of illumination systems – Average lumen method - | 2 |

| | | |
|---|---|---|
| | Space to mounting height ratio- Design of lighting systems for a medium area seminar hall using LED luminaires | |
| 2.3 | Exterior lighting design- point to point method - road lighting and public area lighting- Space to mounting height ratio - selection of luminaires- Metal Halide- High & Low pressure Sodium– LED lamps. | 2 |
| **3** | **Domestic Installation (10 hours):** | |
| 3.1 | General aspects as per NEC and IS 732 related to the design of domestic dwellings availing single phase supply (LV) and three phase supply (MV) for a connected load less than 15kW. | 2 |
| 3.2 | Load Survey- common power ratings of domestic gadgets- connected load-diversity factor-selection of number of sub circuits (lighting and power)-selection of MCB distribution boards to provide over load, short circuit and earth leakage protection. | 2 |
| 3.3 | Principle of operation of MCB, MCB Isolator, ELCB/RCCB and RCBO. Selection of CBs for protection and grading between major and minor sections.<br><br>Selection of wiring cables, conduits as per NEC and IS 732. | 2 |
| 3.4 | Design of electrical schematic and physical layout drawings for low and medium class domestic installation. Preparation of schedule of works and bill of quantities (cost estimation excluded).<br><br>Pre-commissioning tests- Insulation resistance measurement, continuity test, polarity test, and earth resistance measurement as applicable to domestic installations. | 4 |
| **4** | **Industrial installations (9 hours):** | |
| 4.1 | Industrial installations –classifications- Design of electrical distribution systems with main switch board, sub switch boards and distribution boards with ACBs, MCCBs and MCBs as the case may be, for feeding power (mainly motors) and lighting loads of small and medium industries.<br><br>Selection of armoured power cables (AYFY, A2XFY, YWY) – calculation of ampacity, voltage drop, short circuit withstand capacity etc. | 3 |

| | | |
|---|---|---|
| 4.2 | Design of MSB & SSB including Motor Control Centre (MCC) for motor controls - selection of bus bars and switchgears. | 2 |
| 4.3 | Selection of 11kV indoor and outdoor transformer substations upto 630kVA - selection of switchgears and protective devices –Preparation of schedule of works and bill of quantities (cost estimation excluded).<br><br>Short circuit calculations and earthing design for the HV and LV sides of an 11 kV substation of capacity up to 630 kVA. | 3 |
| 4.4 | Pre-commissioning tests of 11kV indoor/outdoor substation of an HT consumer. | 1 |
| **5** | **High Rise building, Solar PV system, Standby generators and Energy conservation (8 hours):** | |
| 5.1 | Electrical installations of high-rise buildings: Distribution systems – rising main, cable system - Installation of lifts, standby generators, fire pumps - electric schematic drawing. | 2 |
| 5.2 | Selection of standby Diesel Generator set (DG set) –power rating - Continuous, Prime and Standby power ratings- installation and essential protections-Introduction to Automatic Mains failure (AMF) systems. | 3 |
| 5.3 | Energy Conservation Techniques in electrical power distribution - Automatic Power Factor Correction (APFC) panel – Principle of operation and advantages. | 1 |
| 5.4 | Introduction to Solar PV Systems, off-grid and on-grid systems, Solar panel efficiencies-design of a PV system for domestic application-Selection of battery for off-grid domestic systems. | 2 |

# SEMESTER VIII
# (PROGRAM ELECTIVE III)

| 22EEE802.1 | ROBOTICS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PEC | 2 | 1 | 0 | 3 |

**Preamble** : This course provides an introduction to the robots types, Configurations and application; Coordinate frames and types, Transformations and types; Forward and Inverse Kinematics of manipulator's; all types of robotic sensors; Open loop and closed loop control systems

**Prerequisite:** NIL

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Identify the anatomy and specifications of robots for typical application |
| **CO 2** | Select the appropriate sensors and actuators for robots |
| **CO 3** | Identify robotic configuration and gripper for a particular application |
| **CO 4** | Solve forward and inverse kinematics of robotic manipulators |
| **CO 5** | Plan trajectories in joint space and Cartesian space |
| **CO 6** | Develop the dynamic model of a given robotic manipulator and its control strategy |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 2 | 1 | | | | | | | | | | 2 |
| CO 2 | 2 | 1 | | | | | | | | | | 2 |
| CO 3 | 2 | 1 | 2 | | | | | | | | | 2 |
| CO 4 | 3 | 3 | 3 | | | | | | | | | 2 |
| CO 5 | 3 | 3 | 3 | | | | | | | | | 2 |
| CO 6 | 3 | 3 | 3 | | | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand | 20 | 20 | 40 |
| Apply | 20 | 20 | 40 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

**Course Level Assessment Questions**

Course Outcome 1 (CO1):

1. Explain the anatomy of a robot which is used for pick and place tasks. (K2, PO1, PO12)

2. What are the specifications of a typical spray painting robot? (DOF, specialties, control method etc.) (K1, PO2, PO12)
3. Which control method is used for a spot welding robot? (Continuous path control or point to point control) (K2, PO2, PO12)

Course Outcome 2 (CO2):

1. Choose a sensor as per robotic application.(K2, PO1, PO12)
2. Describe the functional differences of stepper motors and ac motors.(K1, PO1, PO12)
3. Pneumatic actuators are not suitable for heavy loads under precise control. Justify it.(K2, PO1, PO2, PO12)

Course Outcome 3 (CO3):

1. Explain the features of SCARA, PUMA Robots?(K1, PO1, PO12)
2. What are the different classification of robots based on motion control methods and drive technologies? Explain(K1, PO1, PO2, PO12)
3. What are the factors affecting the selection of grippers?(K1, PO1, PO3, PO12)

Course Outcome 4 (CO4):

1. What do you mean by forward kinematics?(K1, PO1, PO2, PO12)
2. Explain the inverse kinematics of robots.(K1, PO1, PO3, PO12)
3. What are the different coordinate systems used by industrial robots?(K1, PO1, PO3, PO12)

Course Outcome 5 (CO5):

1. Explain about planning the trajectory in Cartesian space and Joint space for robotic manipulators.(K1, PO1, PO2, PO12)
2. Explain about the third order polynomial trajectory planning in Joint space.(K1, PO1, PO2, PO12)
3. A two-degree-of-freedom planar robot is to follow a straight line in Cartesian space between the start (2,6) and the end (12,3) points of the motion segment. Find the joint variables for the robot if the path is divided into 10 segments. Each link is 9 inches long.(K2, PO1, PO3, PO12)

Course Outcome 6 (CO6):

1. Obtain the dynamic model of 1 DOF robot.(K2, PO1, PO2, PO12)
2. Explain the steps to design a PID controller for a single link manipulator.(K2, PO1, PO3, PO12)
3. Write short note on computed torque control.(K1, PO1, PO2, PO12)

**Model question paper**

## TKM COLLEGE OF ENGINEERING

## EIGHTH SEMESTER B.TECH. DEGREE EXAMINATION

**Course Code: 22EEE802.1**

**Course Name: ROBOTICS**

Max. Marks: 100 Duration: 3 Hours

PART A

| | *Answer all questions, each carries 3 marks.* | Marks |
|---|---|---|
| 1 | Define reach and stroke of a robotic manipulator. | (3 ) |
| 2 | What are the characteristics of a spot welding robot? | (3 ) |
| 3 | A strain gauge of gauge factor 2 and resistance of the unreformed wire 100 Ω is used to measure the acceleration of an object of mass 3kg. If the strain is $10^{-6}$, cross sectional area=10mm$^2$ and Young's modulus =6.9 x $10^{-10}$ N/m$^2$, compute the acceleration of the object. | (3 ) |
| 4 | Compare hydraulic and pneumatic actuators. | ( 3) |
| 5 | Explain the features of a SCARA robot. | ( 3) |
| 6 | What are the advantages and disadvantages of a pneumatic gripper? | ( 3) |
| 7 | If a point $P = [3\ 0\ -1\ 1\ ]^T$, find the new location of the point P, if it is rotated by π about the z-axis of the fixed frame and then translated by 3 units along the y-axis. | (3) |
| 8 | How will you compute the end effector position and orientation of a robotic arm? | (3) |
| 9 | What is the necessity of dynamic modelling of robotic manipulators? | (3) |
| 10 | Is a robotic system linear or nonlinear? Justify your answer. | (3) |

## PART B

*Answer any one full question from each module, each carries 14 marks.*

### MODULE1

| | | | |
|---|---|---|---|
| 11 | a) | Explain in detail the specifications of a robotic manipulator. | (10) |
| | b) | What is the typical anatomy of a robotic manipulator? | (8) |
| 12 | a) | Explain in detail any two industrial applications of Robots. | (10) |
| | b) | Compare point to point control and continuous path control. | (4) |

### MODULE II

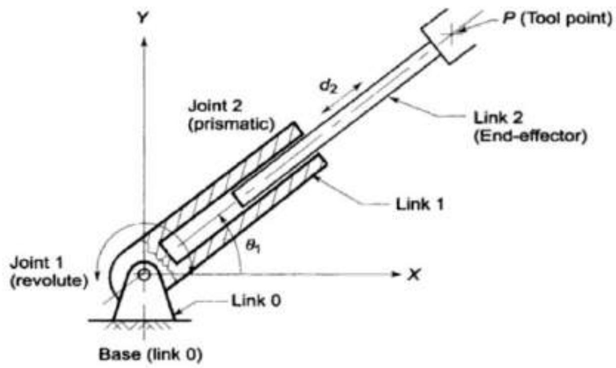
| | | | |
|---|---|---|---|
| 13 | a) | How will you choose an appropriate sensor for a robotic application? | (8 ) |
| | b) | Mention the applications of vision sensor | (6) |
| 14 | a) | Outline the method of varying position using servo motor and stepper motor. | (8) |
| | b) | Explain the working of a typical hydraulic actuator. | (6) |

### MODULE III

| | | | |
|---|---|---|---|
| 15 | a) | Explain in detail all robotic configurations. | (14) |
| 16 | a) | Describe the types of end effector & gripper mechanisms with simple sketches | (14) |

### MODULE IV

| | | | |
|---|---|---|---|
| 17 | a) | Obtain the forward kinematic model of the following robot | (14) |




18 a) The second joint of a SCARA robot has to move from $15^0$ to $45^0$ in 3 sec. Find the coefficients of the cubic polynomial to interpolate a smooth trajectory. Also obtain the position, velocity and acceleration profiles (8)

b) How will you plan a straight line trajectory in Cartesian space? (6)

## MODULE V

19 a) Obtain the dynamic model of 1 DOF robot operated by electric motor. (8)

b) How will you build a servo controlled robotic arm? (6)

20 a) Describe the schematic of PID controlled robotic manipulator and derive the closed loop transfer function. Explain how gains are computed for the PID controller? (10)

b) Comment on the stability of the above controller (4)

*********************

## SYLLABUS

### Module 1

Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot considerations for an application- number of axes, work volume, capacity & speed, stroke & reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control.

Robot Applications- medical, mining, space, defence, security, domestic, entertainment, Industrial Applications-Material handling, welding, Spray painting, Machining.

**Case study**- anatomy and specifications of a typical material handling robot

### Module 2

**Sensors and Actuators**

Sensor classification- Touch, force, proximity, vision sensors.

Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors; External sensors-contact type, non-contact type; Vision - Elements of vision sensor, image acquisition, image processing; Selection of sensors.

Actuators for robots- classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors; Hydraulic actuators- Components and typical circuit, advantages and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages and disadvantages.

**Case study**- sensors and actuators needed for a differential drive robot which is capable of autonomous navigation, study of sensors and actuators for an autonomous pick and place robot

### Module 3

**Robotic configurations and end effectors**

Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist;

Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, factors affecting selection of grippers.

**Case study-** typical robotic configuration for a pick and place robot capable picking objects from a moving conveyor

### Module 4

**Kinematics and Motion Planning**

Robot Coordinate Systems- Fundamental and composite rotations, homogeneous coordinates and transformations, Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward and inverse Kinematics of typical robots upto 3 DOF.

Motion Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.

**Case study**- Obtain the joint profiles of a 2 DOF planar manipulator, if the end effector is moving through an arc.

**Module 5**

**Dynamics and Control of Robots**

Dynamics- Dynamic model of a robot using Lagrange's equation, dynamic modelling of 1 DOF robot.

Control Techniques- Transfer function and state space representation, Performance and stability of feedback control, PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques, Computed torque control.

**Case study**: Closed loop PID control a typical 2 DOF planar robotic manipulator

**Case Studies/Assignments: Any of the three case studies can be given as assignments.**

**Text Books**


1. Introduction to Robotics by S K Saha, Mc Graw Hill Eduaction
2. Robert. J. Schilling, "Fundamentals of robotics – Analysis and control", Prentice Hall of India 1996.
3. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi, 2003.
4. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
5. Ashitava Ghosal, "Robotics-Fundamental concepts and analysis", Oxford University press.
6. Robotics Technology and Flexible Automation, Second Edition, S. R. Deb.
7. Introduction to Robotics, Saeed B. Nikku, Pearson Education, 2001.
8. Rachid Manseur, 'Robot Modeling and Kinematics', Lakshmi publications, 2009.

**Reference Books**

1. D Roy Choudhury and shaail B. jain, ‘Linear Integrated circuits’, New age international Pvt.Ltd 2003

2. Boltans w. ”Mechatronics” Pearson Education , 2009

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction** | |
| 1.1 | Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; | 1 |
| 1.2 | Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; | 1 |
| 1.3 | Robot considerations for an application- number of axes, work volume, capacity & speed, stroke & reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control. | 1 |
| 1.4 | Robot Applications- medical, mining, space, defence, security, domestic, entertainment | 1 |
| 1.5 | Industrial Applications-Material handling, welding, Spray painting, Machining. | 1 |
| **2** | **Sensors and Actuators** | |
| 2.1 | Sensor classification- touch, force, proximity, vision sensors | 1 |
| 2.2 | Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors; | 1 |
| 2.3 | External sensors-contact type, non-contact type; | 1 |
| 2.4 | Vision-Elements of vision sensor, image acquisition, image processing; Selection of sensors. | 1 |

| | | |
|---|---|---|
| 2.5 | Actuators for robots- classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors; | 2 |
| 2.6 | Hydraulic actuators- Components and typical circuit, advantages and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages and disadvantages. | 2 |
| **3** | **Robotic configurations and end effectors** | |
| 3.1 | Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots | 2 |
| 3.2 | Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist; | 2 |
| 3.3 | Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, factors affecting selection of grippers. | 3 |
| **4** | **Kinematics and Motion Planning** | |
| 4.1 | Robot Coordinate Systems- Fundamental and composite rotations, homogeneous coordinates and transformations. | 2 |
| 4.2 | Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward Kinematic analysis of a typical robots up to 3 DOF. | 4 |
| 4.3 | Motion Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning. | 2 |
| **5** | **Dynamics and Control of Robots** | |
| 5.1 | Dynamics- Dynamic model of a robot using Lagrange’s equation,  dynamic modelling of 1 DOF robot | 2 |
| 5.2 | Control Techniques- Transfer function and state space representation, Performance and stability of feedback control. | 3 |

| | | |
|---|---|---|
| 5.3 | PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques, Computed torque control. | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | Credits |
|---|---|---|---|---|---|---|
| **22EEE802.2** | **Energy Management** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble: This course introduces basic knowledge about energy management and audit. Energy management opportunities in electrical and mechanical systems are discussed. Demand side management and ancillary services are explained. Economic analysis of energy conservation measures are also described.**

**Prerequisite: Nil**

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | **Analyse the significance of energy management and auditing.** |
| **CO 2** | **Discuss the energy efficiency and management of electrical loads.** |
| **CO 3** | **Apply demand side management techniques.** |
| **CO 4** | **Explain the energy management opportunities in industries.** |
| **CO 5** | **Compute the economic feasibility of the energy conservation measures.** |

Mapping of course outcomes with program outcomes

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | **2** | | | | | 1 | 1 | | 1 | | | |
| **CO 2** | **2** | | 1 | 1 | | 1 | 1 | | | | | |
| **CO 3** | **2** | | 1 | 1 | | 1 | 1 | | | | | |
| **CO 4** | **2** | | 1 | 1 | | 1 | 1 | | | | | |
| **CO 5** | **2** | | | | | | | | | | 2 | |

Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 15 | 15 | 30 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 15 | 15 | 30 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Define energy management. (K1, PO1, PO6, PO7)

2. List the different phases involved in energy management planning. (K1, PO1, PO6, PO7)

3. State the need for energy audit. (K2, PO1, PO6, PO7, PO9)

**Course Outcome 2 (CO2)**

1. State the different methods which can be adopted to reduce energy consumption in lighting. (K2, PO1, PO3, PO4)

2. Describe how energy consumption can be reduced by energy efficient motors. (K2, PO1, PO3, PO4, PO6, PO7)

3. Discuss the maximum efficiency standards for distribution transformers. (K1, PO1, PO3, PO4, PO6, PO7)

**Course Outcome 3 (CO3):**

1. Discuss the different techniques of DSM. (K2, PO1, PO3, PO4)

2. Illustrate the different techniques used for peak load management. (K2, PO1, PO3, PO4, PO6, PO7)

3. Explain the different types of ancillary services. (K2, PO1, PO3, PO4)

**Course Outcome 4 (CO4):**

1. Define Coefficient of performance. (K1, PO1)

2. Demonstrate how waste heat recovery can be done. (K2, PO1, PO3, PO4, PO6, PO7)

3. Describe how energy consumption can be reduced by cogeneration. (K3, PO1, PO3, PO4, PO6, PO7)

**Course Outcome 5 (CO5):**

1. State the need for economic analysis of energy projects. (K2, PO1, PO11)

2. Define pay back period. (K2, PO1, PO11)

3. Demonstrate how life cycle costing approach can be used for comparing energy projects. (K3, PO1, PO11)

**Model Question paper**

**QP CODE:**

PAGES: 3

Reg. No:_______________

Name:_______________

**TKM COLLEGE OF ENGINEERING**
**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,**
**MONTH & YEAR**

**Course Code: 22EEE802.2**

**Course Name: ENERGY MANAGEMENT**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all questions. Each question carries 3 Marks**

1. Explain what you mean by power quality audit.
2. Write notes on building management systems.
3. Compare the efficacy of different light sources.
4. Write notes on design measures for increasing efficiency in transformers.
5. Discuss the benefits of demand side management.
6. Explain the benefits of power factor improvement.
7. Discuss any two opportunities for energy savings in steam distribution.
8. Explain the working of a waste heat recovery system.
9. What are the advantages and disadvantages of the payback period method?
10. Write notes on computer aided energy management systems.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 marks**

**Module 1**

| | | | |
|---|---|---|---|
| 11. | a. | With the help of case studies, explain any four energy management principles. | 8 |
| | b. | Explain the different phases of energy management planning. | 6 |
| 12. | a. | Explain the different steps involved in a detailed energy audit. | 7 |
| | b. | Discuss the different instruments used for energy audit. | 7 |

**Module 2**

| | | | |
|---|---|---|---|
| 13. | a. | With the help of case studies, explain any four methods to reduce energy consumption in lighting. | 8 |
| | b. | Explain how energy efficient motors help in reducing energy consumption. | 6 |
| 14. | a. | With the help of case studies, explain any four methods to reduce energy consumption in motors. | 8 |
| | b. | Define cascade efficiency of an electrical system. How it can be calculated? | 6 |

**Module 3**

| | | | |
|---|---|---|---|
| 15. | a. | Explain the different techniques of demand side management. | 6 |
| | b. | The load on an installation is 800 kW, 0·8 lagging p.f. which works for 3000hours per annum. The tariff is Rs 100 per kVA plus 20 paise per kWh. If the power factor is improved to 0·9 lagging by means of loss-free capacitors costing Rs 60 per kVAR, calculate the annual saving effected. Allow 10% per annum for interest and depreciation on capacitors. | 8 |
| 16. | a. | Discuss the importance of peak demand control. Explain the different methods used for that. | 8 |
| | b. | Explain the different types of ancillary services. | 6 |

## Module 4

17. a. Explain any four energy conservation opportunities in furnaces 7

b. Explain the working of different types of cogeneration systems. 7

18. a. Discuss the different energy conservation opportunities in boiler. 7

b. Explain any five energy saving opportunities in heating, ventilating and air conditioning systems. 7

## Module 5

19. a. Calculate the energy saving and payback period which can be achieved by replacing a 11 kW, existing motor with an EEM. The capital investment required for EEM is Rs. 40,000/-. Cost of energy/kWh is Rs. 5. The loading is 70% of the rated value for both motors. Efficiency of the existing motor is 81% and that of EEM is 84.7%. 8

b. Compare internal rate of return method with present value method for the selection of energy projects. 6

20. a. Explain how the life cycle costing approach can be used for the selection of energy projects. 6

b. The cash flow of an energy saving project with a capital investment cost of Rs. 20,000/- is given in the table below. Find the NPV of the project at a discount rate of 10%. Also find the Internal Rate of Return of the project. 8

| **Year** | **Cash flow** |
|---|---|
| 1 | 7000 |
| 2 | 7000 |
| 3 | 7000 |
| 4 | 7000 |
| 5 | 7000 |
| 6 | 7000 |

## Syllabus

**Module 1 (7 hours)**

**Energy Management - General Principles and Planning:**

General principles of energy management and energy management planning

**Energy Audit:** Definition, need, types and methodologies. Instruments for energy audit, Energy audit report - Power quality audit

Energy conservation in buildings: ECBC code (basic aspects), Building Management System (BMS).

**Module 2 (9 hours)**

**Energy Efficiency in Electricity Utilization:**

Electricity transmission and distribution system, cascade efficiency.

Lighting: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation.

Motors: Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads.

Transformers: Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components.

**Module 3 (8 hours)**

**Demand side Management:** Introduction to DSM, benefits of DSM, different techniques of DSM –time of day pricing, multi-utility power exchange model, time of day models for planning.

Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment.

Power factor improvement, numerical examples.

DSM and Environment.

**Ancillary services:** Introduction of ancillary services – Types of Ancillary services

**Module 4 (6 hours)**

**Energy Management in Industries and Commercial Establishments:**

Boilers: working principle - blow down, energy conservation opportunities in boiler.

Steam: properties of steam, distribution losses, steam trapping. Identifying opportunities for energy savings in steam distribution.

Furnace: General fuel economy measures, energy conservation opportunities in furnaces.

HVAC system: Performance and saving opportunities in Refrigeration and Air conditioning systems.

**Heat Recovery Systems:**

Waste heat recovery system - Energy saving opportunities.

Cogeneration: Types and schemes, optimal operation of cogeneration plants, combined cycle electricity generation.

**Module 5 (6 hours)**

**Energy Economics:**

Economic analysis: methods, cash flow model, time value of money, evaluation of proposals, pay-back period, average rate of return method, internal rate of return method, present value method, life cycle costing approach. Computer aided Energy Management Systems (EMS).

**Reference Books**

1. Energy Conservation Act – 2001 and Related Rules and Standards.
2. Publications of Bureau of Energy Efficiency (BEE).
3. Albert Thumann, William J. Younger, Handbook of Energy Audits, CRC Press, 2003.
4. IEEE recommended practice for energy management in industrial and commercial facilities
5. D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook, CRC Press, 2007
6. Operation of restructured power systems Kankar Bhattacharya, Jaap E. Daadler, Math H.J Bollen, Kluwer Academic Pub., 2001.
7. Wayne C. Turner, Energy management Hand Book - the Fairmount Press, Inc., 1997
8. Charles M. Gottschalk, Industrial energy conservation, John Wiley & Sons, 1996.

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Energy Management - General Principles and Planning; Energy audit (7 hours)** | |
| 1.1 | Energy management; General principles of energy management | 2 |
| 1.2 | Energy management planning | 1 |
| 1.3 | **Energy audit:** Definition, need, types and methodologies. | 2 |
| 1.4 | Instruments for energy audit, Energy audit report. Power quality audit | 1 |
| 1.5 | ECBC code (basic aspects), Building Management System (BMS). | 1 |
| 2 | **Energy management in Electricity Utilization (8 hours)** | |
| 2.1 | Electricity transmission and distribution system, cascade efficiency. | 1 |
| 2.2 | Energy management opportunities in Lighting: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting, use of sensors and lighting automation. | 2 |
| 2.3 | Energy management opportunities in Motors: Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads. | 2 |
| 2.4 | Transformers: Present maximum efficiency standards for power and distribution transformers, design measures for increasing efficiency in electrical system components. | 3 |
| 3 | **Demand side Management and Ancillary service management:(8 hours)** | |
| 3.1 | Introduction to DSM, benefits of DSM, different techniques of DSM, DSM and Environment. | 2 |

| | | |
|---|---|---|
| 3.2 | Time of day pricing, multi-utility power exchange model, time of day models for planning. | 2 |
| 3.3 | Load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment. | 2 |
| 3.4 | Power factor improvement, simple problems. | 1 |
| 3.5 | Introduction of ancillary services – Types of Ancillary services | 1 |
| 4 | **Energy Management in Industries and Commercial Establishments (6 hours):** | |
| 4.1 | Boilers: working principle - blow down, energy conservation opportunities in boiler. | 1 |
| 4.2 | Steam: properties of steam, distribution losses, steam trapping. identifying opportunities for energy savings in steam distribution. | 1 |
| 4.3 | Furnace: General fuel economy measures, energy conservation opportunities in furnaces. | 1 |
| 4.4 | Performance and saving opportunities in Refrigeration and Air conditioning systems. | 2 |
| 4.5 | Waste heat recovery system - Energy saving opportunities.<br>Cogeneration: types and schemes, optimal operation of cogeneration plants, combined cycle electricity generation. | 1 |
| 5 | **Energy Economics (6 hours)** | |
| 5.1 | Economic analysis methods | 1 |
| 5.2 | Cash flow model, time value of money, evaluation of proposals | 1 |
| 5.3 | Pay-back method, average rate of return method, internal rate of return method | 2 |
| 5. 4 | Present value method, life cycle costing approach. | 1 |
| 5.4 | Computer aided Energy Management Systems (EMS). | 1 |

| 22EEE802.3 | SMART GRID TECHNOLOGIES | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PEC | 2 | 1 | 0 | 3 |

**Preamble:** This course introduces various advancements in the area of smart grid. It also introduces distributed energy resources and micro-grid. In addition, cloud computing, cyber security and power quality issues in smart grids are also introduced.

**Prerequisite:** Nil

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the basic concept of distributed energy resources, micro-grid and smart grid |
| **CO 2** | Choose appropriate Information and Communication Technology (ICT) in smart grid |
| **CO 3** | Select infrastructure and technologies for consumer domain of smart grid |
| **CO 4** | Select infrastructure and technologies for smart substation and distribution automation |
| **CO 5** | Formulate cloud computing infrastructure for smart grid considering cyber security |
| **CO 6** | Categorize power quality issues and appraise it in smart grid context |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | | | | | | | | | | |
| **CO 2** | 3 | 3 | 3 | 3 | 2 | | | | | | | |
| **CO 3** | 3 | 3 | 3 | 3 | 2 | | | | | | | |
| **CO 4** | 3 | 3 | 3 | 3 | | | | | | | | |
| **CO 5** | 3 | 3 | 3 | 3 | 3 | | | | | | | |
| **CO 6** | 3 | 3 | 3 | 3 | 3 | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 30 | 30 | 60 |
| Apply (K3) | 10 | 10 | 20 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum of 2 subdivisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1)**

1. Explain the drivers, functions, opportunities, barriers, challenges, technologies and standards of smart grid (K2, PO1)
2. Explain the basic concept of distributed energy resources and their grid integration. (K2, PO1, PO2)
3. Explain the basic concept of microgrid. (K1, PO1)

**Course Outcome 2 (CO2)**

1. Choose appropriate communication technology for smart grid. (K3, PO1, PO2, PO3, PO4, PO5)
2. Explain the communication protocols and standards in Smart grid. (K2, PO1)

**Course Outcome 3 (CO3)**

1. Explain the features and merits of Smart Meters, for smart grid implementation. (K2, PO1, PO2, PO3)
2. Explain the role of real time pricing in smart grid. (K3, PO1, PO2, PO3)
3. Describe the concept and role of AMR and AMI in smart grid. (K2, PO1, PO2)
4. Choose various end use devices and explain their role in Home & Building Automation. (K3, PO1, PO2, PO3, PO4, PO5)
5. Explain the various methods for energy management and role of technology for its implementation. (K3, PO1, PO2, PO3, PO4, PO5)

**Course Outcome 4 (CO4)**

1. Explain the concept of smart substation. (K1, PO1)
2. Describe the functionalities and applications of IED in substation and distribution automation. (K2, PO1, PO2, PO3, PO4)

3. Explain the architecture components and applications of Wide Area Monitoring Systems. (K3, PO1, PO2, PO3)
4. Explain the role of PMU in WAMS. (K2, PO1, PO2,)
5. Explain the role of various application modules in distribution automation. (K2, PO1, PO2, PO3)

**Course Outcome 5 (CO5)**

1. Classify cloud computing based on its deployment and services. (K2, PO1)
2. Design cloud architecture of smart grid. (K3, PO1, PO2, PO3, PO4, PO5)
3. Explain the challenges and solutions related to cyber security in smart grid. (K2, PO1, PO2, PO3, PO4, PO5)

**Course Outcome 6 (CO6)**

1. Explain the power quality issues in smart grid. (K2, PO1, PO2)
2. Choose technologies for the mitigation of power quality issues in the smart grid. (K3, PO1, PO2, PO3, PO4, PO5)

Model Question Paper

QP CODE: Pages:

Reg No.:_______________

Name:_________________

TKM COLLEGE OF ENGINEERINGEIGHTH SEMESTER

B.TECH DEGREE EXAMINATION,

MONTH & YEAR

**Course code: 22EEE802.3**

**Course Name: SMART GRID TECHNOLOGIES (E)**

**Max. Marks: 100** **Duration: 3hrs**

**PART A**

(Answer all questions. Each question carries 3 marks)

1. Define smart grid concept and explain its necessity.
2. Explain the concept of resilient and self-healing grid.
3. Write a note on ZIGBEE.
4. Discuss 61850 standard and its benefits.
5. Explain how automatic meter reading can make the system smarter.
6. What is meant by real time pricing?
7. Describe substation automation.
8. Explain outage management system.
9. Explain the necessity of cyber security in smart grid
10. Write a note on power quality conditioners in smart grid.

**PART B**

11. (a) With the help of block diagram explain the architecture of smart grid (7)

 (b) What are the challenges of smart grid technology? (7)

OR

12. (a)Explain smart grid drivers (6)

 (b)What are the functions of smart grid components (8)

13. (a) Explain the various communication protocols used in smart grid. (7)

(b) Write a note on Wi-Max based communication in smart grid. (7)

OR

14. (a) Write a note on various mobile communication technologies used in smart grid. (7)

(b) Explain the role of HAN in smart grid. (7)

15. (a) Explain plug in electric vehicles (7)

(b) Explain the role of phasor measurement unit in smart grid (7)

**OR**

16. (a) What are the advantages of smart meters? (5)

(b) What are IEDs? What are their application in monitoring and protection (9)

17. (a) With the help of block diagram explain the main features of smart substation (10)

(b) Explain GIS (4)

OR

18. (a) Explain demand side ancillary services. (7)

(b) Write a note on smart inverters. (7)

19. (a) Describe cloud architecture of smart grid. (7)

(b) Explain the role of EMC in the smart grid. (7)

**OR**

20. (a)Why is cyber security of prime importance in smart grid and how can it be achieved? (7)

(b) Describe the power quality issues of grid connected renewable energy source (7)

**Syllabus**

**Module 1 Introduction to Smart Grid**: Evolution of electric grid, Definitions, Need for smart grid, Smart grid drivers, Functions of smart grid, Opportunities and barriers of smart grid, Difference between conventional grid and smart grid, Concept of resilient and self- healing grid.

Components and architecture, Inter-operability, Impacts of smart grid on system reliability, Present development and international policies in smart grid, Smart grid standards.

**Module 2 Information and Communication Technology in Smart Grid**: Wired and wireless communication -radio mesh, ZIGBEE, 3G, 4G and 5G. Digital PLC, DSL, Wi-Max, LAN, NAN, HAN, Wi-Fi, Bluetooth, Bluetooth Low Energy (BLE), Li-Fi.
Communication Protocols in Smart grid, Introduction to IEC 61850 standard and benefits, IEC Generic Object-Oriented Substation Event - GOOSE, Substation model.

**Module 3 Smart grid Technologies Part I:** Introduction to smart meters, Electricity tariff, Real Time Pricing- Automatic Meter Reading (AMR) - System, Services and Functions, Components of AMR Systems, Advanced Metering Infrastructure (AMI).

Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid (V2G), Grid to Vehicle (G2V), Smart Sensors, Smart energy efficient end use devices, Home & Building Automation.

Intelligent Electronic Devices (IED) and their application for monitoring & protection: Digital Fault Recorder (DFR), Digital Protective Relay (DPR), Circuit Breaker Monitor (CBM), Phasor Measurement Unit (PMU), Standards for PMU. Time synchronization techniques, Wide Area Monitoring System (WAMS), control and protection systems (Architecture, components of WAMS, and applications: Voltage stability assessment, frequency stability assessment, power oscillation assessment, communication needs of WAMS, remedial action scheme).

**Module 4 Smart grid Technologies Part II**: Smart substations, Substation automation, Feeder automation, Fault detection, Isolation, and Service Restoration (FDISR), Geographic Information System (GIS), Outage Management System (OMS).
Introduction to Smart distributed energy resources and their grid integration,Smart inverters,Concepts of microgrid, Need and application of microgrid – Energy Management- Role of technology in demand response- Demand side management, Demand side Ancillary Services, Dynamic line rating.

**Module 5 Cloud computing in smart grid**: Private, Public and hybrid cloud. Types of cloud computing services- Software as a Service (SaaS), Platform as a service (PaaS), Infrastructure as a service (IaaS), Data as a service (DaaS), Cloud architecture for smart grid.
**Cyber Security -** Cyber security challenges and solutions in smart grid**,** Cyber security risk assessment, Security index computation.
**Power Quality Management in Smart Grid**- Fundamentals, Power Quality (PQ) & Electromagnetic Compatibility (EMC) in smart grid, Power quality conditioners for smart grid.
Case study of smart grid.

**Reference Books**


1. **Stuart Borlase** "Smart Grid Infrastructure Technology and Solutions", CRC Press; 2nd edition.
2. **James Momoh**, "Smart Grid: Fundamentals of Design and Analysis", Wiley, 2012.
3. **S. Chowdhury**, "Microgrids and Active Distribution Networks." Institution of Engineering and Technology, 2009.
4. **Janaka Ekanayake, Kythira Liyanage, Jianzhong Wu, Akihiko Yokohama, Nick Jenkins**- "Smart Grids Technology and Applications", Wiley, 2012.
5. **Clark W.Gellings,** "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press.
6. **Jean Claude Sabonnadière, Nouredine Hadjsaïd,** "Smart Grids", Wiley Blackwell.
7. **James Larminie, John Lowry**, Electric Vehicle Technology Explained, Wiley, 2003.
8. **Chris Mi, M. AbulMasrur, David WenzhongGao**, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2011, Wiley publication.
9. **Danda B. Rawat; Chandra Bajracharya,** Cyber security for smart grid systems: Status, challenges and perspectives IEEE SoutheastCon 2015, DOI: 10.1109/SECON.2015.7132891.
10. **Pillitteri, V. and Brewer, T. (2014),** Guidelines for Smart Grid Cybersecurity, NIST Interagency/Internal Report (NISTIR), National Institute of Standards and Technology, Gaithersburg, MD, [online], https://doi.org/10.6028/NIST.IR.7628r1.
11. **Barker, Preston, Price, Rudy F**., "Cybersecurity for the Electric Smart Grid: Elements and Considerations", Nova Science Publishers Inc, 2012.
12. **Eric D. Knapp, Raj Samani, "**Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure", Syngress; 1st edition (26 February 2013).
13. **Richard J. Campbell, "**The Smart Grid and Cybersecurity: Regulatory Policy and Issues", Congressional Research Service, 2011.
14. **Dariusz Kloza, Vagelis Papakonstantinou, Sanjay Goel, Yuan Hong**, "Smart grid security", Springer.
15. **Roger C. Dugan**, "Electrical Power Systems Quality", McGraw-Hill Publication, 3/e.
16. **G.T.Heydt**, "Electric Power Quality", Stars in a Circle Publications, 2/e.


**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction to Smart Grid**: | (7) |
| 1.1 | Evolution of electric grid, definitions need for smart grid, smart grid drivers, functions of smart grid, opportunities and barriers of smart grid, difference between conventional grid and smart grid, concept of resilient and self- healing grid | 3 |
| 1.2 | Components and architecture, inter-operability, impacts of Smart Grid on system reliability | 2 |
| 1.3 | Present development and international policies in smart grid. smart grid standards. | 2 |
| 2 | **Information and Communication Technology in Smart Grid**: | (8) |
| 2.1 | Wired and wireless communication -radio mesh, ZIGBEE, 3G, 4G and 5G, digital PLC, DSL, Wi-Max, LAN, NAN, HAN, Wi-Fi, bluetooth, Bluetooth Low Energy (BLE), Light-Fi, substation event - GOOSE, IEC 61850 substation model | 4 |

| | | |
|---|---|---|
| 2.2 | Communication protocols in smart grid, introduction to IEC 61850 standard and benefits, IEC Generic Object-Oriented Substation Event - GOOSE. | 2 |
| 2.3 | IEC 61850 ,Substation model | 2 |
| 3 | **Smart grid Technologies Part I** | **( 7)** |
| 3.1 | Introduction to smart meters, electricity tariff, real time pricing-Automatic Meter Reading (AMR) System, services and functions, components of AMR systems, Advanced Metering Infrastructure (AMI) | 2 |
| 3.2 | Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Grid to Vehicle. | 1 |
| 3.3 | Smart sensors, smart energy efficient end use devices, home & building automation, Intelligent Electronic Devices (IED) and their application for monitoring & protection, DFRA, DPRA, CBMA | 1 |
| 3.4 | Phasor Measurement Unit (PMU), standard for PMU. time synchronization techniques, Wide Area Monitoring, control and protection systems - architecture, components of WAMS, and applications: voltage stability assessment, frequency stability assessment, power oscillation assessment, communication needs of WAMS, remedial action scheme. | 3 |
| 4. | **Smart grid Technologies Part II** | **(7)** |
| 4.1 | Smart substations, substation automation, feeder automation, fault detection, isolation, and service restoration, Geographic Information System (GIS), Outage Management System (OMS). | 2 |
| 4.2 | Introduction to smart distributed energy resources and their grid integration, smart inverters. | 2 |
| 4.3 | Concepts of micro grid, need & application of micro grid – Energy Management-Role of technology in demand response- Demand Side Management, Demand Side Ancillary Services, Dynamic Line rating. | 3 |
| 5 | **Cloud computing in smart grid**: | **( 8)** |
| 5.1 | Public and hybrid cloud, cloud architecture of smart grid, types of cloud computing services- IaaS, SaaS, PaaS, DaaS. | 2 |
| 5.2 | **Cyber Security -** Cyber security challenges and solutions in smart grid**,** cyber security risk assessment, security index computation . | 2 |
| 5.3 | **Power Quality Management in Smart Grid-** Fundamentals, power quality & EMC in Smart Grid. | 2 |
| 5.4 | Power quality conditioners for smart grid -case study of smart grid | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEE802.4** | **ELECTRICAL MACHINE DESIGN** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble:** This course provides an introduction to the design of DC and AC machines and gives a general idea to the computer aided design of electrical machines.

**Prerequisite:** 1. EET202 DC Machines and Transformers

2. EET307 Synchronous and Induction Machines

**Course Outcomes:** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO1** | Identify the general design considerations of electrical machines. |
| **CO2** | Design armature and field system of DC machines. |
| **CO3** | Design core, yoke, windings and cooling systems of transformers. |
| **CO4** | Design stator and rotor of induction machines. |
| **CO5** | Design stator and rotor of synchronous machines. |
| **CO6** | Apply software tools in electrical machine design. |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | - | - | - | - | - |
| **CO2** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - |
| **CO3** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - |
| **CO4** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - |
| **CO5** | 3 | 2 | 2 | - | - | - | - | - | - | - | - | - |
| **CO6** | 3 | 2 | 1 | 1 | 1 | - | - | - | - | - | - | - |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand(K2) | 10 | 10 | 20 |
| Apply (K3) | 30 | 30 | 60 |
| Analyse (K4) | | | |
| Evaluate(K5) | | | |
| Create(K6) | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Part A:** 10 Questions x 3 marks=30 marks; **Part B:** 5 Questions x 14 marks =70 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1)**

1. List five types of enclosures used in electrical machines. (K1,PO2)
2. Explain the various insulation classes and the modern insulating materials. (K1,PO1)
3. Problems based on temperature rise calculations. (K2,PO2)

**Course Outcome 2 (CO2)**

1. Derive the output equation of a DC machine. (K2, PO1)
2. Discuss the factors that influence the choice of number of poles in a DC machine. (K1,PO2)
3. Problems based on the design of main dimensions and armature of a DC machine. (K3,PO3)
4. Problems based on the design of field system of a DC machine. (K3,PO3)

**Course Outcome 3 (CO3)**

1. Define window space factor in transformer design. (K1,PO2)
2. Derive output equation of transformers. (K2,PO1)
3. Problems based on the dimensions of transformers. (K3,PO3)

**Course Outcome 4 (CO4)**

1. Derive the expression for end ring current of a squirrel cage induction motor. (K2,PO1)
2. Write a short note on selection of current density in an induction motor in consideration to the insulation system. (K2,PO2)
3. Problems based on the design of an induction motor. (K3,PO3)

**Course Outcome 5 (CO5)**

1. Briefly explain the factors affecting the choice of specific electric and magnetic loadings in a synchronous machine. (K2,PO2)
2. Problems based on the design of synchronous machines. (K3,PO3)

3. Briefly explain the features of a brushless alternator. (K1,PO1)

**Course Outcome 6 (CO6)**

1. Explain how the finite element method is used for the analysis of electrical machines. (K2,PO1)
2. Explain various methods for the computer aided design of electrical machines. (K1,PO2)
3. Explain the analysis method with flow chart for computer aided design of electrical machines. (K1,PO2)

N*ote: Design, simulation and optimization using electromagnetic field simulation software can be achieved* ***through assignments****. (PO3, PO4 and PO5)*

**Model Question paper**

QP CODE:

PAGES: 3

Reg. No: ________________
Name : ________________

**TKM COLLEGE OF ENGINEERING**
**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,**
**MONTH & YEAR**

**Course Code: 22EEE802.4**

**Course Name: ELECTRICAL MACHINE DESIGN**

Max. Marks: 100
Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all questions. Each question carries 3 marks**

1. List any four types of enclosures used in electrical machines.
2. Derive the gap contraction factor for slots.
3. Derive the output equation of a DC machine.
4. Explain the importance of proper pole proportions while separating the values of D and L in a DC machine.
5. Derive the output equation of a single phase transformer.
6. Briefly explain the cast resin transformer.
7. Discuss the choice of specific magnetic loading and specific electric loading in induction machines.
8. Derive the expression for end ring current in a squirrel cage induction motor.
9. Explain the synthesis method for computer aided design with a flow chart.
10. Briefly explain the features of a brushless alternator.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 marks.**

**Module 1**

11. a) Discuss the thermal and dielectric properties of the following insulating materials used in electrical machines. i) Nomex and ii) Polyamide films. (4 marks)
b) The temperature rise of a transformer is 25°C after one hour and 37.5°C after 2 hours starting from cold conditions. Calculate its final steady temperature rise and the heating time constant. If its temperature falls from the final steady value to 40°C in 2.5 hours when disconnected, calculate its cooling time constant. The ambient temperature is 30°C. (10 marks)

12. a) What is Carter's coefficient and how does it help in the estimation of mmf of a machine with slotted armature? (6 marks)

b)Derive the expression for the temperature rise in a machine. Is heating time constant greater than cooling time constant? Justify your answer. (8 marks)

## Module 2

13. a) Discuss the factors that influence the choice of number of poles in DC machines. (4 marks)

b) Find out the main dimensions of a 50kW, 4 pole, 600rpm DC shunt generator to give a square pole face. The full load terminal voltage being 220 V. The maximum gap density is 0.83Wb/$m^2$ and the ampere conductors per meter is 30000. Assume that full load armature voltage drop is 3 percent of rated terminal voltage and that the field current is 1 percent of rated full load current. Ratio of pole arc to pole pitch is 0.67. (10 marks)

14. a) Explain the design procedure of brushes and commutators for a DC machine. (4marks)

b) The following particulars refer to the shunt field coil for a 440V, 6pole, DC generator: mmf per pole = 7000A; depth of winding = 50mm; length of inner turn = 1.1m; length of outer turn = 1.4m; loss radiated from outer surface excluding ends = 1400 W/m2; space factor = 0.62; resistivity = 0.02 Ω/m and $mm^2$. Calculate a) the diameter of wire b) length of coil c) no. of turns and d) exciting current. Assume a voltage drop of 20% of terminal voltage across the field regulator. (10 marks)

## Module 3

15. a) Compare distribution and power transformers. (4marks)

b) Determine the dimensions of core and window of a 5kVA, 50 Hz, single phase core type transformer. A rectangular core is used with long side twice as long as short side. The window height is 3 times the width. Voltage per turn is 1.8 V, space factor is 0.2, current density is 1.8A/$mm^2$ and flux density is 1Wb/$m^2$. (10 marks)

16. a) Define window space factor in transformer design. (4marks)

b) A 300kVA, 11000/400V, 3 phase, core type transformer has a total loss of 5000W at full load. The transformer tank is 1.25m in height and 1m x 0.75 m in plan. Design a suitable design for tubes if average temperature rise is to be limited to 360C. The diameter of the tube is 50mm and is placed 75mm apart. Average height of tubes is 1.05m, specific heat dissipation due to radiation = 6W/$m^2$ $^{o}$C and specific heat dissipation due to convection = 6.5W/$m^2$ $^{o}$C. Assume that convection is improved by 35 percent due to provision of tubes. (10 marks)

## Module 4

17. Find the main dimensions, number of radial ducts, number of stator slots and number of turns per phase of a 3.7kW, 4 pole, 50 Hz, squirrel cage induction motor to be started by star-delta starter. Work out the winding details. The average flux density in the air gap = 0.45 T, ampere conductors per meter = 23000, efficiency = 0.85, power factor = 0.84. Choose main dimensions to achieve cheap design. Winding factor = 0.955, Iron stacking factor = 0.9. (14 marks)

18. a) What is cogging in an induction motor? (4 marks)

b) Determine approximate values for the stator bore and the effective core length of a 55kW, 415V, 3-phase, star connected, 50Hz, four pole induction motor, Efficiency = 90%, power factor= 0.91, winding factor = 0.955, Assume suitable data wherever necessary with proper justification. (10 marks)

**Module 5**

19. a) What is short circuit ratio? How does the value of SCR affect the design of a synchronous generator? (4 marks)

b) Determine the main dimensions of a 2500 kVA, 187.5rpm, 50Hz, 3 phase, 3 kV, salient pole alternator. The generator is to be a vertical, water wheel type. The specific magnetic loading is $0.6 Wb/m^2$ and the specific electric loading is 34000A/m. Use circular poles with ratio of core length to pole pitch= 0.65. Specify the type of pole construction used if the run-away speed is about 2 times the normal speed. (10 marks)

20. a) Explain the design procedure for a synchronous generator using finite element software technique. (4 marks)

b) Determine the diameter, core length, size, no. of conductors and no. of slots for stator of a 15MVA, 11kV, 50Hz, 2 pole, star connected turbo-alternator with $60^0$ phase spread. Assume specific magnetic loading = 0.55 Tesla, specific electric loading = 36,000, current density = $5A/mm^2$, peripheral speed = 160m/s. The winding should be arranged to eliminate $5^{th}$ harmonic. (10 marks)

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## Syllabus

**Module 1 (7 hours)**

**Principles of electrical machine design:** General design considerations, types of enclosures - types of ventilation. Heating - cooling and temperature rise calculation – numerical problems. Continuous, short time and intermittent ratings. Insulation classes – Introduction to modern insulating materials, such as Nomex, Polyamide films and Silicone. Types of cooling in transformers and rotating electrical machines.

Magnetic system - Carter's coefficient – real and apparent flux density. Unbalanced magnetic pull and its practical aspects.

**Module 2 (7 hours)**

**DC Machines:** Output equation - main dimensions - choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered - choice of speed and number of poles - design of armature conductors, slots and winding - design problems. Design of air-gap - design of field system – design problems. Fundamental design aspects of interpoles, compensating winding, commutator and brushes.

**Module 3 (7 hours)**

**Transformers:** Design of transformers - single phase and three phase transformers - distribution and power transformers - output equation - core design with due consideration to percentage impedance required - window area - window space factor - overall dimensions of core – design problems. Windings - no. of turns - current density in consideration to the insulation scheme - conductor section. Design of cooling tank with tubes – design problems. Essential design features of cast resin dry type transformers. Fundamentals of K-factor rated transformer, ECBC standards for transformers, BEE Star rating of transformers.

**Module 4 (7 hours)**

**Induction machines:** Output equation - main dimensions - choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered - design of stator and rotor windings - round conductor or rectangular conductor - design of stator and rotor slots, air-gap of slip ring and squirrel cage motors - calculation of rotor bar and end ring currents in cage rotor - design of slip ring rotor winding - design problems. Design aspects of induction motor for drive applications (basic principles only).

**Module 5 (8 hours)**

**Synchronous Machines:** Output equation - salient pole and turbo alternators - main dimensions - choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered - significance of short circuit ratio - choice of speed and number of poles - design of armature conductors, slots and winding - round conductor or rectangular conductor - design of air-gap - design problems. Fundamental design aspects of the field system and damper winding. Features of brushless alternators.

**Introduction to computer aided design:** Analysis and synthesis methods - hybrid techniques. Introduction to machine design softwares using Finite Element Method.

Design, simulation and optimization using electromagnetic field simulation software (Assignment only).

**Text Books**

1. Sawhney A K, A Course in Electrical Machine Design, Dhanpat Rai & Co., 2016.
2. Say M G, The Performance and Design of AC Machines, CBS Publishers, New Delhi, 3rd edition, 2002.
3. Clayton A E & Hancock N N, Performance and Design of DC Machines, ELBS, 1971.

**References**


1. IS 1180 (Part 1):2014, Bureau of Indian Standards. https://bis.gov.in
2. S.O. No. 4062 (E) for Distribution Transformer dated 16th December, 2016, Bureau of Energy Efficiency, Govt. of India, Ministry of Power. https://www.beestarlabel.com
3. M. V. Deshpande, “Design and Testing of Electrical Machines”, Wheeler Publishing.
4. R. K. Agarwal, “Principles of Electrical Machine Design”, Essakay Publications, Delhi.
5. Ramamoorthy M, “Computer Aided Design of Electrical Equipment”, East-West Press.
6. M. N. O. Sadiku, “Numerical techniques in Electromagnetics”, CRC Press Edition-2001.


**Course Contents and Lecture Schedule**

| No. | Topic | No. of Lectures |
|---|---|---|
| 1 | **Principles of electrical machine design (7 hours)** | |
| 1.1 | General design considerations, types of enclosures - types of ventilation. | 1 |
| 1.2 | Heating - cooling and temperature rise calculation – numerical problems. | 1 |
| 1.3 | Continuous, short time and intermittent ratings. | 1 |
| 1.4 | Insulation classes – Introduction to modern insulating materials, such as Nomex, Polyamide films and Silicone. | 1 |
| 1.5 | Types of cooling in transformers and rotating electrical machines. | 1 |
| 1.6 | Magnetic system - Carter’s coefficient – real and apparent flux density. | 1 |
| 1.7 | Unbalanced magnetic pull and its practical aspects. | 1 |
| 2 | **Design of DC Machines (7 hours)** | |
| 2.1 | Output equation - main dimensions | 1 |

| | | |
|---|---|---|
| 2.2 | Choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered | 1 |
| 2.3 | Choice of speed and number of poles | 1 |
| 2.4 | Design of armature conductors, slots and winding | 1 |
| 2.5 | Design problems and design of air-gap | 1 |
| 2.6 | Design of field system – design problems. | 1 |
| 2.7 | Fundamental design aspects of interpoles, compensating winding, commutator and brushes | 1 |
| 3 | **Design of Transformers (7 hours)** | |
| 3.1 | Single phase and three phase transformers - distribution and power transformers - output equation | 1 |
| 3.2 | Core design with due consideration to percentage impedance required | 1 |
| 3.3 | Window area - window space factor - overall dimensions of core – design problems. | 1 |
| 3.4 | Windings - no. of turns - current density in consideration to the insulation scheme - conductor section. | 1 |
| 3.5 | Design of cooling tank with tubes – design problems. | 1 |
| 3.6 | Essential design features of cast resin dry type transformers. | 1 |
| 3.7 | Fundamentals of K-factor rated transformer, ECBC standards for transformers, BEE Star rating of transformers. | 1 |
| 4 | **Design of Induction machines (7 hours)** | |
| 4.1 | Output equation - main dimensions | 1 |
| 4.2 | Choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered | 1 |
| 4.3 | Design of stator and rotor windings - round conductor or rectangular conductor | 1 |
| 4.4 | Design of stator and rotor slots, air-gap of slip ring and squirrel cage motors - calculation of rotor bar and end ring currents in cage rotor | 1 |
| 4.5 | Design of slip ring rotor winding | 1 |
| 4.6 | Design problems | 1 |
| 4.7 | Design aspects of induction motor for drive applications (basic principles only). | 1 |
| 5 | **Design of Synchronous Machines and Introduction to computer aided design (8 hours)** | |
| 5.1 | Output equation - salient pole and turbo alternators - main dimensions | 1 |
| 5.2 | Choice of specific electric and magnetic loadings corresponding to the insulating materials, magnetic material and type of cooling considered | 1 |

| | | |
|---|---|---|
| 5.3 | Significance of short circuit ratio - choice of speed and number of poles | 1 |
| 5.4 | Design of armature conductors, slots and winding - round conductor or rectangular conductor - design of air-gap | 1 |
| 5.5 | Design problems | 1 |
| 5.6 | Fundamental design aspects of field system and damper winding. Features of brushless alternators. | 1 |
| 5.7 | Analysis and synthesis methods - hybrid techniques. | 1 |
| 5.8 | Introduction to machine design softwares using Finite Element Method. Design, simulation and optimization using electromagnetic field simulation software (Assignment only). | 1 |

| CODE 22EEE802.5 | SWITCHED MODE POWER CONVERTERS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PEC | 2 | 1 | 0 | 3 |

**Preamble:** This course builds upon the course EET 306: Power Electronics, to give the students a detailed exposure to switched-mode power converter analysis and design. The objectives of this course are:

1. To give a comprehensive exposure to the power converter topologies widely used in the industry for power supply applications.
2. To equip the students with necessary theoretical knowledge to develop practical power converter designs.

**Prerequisite: EET306 POWER ELECTRONICS**

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Develop the basic design for non-isolated DC-DC converter topologies. |
| **CO 2** | Analyse isolated DC-DC converter topologies. |
| **CO 3** | Describe the operation of Switched mode inverters and rectifiers. |
| **CO 4** | Distinguish between inverter modulation strategies. |
| **CO 5** | Describe the operation of Soft switching resonant converters. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 1 | 1 | | | | | | | | 2 |
| **CO 2** | 3 | 2 | 1 | 1 | | | | | | | | 2 |
| **CO 3** | 3 | 1 | 1 | | | | | | | | | 2 |
| **CO 4** | 3 | 1 | 1 | | | | | | | | | 2 |
| **CO 5** | 3 | 1 | 1 | | | | | | | | | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 10 | 10 | 50 |
| Apply | 20 | 20 | 30 |

| | | | |
|---|---|---|---|
| Analyse | 10 | 10 | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Design the power circuits of basic dc-dc converters (K2, K3 and K4 level, PO1, PO2, PO3, PO4)

2. Analyse and determine the mode of operation of the given circuit. (K2, K3, K4, PO1, PO2)

3. Design dc-dc non-isolated converters to operate under given conditions/specifications. (K2, K3, K4, PO1, PO2, PO3, PO4)

4. What is the primary difference between switched mode power conversion and linear power conversion? (K1, PO1)

**Course Outcome 2 (CO2)**

1. Analyse circuits of isolated dc-dc topologies. give relevant waveforms. (K2, K3, K4 levels, PO1, PO2).

2. Explain unidirectional and bidirectional magnetic core excitation.(K1, PO1)

3. Explain double ended forward converter with neat diagram. (K1, PO1)

4. Describe the operation of the push-pull dc-dc converter. Also derive the expression of output voltage. (K1, PO1, PO2)

**Course Outcome 3(CO3):**

1. Describe the operation of three-phase/single-phase rectifiers (K2, K3, PO1)

2. Explain active wave shaping of input line current through PFC boost converter. (K1, PO1)

3. With a neat circuit diagram, explain the working of the switched mode rectifier. (K1, PO1)

4. Find the Switch utilization factor for single phase full bridge dc-dc converter.(K1, PO1, PO2)

**Course Outcome 4 (CO4):**

1. Compare PWM schemes and select an appropriate method for given application (K2, K3, K4, PO1)

2. Explain switching times and space vector sequence of space vector modulation. (K1, PO1)

3. With waveform explain hysteresis current control . (K1, PO1)

4. With waveform explain programmed harmonic elimination of single phase inverter. (K1, PO1)

**Course Outcome 5 (CO5):**

1. Distinguish between hard-switching and soft-switching methods. (K2, PO1)

2. Explain with a neat diagram, series resonant and parallel resonant circuit . Also draw the frequency characteristics . (K1, PO1)

3. Explain significance of Zero voltage and Zero current switching in dc –dc converters. (K1, PO1)

4. Illustrate how switching losses are reduced in ZVS configuration. (K1, PO1, PO2)

**Model Question Paper**

**QP CODE:** **Pages:**

**Reg No.:_______________**

**Name:_________________**

**TKM COLLEGE OF ENGINEERING**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,**

**MONTH & YEAR**

**Course Code: 22EEE802.5**

**Course Name: SWITCHED MODE POWER CONVERTERS**

**Max. Marks: 100** **Duration: 3 hours**

## PART A

**Answer all questions; each question carries 3 marks.**

1. What is the primary difference between switched mode power conversion and linear power conversion?

2. Draw the circuit diagram of a dc-dc converter that, when operated in continuous conduction mode yields continuous currents in both input and output terminals, and inverted output voltage.

3. Draw the circuit diagram of a two-switch flyback converter and explain why it cannot operate with duty ratios beyond 50%.

4. What are the advantages of a current-fed isolated dc-dc converter?

5. In a single-phase full-bridge PWM inverter operating with Sine PWM and in linear modulation range, what would be the maximum possible rms value of the fundamental voltage that can be obtained at the output if the dc voltage is fixed at 500V?

6. Draw the circuit diagram of the single-phase boost power factor correction rectifier topology. Which signals need to be sensed in order to control this converter?

7. How many space vectors can be produced by a three-phase bridge inverter? Represent them in a table in the given format below:

| Sl. No. | Switch states | Space vector magnitude | Location (angle) |
|---|---|---|---|
| | | | |

8. Differentiate between current controlled voltage source inverter and hysteresis current controlled inverter.

9. Differentiate between PWM hard-switching and Soft-switching.

10 Draw the ZCS switch configuration and explain how the position of the resonant components aid in zero-current switching.

## PART B

**Answer any one complete question from each section; each question carries 14 mark**

11 (a) Derive an expression for the peak-to-peak current ripple in the inductor in a buck converter operating in continuous conduction mode, in terms of the output voltage, operating duty ratio and the value of the inductor. Draw the relevant waveforms used in the derivation. (4)

(b) A photovoltaic panel is rated for an output voltage range between 15 V to 18 V, 36 W peak output power. This panel is to be connected to a dc load that demands a fixed dc voltage of 12 V, with ripple less than 1% of the rated output voltage. Assume the converter is to be operated in discontinuous conduction mode when the load is less than 50% of the rated output power. Select a converter topology suitable for this application, and design it to meet the given specifications. Evaluate the duty ratio D when the input voltage is 18 V and the load is 30% of the rated output power, with the component values selected for the design. (10)

OR

12 (a) A Ćuk converter is supplied with an input voltage that varies between 5V and 10V. The output is required to be regulated at 15V. Find the duty ratio range. Assume the converter is working with continuous conduction mode for the entire range. If the load power is 50W, evaluate the input currents for the minimum and maximum input voltages, assuming an ideal converter. (5)

(b) Develop the voltage transfer ratio of a buck converter operating in Discontinuous Conduction Mode. (9)

13 (a) Compare the features of single-switch and two-switch flyback converter topologies. (4)

(b) It is required to design a power converter with the following features:

(i). Electrical isolation is required.

(ii). Gate drives should be referenced to the same electrical potential.

(iii). The input voltage is 200 V, and the output voltage is 12 V; Power is 250 W. (10)

A junior technician came up with the options: Two-switch Flyback converter, Two-switch forward converter, Push-pull converter, Full-bridge isolated converter and Half-bridge isolated converter. As a design engineer, which out of these options will you choose that can meet the requirements? Develop a basic design of the inductor and capacitor, by assuming a current ripple of 20% of output current and 1% of nominal output voltage as voltage ripple. Evaluate the duty ratio and choose an appropriate turns ratio for the transformer.

OR

14 (a) A flyback converter with 15V input voltage is operating with a duty ratio of 0.4. If the turns ratio of the coupled inductor is 1:0.5, evaluate the output voltage. Assume continuous conduction mode. What is the peak voltage appearing across the switch? Draw the waveforms of the input current, output diode current and voltage across the switch under the given operating conditions and mark the salient features. (6)

(b) For a forward converter with Vd=48V+/-10%; Vo= 5V (regulated); fs=100kHz; Pload=15-50W. If the flux reset winding N3=N1, calculate the turns ratio N2/N1 if this turns ratio is desired to be as small as possible. (8)

15 (a) What are the dominant harmonics in the output line-to-line voltage of a three-phase bridge inverter operating in square-wave mode? Show the line voltage waveform and the harmonic spectrum upto the first 7 dominant harmonics (not upto the 7th). (5)

(b) Describe a single-phase power factor corrected rectification scheme utilising boost converter and its control. Explain how the input current is actively shaped for reduced THD. (9)

OR

16 (a) In a single phase full bridge sine PWM inverter, the input dc voltage varies in a range of 295-325 V. Because of the low distortion required in the output, the inverter is operated in the linear modulation range. What is the highest output fundamental rms voltage that can be obtained from this inverter? If the inverter is to be rated at 2 kVA, calculate the combined switch utilisation ratio of the inverter when it is supplying rated VA. Assume the load current is sinusoidal. (6)

(b) Explain how a single-phase full-bridge topology can be used as a utility interfaced high-power factor rectifier. (8)

17 (a) For a Space Vector PWM based inverter, the dc voltage is 600 V. The switching frequency is 20 kHz. The reference voltage vector is $200\angle 30^{o}$ Vrms, at a particular sampling interval.

(i). Identify the active vectors to be used during the given sampling interval. Indicate the corresponding switch states. (8)

(ii). The dwell-times of the active vectors and the zero vector during the interval.

(iii). Evaluate the dwell times when the reference vector is at $180^{o}$ out-of phase with the original location.

(b) What is Selective Harmonic Elimination? Explain with respect to a single-phase inverter. (6)

OR

18 (a) Explain the working of a current controlled voltage source inverter with fixed switching frequency. (6)

(b) Explain how the number of switchings per sampling period are minimised by proper sequencing of the active and zero vectors in Space Vector Modulation. (8)

19 (a) Differentiate between ZCS and ZVS topologies. What are the parasitic elements which are usefully employed in these topologies? (6)

(b) With circuit diagram and relevant waveforms, describe the operation of a series loaded resonant converter operating in discontinuous conduction mode. (8)

OR

20 (a) The ZCS and ZVS resonant switches are dual implementations. Explain why. (6)

(b) Which of the load resonant converters is a voltage-boosting converter? Explain with relevant diagrams/graphs. (8)

# Syllabus

## Module 1

**Switched Mode non-isolated DC-to-DC Converters:**

Linear Vs Switching Power Electronics.

Buck, Boost, Buck-boost and Ćuk converters: Principles of steady-state analysis - Inductor volt-seconds balance and capacitor amp-seconds balance – Operation in Continuous Conduction Mode (CCM)- Voltage Gain – design of filter inductance & capacitance - boundary between continuous and discontinuous conduction – critical values of inductance/load resistance - Examples for buck and boost converters.

Discontinuous Conduction Mode (DCM) of buck converter with constant output voltage – Output voltage ripple in DCM. Voltage Gain in DCM for buck converters.

## Module 2

**DC-DC converters with electrical isolation:**

High-frequency transformers for DC-DC converters: unidirectional magnetic core excitation & bidirectional core excitation.

Fly back converter: Operation and waveforms in continuous & discontinuous conduction modes – Voltage gain.

CCM operation of double ended fly-back converter.

Forward converter in CCM: Basic forward converter with ideal transformer – practical forward converter with core reset – double ended forward converter

Push-Pull, Half-Bridge and Full-Bridge converters: Operation in Continuous Conduction Mode (CCM) – Flux-walking in isolated converters.

Current-source DC-DC converter.

## Module 3

**Switched Mode DC to AC converters:**

Review of single-phase bridge inverters - 3-phase Sine-PWM inverter: – Linear Modulation, RMS fundamental line to line voltage & RMS fundamental line-to-line voltage – Overmodulation - Square wave operation in three-phase inverters - Switch utilisation ratio of 1-phase & 3-phase full-bridge inverters.

**PWM Rectifiers:** Generation of current harmonics in diode bridge rectifiers - Power factor - Improved single-phase utility interface - Active shaping of input line current through PFC boost converter - Single phase Switched mode rectifier.

**Module 4**

**Modulation Schemes:**

Space Vector Modulation: Concept of space vector – space vector modulation – reference vector & switching (dwell) times – space vector sequence – comparison of sine PWM & space vector PWM.

Programmed (selective) harmonic elimination switching in single phase inverters (Formulation example with elimination of two harmonics at a time) – current controlled voltage source inverter -

Hysteresis current control.

**Module 5**

**Softswitching and resonant converters:**

Hard-switched Vs Soft-switched converters -

Resonant Converters - Basic resonant circuit concepts – series resonant circuit – parallel resonant circuit – series-loaded and parallel loaded resonant converters (Operation in discontinuous conduction mode with $\omega s < 0.5\ \omega r$).

Resonant Switch (Quasi-resonant) Converters: ZCS buck converter - L type - ZVS buck converter – comparison of ZCS & ZVS Resonant Converters.

**Note:** Assignments may be given to develop simulations of the converter topologies in open-loop and/or closed-loop using appropriate simulation tools. Assignments may also be given to develop design automation scripts/tools using Python, MATLAB, C, Spreadsheets etc.

**Text Books**

1. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics: Converters, Applications and Design," Third Edition, John Wiley and Sons, 2003.

**Reference Books**

1. Joseph Vithayathil, "Power Electronics: Principles and Applications," Tata McGrawhill edition.
2. Robert W. Erickson and Dragan Maksimovic, "Fundamentals of Power Electronics," Second Edition, Springer International Edition (Indian reprint).
3. L. Umanand, "Power Electronics: Elements and Applications," Wiley India, 2009.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Non-isolated DC-DC converters:** | **7 Hours** |
| 1.1 | Introduction: Linear Vs Switching Power Electronics.<br><br>Buck and Boost Converters: Topology, principles of low-ripple approximation and inductor volt-sec/capacitor amp-sec balance., Application in developing the voltage transformation ratio in CCM. Evaluation of Inductances and Capacitance for specified current/voltage ripple. | 2 |
| 1.2 | Buck-boost and Cuk Converters: Topology, Application of inductor volt-sec balance/Capacitor amp-sec balance in developing the voltage transformation ratio in CCM. Evaluation of Inductances and Capacitor for specified current/voltage ripple. | 2 |
| 1.3 | Boundary between continuous and discontinuous conduction modes–critical values of inductance/load resistance - Examples for buck and boost converters. | 1 |
| 1.4 | Discontinuous Conduction Mode (DCM) of buck converter with constant output voltage – Output voltage ripple in DCM. Voltage Gain in DCM for buck converters. | 2 |
| 2 | **DC-DC converters with electrical isolation:** | **8 Hours** |
| 2.1 | High-frequency transformers for DC-DC converters: unidirectional magnetic core excitation & bidirectional core excitation. | 1 |
| 2.2 | Fly back converter: Operation and waveforms in continuous & discontinuous conduction modes – Voltage gain; CCM operation of double ended fly-back converter. | 2 |
| 2.3 | Forward converter in CCM: Basic forward converter with ideal transformer – practical forward converter with core reset – double ended forward converter. | 2 |
| 2.4 | Push-Pull, Half-Bridge and Full-Bridge converters: Operation in Continuous Conduction Mode (CCM) – Flux-walking in isolated converters. | 2 |
| 2.5 | Current-source DC-DC converter | 1 |
| 3 | **Switched Mode Inverters and Rectifiers** | **6 hours** |
| 3.1 | Review of single-phase bridge inverters - 3-phase voltage source inverter: 3-phase Sine-PWM inverter – RMS line to line voltage & | 2 |

| | | |
|---|---|---|
| | RMS fundamental line-to-line voltage – square wave operation - Switch utilisation ratio of 1-phase & 3-phase full-bridge inverters. | |
| 3.2 | **PWM Rectifiers: (Ch. 8 of Ref. 1):** Generation of current harmonics in diode bridge rectifiers - Power factor - Improved single-phase utility interface - Active shaping of input line current through PFC boost converter -Single phase Switched mode rectifier operation and control. | 4 |
| 4 | **Modulation Schemes:** | **7 Hours** |
| 4.1 | Concept of space vector; Origin of flux space phasor representation. | 1 |
| 4.2 | Space vector modulation – reference vector & switching times – space vector sequence | 2 |
| 4.3 | Comparison of sine PWM & space vector PWM. | 1 |
| 4.4 | Programmed (selective) harmonic elimination switching in single phase inverters (example with elimination of third and fifth harmonics) | 2 |
| 4.5 | Current controlled voltage source inverter - Hysteresis current control. | 1 |
| 5 | **Softswitching and Resonant Converters:** | **8 hours** |
| 5.1 | Softswitching and resonant converters: Hard-switched Vs Soft-switched converters - Switching losses and transition of voltage and current during switching in Hard Switched converters. | 1 |
| 5.2 | Resonant Converters - Basic resonant circuit concepts – series resonant circuit – parallel resonant circuit | 2 |
| 5.3 | Series-loaded (Operation in discontinuous conduction mode with $\omega_{sw} < 0.5\ \omega_r$; $\omega_{sw}$:Switching frequency and $\omega_r$: Resonant frequency) | 1 |
| 5.4 | Parallel loaded resonant converters (Operation in discontinuous conduction mode with $\omega_{sw} < 0.5\ \omega_r$; $\omega_{sw}$:Switching frequency and $\omega_r$: Resonant frequency). | 1 |
| 5.5 | Resonant Switch (Quasi-resonant) Converters: ZCS buck converter - L type. | 2 |
| 5.6 | ZVS buck converter – Comparison of ZCS & ZVS Resonant Converters. | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEE802.6 | Computer Aided Power Systems Analysis | PEC | 2 | 1 | 0 | 3 |

**Preamble:** The basic objective of this course is to familiarize the efficient computational techniques applied in analyzing the power system.

**Prerequisite:** Circuits and Networks, Power Systems I, Power Systems II

**Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| CO1 | ower system networks |
| CO2 | Solve linear systems using computationally efficient methods |
| CO3 | Solve load flow problem to analyse the state of power systems |
| CO4 | Formulate optimal power flow problem in power system networks |
| CO5 | Analyse power system under short circuit conditions and infer the results to design a protective system |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 1 | - | 1 | - | - | - | - | - | - | - |
| **CO2** | 3 | 2 | 1 | - | 1 | - | - | - | - | - | - | - |
| **CO3** | 3 | 2 | 2 | - | 2 | - | - | - | - | - | - | - |
| **CO4** | 3 | 2 | 2 | - | 2 | - | - | - | - | - | - | - |
| **CO5** | 3 | 3 | 3 | - | 2 | - | - | - | - | - | - | - |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 10 | 10 | 20 |
| Apply (K3) | 20 | 20 | 40 |
| Analyse (K4) | 10 | 10 | 20 |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

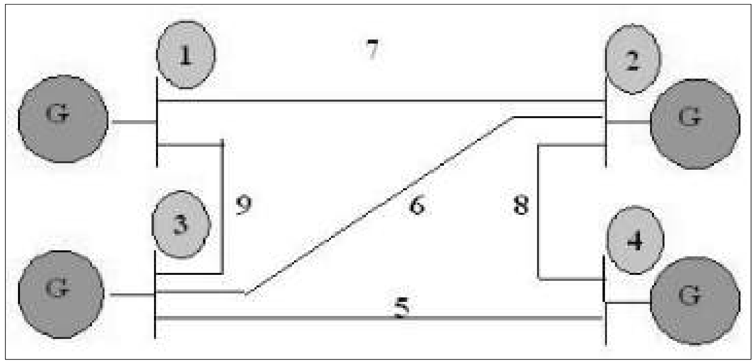
**End Semester Examination Pattern:**

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

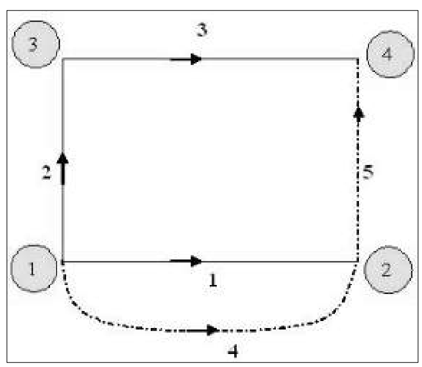
**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. For the network shown in Fig. obtain the bus incidence matrix A. (K3)(PO1,PO2,PO3,PO5)




2. For the network in Fig, form the primitive matrices [z] & [y] and obtain the bus admittance matrix by singular transformation. (K2, K3)(PO1,PO2,PO3,PO5)




**Course Outcome 2 (CO2):**

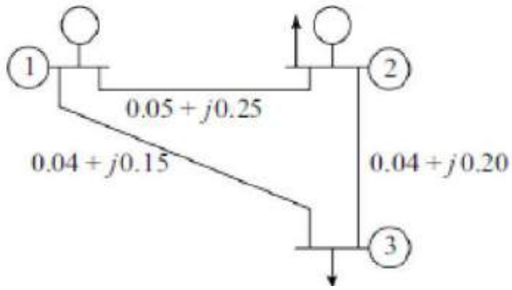
1. Solve Ax=b using Gaussian elimination, given (K2)(PO1,PO2,PO3,PO5)

$$A = \begin{bmatrix} 5 & -2 & -3 \\ -3 & 7 & -2 \\ -3 & -3 & 8 \end{bmatrix} \quad \boldsymbol{b} = \begin{bmatrix} 4 \\ -10 \\ 6 \end{bmatrix}$$

2. Enumerate Tinney's optimal ordering schemes. (K2)(PO1,PO2,PO3,PO5)

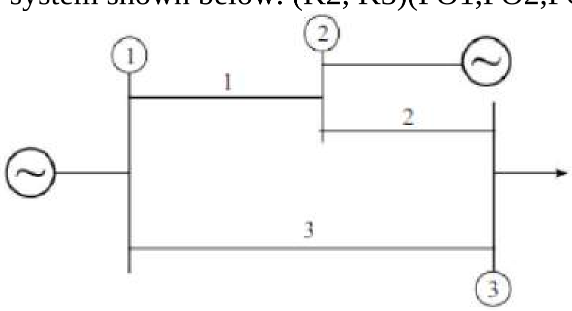
**Course Outcome 3 (CO3):**

1. Exhibit the structure of fast decoupled load flow equations and DC load flow equations with numerical values for the 3 bus power system shown in the figure. (K3)(PO1,PO2,PO3,PO5)




| Load/Gen. Data | | | | |
|---|---|---|---|---|
| *Bus* | *Gen.* | | *Load* | |
| | *MW* | *MVAR* | *MW* | *MVAR* |
| **1** | 0 | 0 | 0 | 0 |
| **2** | 100 | 50 | 50 | 25 |
| **3** | 0 | 0 | 75 | 30 |
| **4** | 0 | 0 | 100 | 50 |

2. Considering Bus 1 as slack bus, use DC load flow to obtain one iteration of load flow solution for the system shown below. (K2, K3)(PO1,PO2,PO3,PO5)




Line data (all are in p.u)

| *Line number* | *Between buses* | *Line impedance* |
|---|---|---|
| 1 | 1-2 | 0 + j0.1 |
| 2 | 2-3 | 0 + j0.2 |
| 3 | 1-3 | 0 + j0.3 |

Bus data (all are in p.u)

| Bus no. | Type | Generator | | Load | | Voltage magnitude | Reactive power limits | |
|---|---|---|---|---|---|---|---|---|
| | | ***P*** | ***Q*** | ***P*** | ***Q*** | ***lVl*** | $Q_{min}$ | $Q_{max}$ |
| 1 | Slack | - | - | - | - | 1.0 | - | -8 |
| 2 | P-V | 5.3217 | - | - | - | 1.0 | 0 | 5.3217 |
| 3 | P-Q | - | - | 3.6392 | 0.5339 | - | - | - |

**Course Outcome 4 (CO4):**

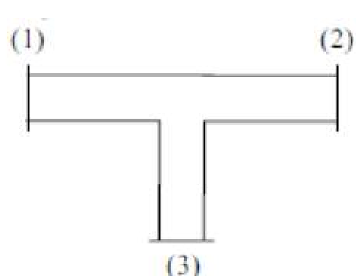
1. Formulate the optimal power flow problem with equality constraints. (K2,K3)(PO1,PO2,PO3,PO5)
2. Discuss the equality and inequality constraints in optimal power flow. (K1)(PO1,PO2,PO3,PO5)
3. Incremental fuel costs in Rs/ mega watthour for a plant consisting of two units are given by

$$\lambda_1 = \frac{df_1}{dP_1} = 0.008P_1 + 8\lambda_2 = \frac{df_2}{dP_2} = 0.0096P_2 + 6.4$$

Assume that both units are operating at all times, determine the saving in fuel cost in Rs/hr for the economic distribution of total load of 900 MW between the two units of the plant compared with equal distribution of the same total load. (K3)(PO1,PO2,PO3,PO5)

**Course Outcome 5 (CO5):**

1. All lines in the network shown in figure have a positive sequence impedance of j0.2 p.u. Generators with transient reactances j0.05 p.u. are connected at buses 1 and 2. Assuming prefault voltage as 1< 0°, for a three-phase to ground fault bus 3, find fault current, fault voltages at buses and currents in all the lines. Determine the fault level at bus 3. (K3, K4)(PO1,PO2,PO3,PO5)




2. A 50-Hz turbo generator is rated 500 MVA, 22 kV. It is Y- connected and solidly grounded and is operating at rated voltage at no load. It is disconnected from the rest of the system. Its reactances are $X_d'' = X_1 = X_2 = 0.15$ and $X_0 = 0.05$ per unit. Determine the ratio of the subtransient line current for a single line to ground fault to the subtransient line current for a symmetrical fault. (K3)(PO1,PO2,PO3,PO5)

**Model Question paper**

**QP CODE:**

PAGES:4

Reg.No:______________

**Name:______________**

**TKM COLLEGE OF ENGINEERING**

**EIGHT SEMESTER B. TECH. DEGREE EXAMINATION,**

**MONTH & YEAR**

**Course Code: 22EEE802.6**

**Course Name: COMPUTER AIDED POWER SYSTEM ANALYSIS**

Max. Marks: 100 Duration: 3 Hours

**PART A**

**Answer all Questions. Each question carry 3 marks**

1. Define tree, co-tree, link and branch of a graph.
2. How will the ZBUS matrix be modified, if any line is removed from the previous existing network, or the impedance value of the existing line gets modified.
3. Write short notes on Tinney's optimal ordering.
4. Discuss about triangular factorization of system matrices.
5. Compare NR load flow, decoupled load flow and fast decoupled load flow.
6. What is the principle underlying the decoupled approach in load flow solutions? Narrate its typical solution strategy.
7. Explain the constraints considered in formulating Optimal Power Flow.
8. Explain the concept of economic dispatch problem in the power system.
9. What is the need of performing short circuit analysis in a power system?
10. The Thevenin impedance and voltage at a fault point is $0.576\angle 84^{o}$ p.u. and $1\angle 0^{o}$ p.u. respectively. Determine the short circuit MVA for a base of 30MVA, 11kV.

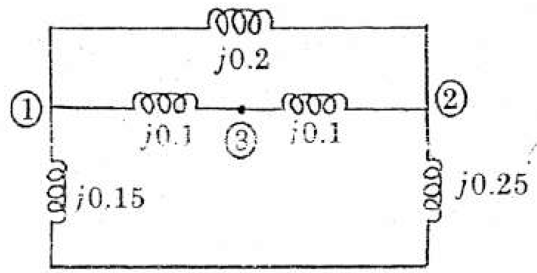
## PART B

**Answer any one full question from each module. Each full question carry 14 marks**

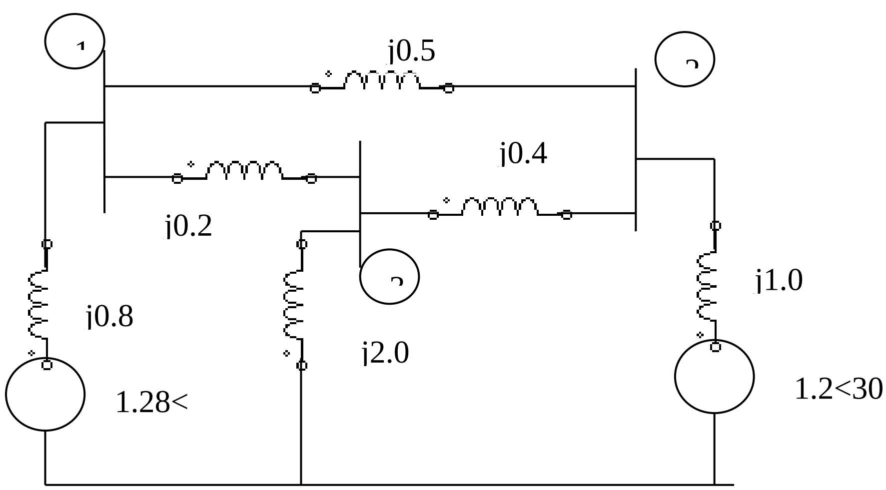
### Module-1

11. a) Prove $Y_{Bus}=A^TyA$ where A is bus incidence matrix, y is primitive admittance matrix and $Y_{Bus}$ is bus admittance matrix. (7)

b) For the network shown in figure below, obtain $Y_{Bus}$ by singular transformation. All line impedances are in p.u. (7)




12. For the reactance network shown in figure find Z bus by direct determination (14)

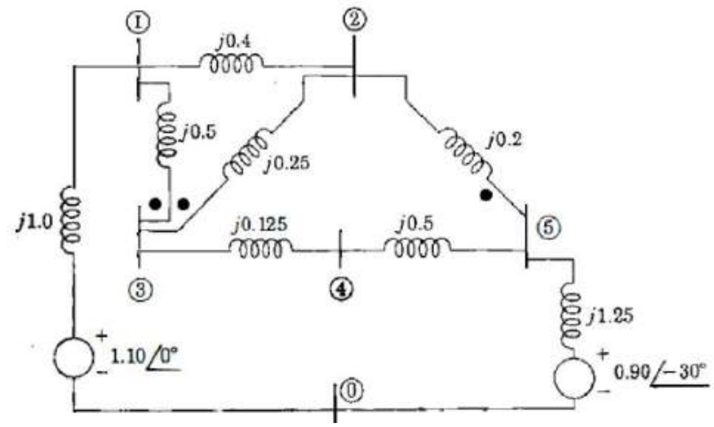



### Module-2

13. Find the L and U triangular factors of the symmetric matrix. (14)

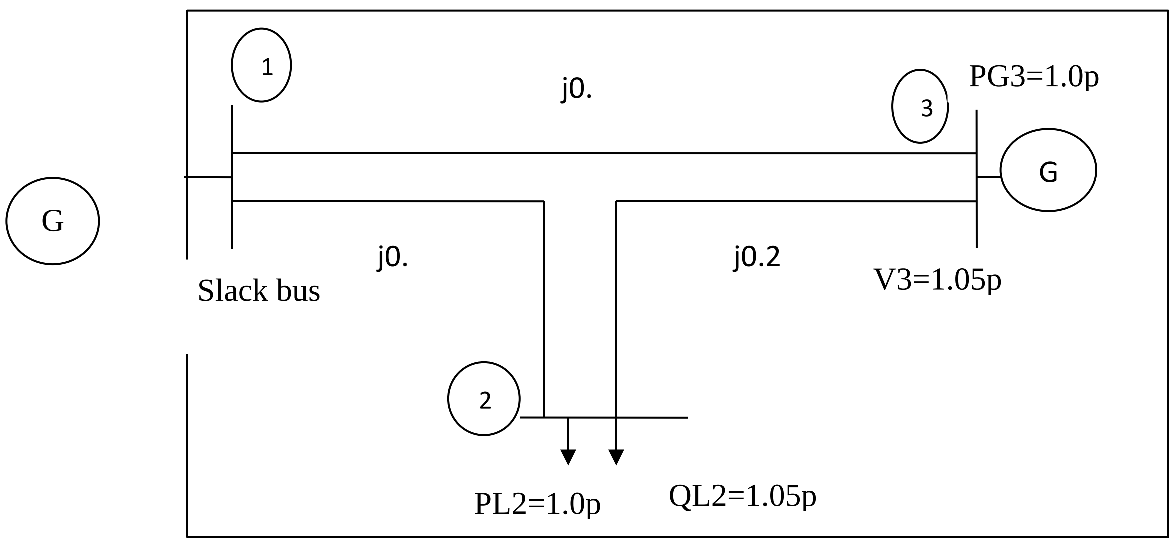
$$\mathbf{M} = \begin{bmatrix} 2 & 1 & 3 \\ 1 & 5 & 4 \\ 3 & 4 & 7 \end{bmatrix}$$

14. Using the Guassian elimination find the triangular factors of Y bus for the circuit given (14)




**Module-3**

15. For the three bus power system shown in figure, carry out one iteration of load flow solution by FDLF method. Line reactances are given in pu. (14)




16. a) Discuss the Newton Raphson algorithm of Load Flow (8)

b) Stating the assumptions, discuss DC Load Flow (6)

**Module-4**

17**.** Explain the Optimal Power Flow problem and its solution by gradient method (with equality constraints only)

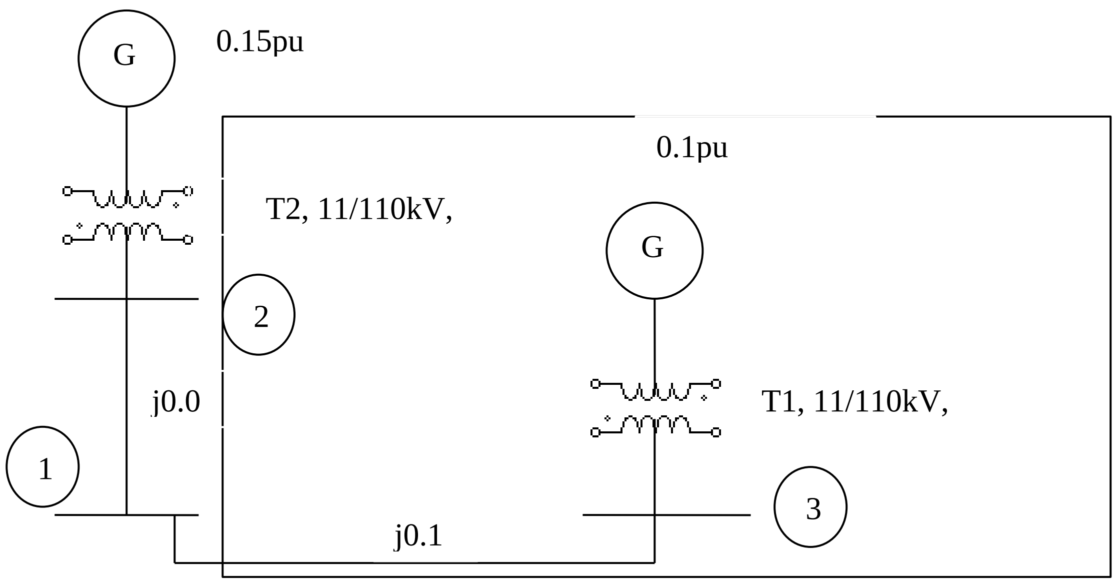
(14)

18. a) Explain the formulation of optimal power flow problem and its solution by Newton method (8)

b) Explain security constrained optimal power flow (6)

## Module-5

19. For the system shown in figure a three phase fault occurs in bus 1. Using $Z_{Bus}$ method, find the short circuit current in the fault, currents in line 1-2 and 1-3 and bus voltages. Prefault system is on no load with 1pu voltage and prefault currents are zero. (14)




20. Obtain the sequence network for a LL fault through impedance at the terminals of an unloaded synchronous generator. (14)

## Syllabus

**Module I (7 hours)**

Overview of graph theory - tree, co-tree and bus incidence matrix, development of network matrices $Z_{bus}$ and $Y_{bus}$ from graph theoretic approach (singular transformation only), building algorithm for bus impedance matrix for elements without mutual coupling.

**Module II (8 hours)**

Review of solution of linear system of equations by Gauss-Jordan method, Gauss elimination, and LDU factorization. Inversion of $Y_{bus}$ for large systems using LDU factors, Tinney's Optimal ordering.

**Module III (7 hours)**

Review of Load Flow analysis, Newton-Raphson method(only qualitative analysis), Fast Decoupled Load Flow and DC Load Flow (numerical problems upto two iterations).

**Module IV (7 hours)**

Review of economic load dispatch, formulation of optimal power flow with active power cost minimization, Solution of OPF using Gradient and Newton's methods (Qualitative analysis only), Security Constrained Optimal Power Flow (concept only).

**Module V (7 hours)**

Network fault calculations using $Z_{bus}$, algorithm for calculating system conditions after fault – three phase to ground fault.

**Text Books**:

1. Stagg and E l Abiad, "Computer Methods in Power System Analysis", McGraw Hill, 1968.

2. G. L. Kusic, Computer Aided Power System Analysis, PHI, 1989

3. John J. Grainger, William D. Stevenson, Jr., Power System Analysis, Tata McGraw-Hill Series in Electrical and Computer Engineering.

**References:**

1. I. J. Nagrath and D. P. Kothari, "Modern Power System Analysis", Tata McGraw Hill, 1980.
2. J. Arriliga and N.R. Watson, Computer Modelling of Electrical Power Systems, 2/e, John Wiley, 2001.

3. L. P. Singh, “Advanced Power System Analysis and Dynamics”, 3/e, New Age Intl, 1996.
4. M. A. Pai, Computer Techniques in Power Systems Analysis, Tata McGraw-Hill, Second edition 2005.
5. Arthur R. Bergen, Vijay Vittal, Power Systems Analysis (English) 2nd Edition, Pearson Higher Education
6. Wood, Allen J., Bruce F. Wollenberg, and Gerald B. Sheblé. Power generation, operation, and control. John Wiley & Sons, 2013

**Course Content and Lecture Schedule:**

| **Sl. No.** | **Topic** | **No. of Lecture Hrs** |
|---|---|---|
| 1 | **Module I (7 Hrs)** | |
| 1.1 | Introduction, Network Equation, Concept of Linear Graph – tree, cotree | 1 |
| 1.2 | Bus Incidence matrix, A | 1 |
| 1.3 | Formation of $Y_{bus}$ and $Z_{bus}$ by singular transformation, Numerical problem | 2 |
| 1.4 | $Z_{bus}$ building algorithm without mutual coupling(derivation not required), Numerical example | 3 |
| 2 | **Module II (8 Hrs)** | |
| 2.1 | Solution of linear system of equations by Gauss Jordan method and Gauss elimination method, Numerical problems | 3 |
| 2.2 | Triangular factorization –LDU factors, Numerical problems | 2 |
| 2.3 | Inversion of the $Y_{BUS}$ matrix for large systems, Numerical problems | 2 |
| 2.4 | Tinney’s Optimally Ordering | 1 |
| 3 | **Module III (7 Hrs)** | |
| 3.1 | Review of Load Flow | 1 |
| 3.2 | Newton-Raphson method  (Qualitative analysis only) | 2 |
| 3.3 | Fast Decoupled Load Flow (Numerical problems up to 2 iterations) | 2 |
| 3.4 | DC Load Flow (Numerical problems up to 2 iterations) | 2 |

| | | |
|---|---|---|
| 4 | **Module IV (7 Hrs)** | |
| 4.1 | Review of Economic Load Dispatch - Economic dispatch of generation without and with transmission line losses | 2 |
| 4.2 | Concept of optimal power flow – formulation with equality and inequality constraints (with active power cost minimization) | 2 |
| 4.3 | Solution of OPF using Gradient and Newton method (Qualitative analysis only) | 2 |
| 4.4 | Security Constrained Optimal Power Flow (concept only). | 1 |
| 5 | **Module V (7 Hrs)** | |
| 5.1 | Symmetrical and Unsymmetrical fault calculations using $Z_{BUS}$ – Numerical Problems (Symmetrical faults up to 3 bus systems) | 4 |
| 5.2 | Algorithm for SC calculations for balanced 3 phase network – three phase to ground fault only –Numerical problem | 3 |
| | | 36 hrs |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEE802.7** | **MACHINE LEARNING** | | **2** | **1** | **0** | **3** |

**Preamble:**. This course will enable students to:

1) Develop an appreciation for what is involved in learning models from data.
2) Understand a wide variety of learning algorithms.
3) Understand how to evaluate models generated from data.
4) Apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

**Prerequisite:**

**Course Outcomes:** After the completion of the course the student will be able to:

| | |
|---|---|
| CO1 | Understand various basic learning techniques |
| CO2 | Perform dimensionality reduction for multivariate problems |
| CO3 | Implement machine learning solutions to classification, regression, and clustering problems |
| CO4 | Use Perceptron modelling based learning techniques and Support Vector Machines to design solutions |
| CO5 | Design and analyse machine learning experiments for real-life problems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | - | - | - | - | - | - | - | - | - | 3 |
| **CO 2** | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 3 |
| **CO 3** | 3 | 3 | 3 | - | - | - | - | - | - | - | - | 3 |
| **CO 4** | 3 | 3 | - | - | - | - | - | - | - | - | - | 3 |
| **CO 5** | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 3 |

**Assessment Pattern:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 10 | 10 | 20 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | 10 | 10 | 10 |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B.
Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.
Part B contains 2 questions from each module of which student should answer any one. Each question carries 14 marks and can have maximum 2 sub-divisions.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Distinguish between overfitting and underfitting. How it can affect model generalization?

2. Explain bias- variance dilemma.

3. Distinguish between classification and regression with an example.

**Course Outcome 2 (CO2)**

1. Define VC dimension. Show that an axis aligned rectangle can shatter 4 points in 2 dimensions.

2. Compare Simple Regression, Multiple Regression and Multivariate Regression.

3. Describe any two techniques used for Ensemble Learning.

**Course Outcome 3(CO3):**

1. Given a linearly separable dataset with one group containing 5 instances and a second group containing 20 instances, is k-means clustering with k =2 guaranteed to find these two clusters? Explain why or why not.

2. Explain Basic decision tree learning algorithm for classification problems

3. Draw the decision tree structure for X1 XOR X2

**Course Outcome 4 (CO4):**

1. What is kernel trick? Why does the kernel trick allow us to solve SVMs with high dimensional feature spaces, without significantly increasing the running time?

2. Can you represent the following Boolean function with a single binary perceptron? If yes, show the weights. If not, explain why not in 1-2 sentences.

| A | B | f(A,B) |
|---|---|---|
| 1 | 1 | 0 |
| 0 | 0 | 0 |
| 1 | 0 | 1 |
| 0 | 1 | 0 |

3. Formulate the SVM regression problem using insensitive loss.

**Course Outcome 5 (CO5):**

1) Suppose that the datamining task is to cluster the following seven points (with (x,y) representing location) into two clusters A1(1,1), A2(1.5,2), A3(3,4), A4(5,7), A5(3.5,5), A6(4.5,5), A7(3.5,4.5) The distance function is City block distance. Suppose initially we assign A1,A5 as the centre for each cluster respectively. Using the K-means algorithm to find the three clusters and their centres after two round of execution.

2) Explain the concept of Reinforcement Learning with a practical example.

3) Draw the structure of CNN, and explain the classification process with an example.

**Model Question Paper** PAGES: 3

QP CODE:

Reg.No:____________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**SIXTH SEMESTER B. TECH DEGREE EXAMINATION**

**MONTH & YEAR**

Course Code**: 22EEE802.7**

Course Name: **MACHINE LEARNING**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Explain false negative, false positive, true negative and true positive with a simple example.
2. While using all features of a data set, if we achieve 100% accuracy on my training set, but ~70% on validation set, discuss whether we might see an underfitting, overfitting or perfect model? Please justify.
3. Differentiate a Perceptron and Logistic Regression?
4. Explain the difference between L1 and L2 regularization.
5. Can we design a neural network without an activation function? Justify your answer.
6. Is Occam's Razor an inductive bias scenario? State reasons with examples.
7. What are the standard use cases for Bayesian belief networks? What is its basic difference with respect to Hidden Markov Models?
8. We have designed an RBF kernel in SVM with high Gamma value. What does this signify?
9. In a binary classification problem, there are 3 models each with 70% accuracy. If we want to ensemble these models using majority voting method, what will be the maximum accuracy we can get?

0. What are the basic elements of reinforcement learning?

**PART B**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

Discuss the influence of model complexity on underfitting and overfitting? (7 Marks)

How do we measure the power of a classifier? What is the VC dimension for a linear classifier? (7 Marks)

List out the critical assumptions for applying linear regression, with emphasis to Heteroscedasticity. How can we improve the accuracy of a linear regression model? (9 Marks)

Discuss L1 and L2 regularization?

(5 Marks)

**Module 2**

Explain Naïve Bayes Classifier (10 Marks)

Discuss the inconsistencies in Bayesian inference (4 Marks)

What are the various multivariate learning techniques? Discuss with use cases and applications(7 Marks)

Suppose we have 3 cards identical in form except that both sides of the first card are colored red, both sides of the second card are colored black, and one side of the third card is colored red and the other side is colored black. The 3 cards are mixed up in a hat, and 1 card is randomly selected and put down on the ground. If the upper side of the chosen card is colored red, what is the probability that the other side is colored black? (7 Marks)

**Module 3**

Consider the following data where x and y are the 2 input variables and Class is the dependent variable. (10 Marks)

| $x$ | $y$ | Class |
|---|---|---|
| −1 | 1 | − |
| 0 | 1 | + |
| 0 | 2 | − |
| 1 | −1 | − |
| 1 | 0 | + |
| 1 | 2 | + |
| 2 | 2 | − |
| 2 | 3 | + |

Draw the scatter plot for this dataset in a two dimensional space. Assuming a Euclidian distance of in 3-NN, to which class will the new point of x=1 and y=1 belong to?

Write four termination conditions for k-means clustering algorithm(4 Marks)

Describe the expectation-maximization algorithm? (9 Marks)

Write short note on Random Forest Decision tree .

(5 Marks)

**Module 4**

Write the pseudo code for back propagation algorithm and explain? (10 Marks)

Differentiate CNN from RNN with respect to its use cases.

(4 Marks)

Discuss the geometric intuition behind SVMs. Discuss soft margin and hard margin SVMs (10 Marks)

When do you apply "Kernel Trick"? (4 Marks)

**Module 5**

In an election, N candidates are competing against each other and people are voting for either of the candidates. Voters don't communicate with each other while casting their votes. Which ensemble method works similar to above-discussed election procedure? (11 Marks)

Illustrate K-Arm bandit algorithm with an example
(3 Marks)

Discuss problem characteristics in the Reinforcement Learning method (5 Marks)

With an example, demonstrate the Q-Function and Q-Learning algorithm, assuming deterministic reward and action. (9 Marks)

## Syllabus

**Course objectives:**

Develop an appreciation for what is involved in learning models from data.

Understand a wide variety of learning algorithms.

Understand how to evaluate models generated from data.

Apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

**Module – 1**

**Introduction:** What Is Machine Learning? Examples of Machine Learning Applications, Learning Associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning

**Supervised Learning:** Learning a Class from Examples, Vapnik-Chervonenkis (VC) Dimension, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization

**Parametric Methods:** Maximum Likelihood Estimation, Evaluating an Estimator: Bias and Variance, Parametric Classification, Regression, Tuning Model Complexity and Model Validation: Bias/Variance Dilemma

Module – 2

**Bayesian Learning:** Introduction to conditional probability and conditional expectations, Bayes theorem, Bayes theorem and concept learning, ML and LS error hypothesis, ML for predicting probabilities, Naive Bayes classifier, Bayesian belief networks,

Multivariate Data, Multivariate Classification, Multivariate Regression

Module – 3

**Clustering:** Introduction, Mixture Densities, k-Means Clustering, Expectation-Maximization Algorithm, Other methods of clustering.

**Nonparametric Methods:** Nonparametric Density Estimation, Histogram Estimator, Kernel Estimator, k-Nearest Neighbor Estimator

**Decision Tree Based Learning:** Decision tree representation, Appropriate problems for decision tree learning, Basic decision tree learning algorithm, hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning

**Module – 4**

**Neural Networks:** Neural Networks as a Paradigm for Parallel Processing, Feed Forward Networks, Backpropagation Algorithm, Fundamentals of Deep Learning, Basic Deep Learning Architectures

**Local Models:** Competitive Learning, Radial Basis Functions, Incorporating Rule-Based Knowledge

**Kernel Machines:** SVM Formulations, Optimal Separating Hyperplane, The Nonseparable Case: Soft Margin Hyperplane, ν-SVM, Kernel Types, Kernel Machines for Regression

**Module – 5**

**Combining Multiple Learners:** Rationale, Generating Diverse Learners, Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging, Boosting

**Reinforcement Learning:** The State Space Theory, K-Armed Bandit, Elements of Reinforcement Learning, Q Learning

**TEXT BOOKS:**

Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006. [CB-2006]
Machine Learning. Tom Mitchell, McGraw-hill, 1997

**REFERENCE BOOKS:**

Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017. [SS-2017]
Haykin, Simon. Neural networks and learning machines, 3/E. Pearson Education India, 2010.
The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009. [TH-2009]
Foundations of Data Science. Avrim Blum, John Hopcroft and Ravindran Kannan. January 2017. [AB-2017]

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Module 1** | **(7 hours)** |
| 1.1 | What Is Machine Learning? Examples of Machine Learning Applications, Learning Associations, Classification, Regression, Unsupervised Learning, Reinforcement Learning | 2 |
| 1.2 | Supervised Learning: Learning a Class from Examples, Vapnik-Chervonenkis (VC) Dimension, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization | 2 |
| 1.3 | Parametric Methods: Maximum Likelihood Estimation, Evaluating an Estimator: Bias and Variance, Parametric Classification, Regression, Tuning Model Complexity and Model Validation: Bias/Variance Dilemma | 3 |
| **2** | **Module 2** | **(7 hours)** |
| 2.1 | Bayesian Learning: Introduction to conditional probability and conditional expectations, Bayes theorem, Bayes theorem and concept learning, ML and LS error hypothesis, | 3 |
| 2.2 | ML for predicting probabilities, Naive Bayes classifier, Bayesian belief networks, | 2 |
| 2.3 | Multivariate Data, Multivariate Classification, Multivariate Regression | 2 |
| **3** | **Module 3** | **(7 hours)** |

| | | |
|---|---|---|
| 3.1 | Clustering: Introduction, Mixture Densities, k-Means Clustering, Expectation-Maximization Algorithm, Other methods of clustering. | 2 |
| 3.2 | Nonparametric Methods: Nonparametric Density Estimation, Histogram Estimator, Kernel Estimator, k-Nearest Neighbor Estimator | 2 |
| 3.3 | Decision Tree Based Learning: Decision tree representation, Appropriate problems for decision tree learning, Basic decision tree learning algorithm, hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning | 3 |
| **4** | **Module 4** | **(7 hours)** |
| 4.1 | Neural Networks: Neural Networks as a Paradigm for Parallel Processing, Feed Forward Networks, Backpropagation Algorithm, Fundamentals of Deep Learning, Basic Deep Learning Architectures | 2 |
| 4.2 | Local Models: Competitive Learning, Radial Basis Functions, Incorporating Rule-Based Knowledge | 2 |
| 4.3 | Kernel Machines: SVM Formulations, Optimal Separating Hyperplane, The Nonseparable Case: Soft Margin Hyperplane, ν-SVM, Kernel Types, Kernel Machines for Regression | 3 |
| **5** | **Module 5** | **(7 hours)** |
| 5.1 | Combining Multiple Learners: Rationale, Generating Diverse Learners | 2 |
| 5.2 | Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging, Boosting | 2 |
| 5.3 | Reinforcement Learning: The State Space Theory, K-Armed Bandit, Elements of Reinforcement Learning, Q Learning | 3 |

**--------------- x -------------**

# SEMESTER VIII
# (PROGRAM ELECTIVE IV)

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEE803.1 | NONLINEAR SYSTEMS | PEC | 2 | 1 | 0 | 3 |

**Preamble:** Most of the systems that we come across are nonlinear. Nonlinear systems exhibit interesting oscillatory behaviours and indeed unexpected phenomena like limit cycles, bifurcation, chaos etc. The course aims in understanding the basic phenomena of limit cycles, determine their existence and non-existence in systems using various theorems. This course also aims to investigate the behaviour of nonlinear systems, analyze their stability using the Lyapunov direct/indirect methods, frequency-domain methods and design various control schemes. For understanding the concepts, a basic mathematical foundation is also built throughout the course.

The course will provide the basis for designing controllers for various applications such as aerospace, power systems, robotics, electric drives etc.

**Prerequisites: EET 302 Linear Control Systems and EET 401 Advanced Control Systems**

**Course Outcomes:** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Analyse the qualitative behaviour of nonlinear systems about their equilibrium points. |
| **CO 2** | Identify the existence and uniqueness of solutions of nonlinear differential equations, the existence of periodic orbits/limit cycles for nonlinear systems. |
| **CO 3** | Analyse the stability of nonlinear systems. |
| **CO 4** | Design feedback control systems for nonlinear systems. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 2** | 3 | 3 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 3** | 3 | 3 | - | - | - | - | - | - | - | - | - | 1 |
| **CO 4** | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 |

**Assessment Pattern:**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 15 | 15 | 30 |
| Apply (K3) | 25 | 25 | 50 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. **Part A** contains 10 questions with 2 questions from each module having 3 marks for each question. Students should answer all questions.

**Part B** contains 2 questions from each module of which student should answer anyone. Each question carries 14 marks and can have sub-divisions.

**Course Level Assessment Questions:**

**Course Outcome 1 (CO1)**

1. Discuss the characteristics of non-linear systems? (K1, PO1)
2. Model a given nonlinear system. (K2, PO1, PO12)
3. Identify and classify the equilibrium solutions of nonlinear systems. (K2, PO1)
4. Analyse the qualitative behaviour of a given system about its equilibrium points and plot a rough sketch of the phase portrait. (K3, PO2, PO12)
5. What are bifurcations? (K1, PO1)
6. Problems to identify the type of bifurcation. (Saddle-node and Pitchfork only) (K2, PO1)

**Course Outcome 2 (CO2):**

1. Identify the existence of limit cycles using the Poincare Bendixson theorem. (K3, PO2, PO12)
2. Identify the non-existence of limit cycles using Bendixson's theorem. (K3, PO2, PO12)
3. Problems to check the existence and uniqueness of initial value problems. (K2, PO2)

**Course Outcome 3 (CO3):**

1. Explain the concept of stability (local and global), instability in the sense of Lyapunov. (K2, PO1)
2. Apply Lyapunov direct/indirect methods to analyze the stability of nonlinear systems. (K3, PO2, PO12)
3. Analyze the stability using LaSalle's invariance theorem. (K3, PO2, PO12)
4. Construct Lyapunov functions using Variable gradient and Krasovskii's method. (K3, PO2)
5. Explain memoryless systems and passivity. (K1, PO1)

6. Examine whether a given system transfer function is positive real or not. (K2, PO1)
7. Explain sector nonlinearity and absolute stability. (K1, PO1)
8. Define KYP Lemma (without proof). (K1, PO1)
9. Examine the stability of the sector nonlinearity using Circle criterion. (K3, PO2)
10. Explain Popov criterion for stability. (K1, PO1)

**Course Outcome 4 (CO5):**

1. Define feedback control problem - state feedback and output feedback. (K1, PO1)
2. Use state feedback control law for stabilizing a given system. (K2, PO1)
3. Explain the concept of input-state and input-output linearization. (K1, PO1)
4. Examine whether a given system is input-output linearizable. (K3, PO2, PO12)
5. Explain stabilization via integral control. (K1, PO1)

**Model Question Paper** PAGES: 2

**QP CODE:**

Reg.No:_____________

Name:_______________

**TKM COLLEGE OF ENGINEERING**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION**

**MONTH & YEAR**

Course Code**: 22EEE803.1**

Course Name: **NONLINEAR SYSTEMS**

**Max. Marks: 100** **Duration: 3 Hours**

**PART A**

**Answer all questions**

**Each question carries 3 marks**

| | | |
|---|---|---|
| 1 | Qualitatively analyse the following nonlinear system about the equilibrium point<br>$\dot{y}+0.5\,\dot{y}+2\,y+y^2=0$ | 3 |
| 2 | What are limit cycles? Give significance and classify them based on stability. | 3 |
| 3 | Define Poincare Index theorem. Check whether there exist periodic orbits for the system defined below using Poincare index theorem.<br>$\dot{y}-y+y^3=0$ | 3 |
| 4 | State the conditions for uniqueness and existence of solutions. | 3 |
| 5 | Check the stability of the nonlinear system using Lyapunov direct method.<br>$\dot{x_1}=x_2$<br>$\dot{x_2}=-x_1-3x_2$ | 3 |
| 6 | What is meant by domain of attraction of a given system? | 3 |
| 7 | What are positive real transfer functions? Check whether G(s)= [s + 2] / [s + 3] is a positive real transfer function. | 3 |
| 8 | Define absolute stability. | 3 |
| 9 | Find the relative degree for the controlled Van der Pol equation with output $y=x_1$<br>$\dot{x_1}=x_2$<br>$\dot{x_2}=-x_1+\varepsilon\,(1-{x_1}^2)\,x_2+u,\ \ \epsilon>0$ | 3 |
| 10 | What is the concept of gain scheduling? | 3 |

**PART B**

**(Answer any one full question from each module)**

**Module 1**

11 a) Find the equilibrium points of the system defined by the system given below and determine the type of each isolated equilibrium point. 7

Also, plot a rough sketch of the qualitative behaviour near the equilibrium points.

$$\dot{x_1} = 5x_1 - x_1x_2$$

$$\dot{x_2} = 3x_2 + x_1x_2 - 3{x_2}^2$$

b) The nonlinear dynamic equation for a pendulum is given by $ml(\ddot{\theta}) = -mgsin(\theta) - kl(\dot{\theta})$ where '*l=1*' is the length of the pendulum, '*m*' is the mass of the bob, and $\theta$ is the angle subtended by the rod and the vertical axis through the pivot point. '*g*' is the gravitational constant. Choose '*k/m=1*'. Find all the equilibria of the system and determine if the equilibria are stable or not. 7

12 a What is saddle-node and Pitch fork bifurcation? 6

b) Obtain the linearized representation of the following system around the origin and check the stability of the linearised system about the origin. 8

$$\dot{x_1} = {x_2}^2 + x_1 cos\, x_2$$

$$\dot{x_2} = x_2 + (x_1 + 1)x_1 + x_1 sin\, x_2$$

**Module 2**

13 a Define a) Bendixson theorem 6

b) Poincare - Bendixson theorem

c Check whether the following functions are locally Lipchitz. Give reasons for your claim. 8

(*i*) $f(x,y) = 2xy^{1/3}$ for (x,y) = [0,0]

(ii) $f(t,x) = 2tx^2$ for (x,y) = [0,3]

14 a) Obtain the Lipschitz constant for 7

(i) $f(t, y) = -3y + 2$

(ii) $f(t, y) = 2ty^2$

b) Check whether the system given below has a stable or unstable limit cycle. 7

$$\dot{x_1} = x_2 - x_1({x_1}^2 + {x_2}^2 - 1)$$

$$\dot{x_2} = -x_1 - x_2({x_1}^2 + {x_2}^2 - 1)$$

**Module 3**

15 a) Explain the concept of the domain of attraction using an example. 5

c) Use variable gradient method to find a suitable Lyapunov function for the system given below 9

$$\dot{x_1} = -2x_1$$

$$\dot{x_1} = -2x_2 + 2x_1{x_2}^2$$

16 a Define stability in the sense of Lyapunov. What is the difference between asymptotic and exponential stability? 6

b) State LaSalle's invariance principle. Show that the origin is locally asymptotically stable for the following system using LaSalle's principle. 8

$$\dot{x_1} = x_2$$

$$\dot{x_2} = -3x_2 - {x_1}^3$$

## Module 4

17 a) What is KYP Lemma? 4

b) State circle criterion. Determine a stability sector from the Nyquist plot of the system using circle criterion. 10

$$G(s) = \frac{4}{(s-1)(s/3+1)(s/5+1)}$$

18 a) Using circle criterion, find a sector [a,b] for which the following system is absolutely stable. 8

$$G(s) = \frac{1}{(s+1)(s+2)(s+3)}$$

b) Describe Popov stability criterion. 6

## Module 5

19 a) Define the following terms 6
(i) Diffeomorphism (ii) Lie derivative

b) Check whether the given system can be input-output linearized for output $y = x_1$ 8

$$\dot{x_1} = x_1$$
$$\dot{x_2} = x_2 + u$$

20 a) What is input-output linearization? 6

b) With a suitable feedback control law, linearize the following system 8

$$\dot{x_1} = a \sin x_2$$

$$\dot{x_2} = -{x_1}^2 + u$$

## Syllabus

**Module 1**

**Introduction and background (7 hours)**

Non-linear system characteristics and mathematical modelling of a non-linear system, Classification of equilibrium points, Stability of a nonlinear system based on equilibrium points, Bifurcation (construction not included), Phase plane analysis of nonlinear systems.

**Module 2**

**Nonlinear characteristics (8 hours)**

Periodic solution of nonlinear systems and existence of limit cycle, Open sets, closed sets, connected sets, Invariant set theorem, Bendixson's theorem and Poincare-Bendixson criteria, Existence and uniqueness of solutions to nonlinear differential equations (Proofs not required), Lipschitz condition.

**Module 3**

**Stability Analysis (7 hours)**

Lyapunov stability theorems (Proofs not required)- local stability - local linearization and stability in the small- region of attraction, the direct method of Lyapunov, Construction of Lyapunov functions - Variable gradient and Krasovskii's methods, La Salles's invariance principle.

**Module 4**

**Analysis of feedback systems (8 hours)**

Passivity and loop transformations, KYP Lemma (Proof not required), Absolute stability, Circle Criterion, Popov Criterion.

**Module 5**

**Nonlinear control systems design (8 hours)**

Feedback linearization, Input state linearization method, Input-output linearization method, Stabilization - regulation via integral control- gain scheduling.

**Text Book:**

1. Khalil H. K., "Nonlinear Systems", 3/e, Pearson, 2002
2. Gibson J. E., "Nonlinear Automatic Control", Mc Graw Hill, 1963

3. Slotine J. E. and Weiping Li, "Applied Nonlinear Control", Prentice-Hall, 1991

**References:**

1. Alberto Isidori, "Nonlinear Control Systems: An Introduction", Springer-Verlag, 1985.
2. M. Vidyasagar, "Nonlinear Systems Analysis", Prentice-Hall, India, 1991.
3. Shankar Sastry, "Nonlinear System Analysis, Stability and Control", Springer, 1999.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction and background (7 hours)** | |
| 1.1 | Non-linear system characteristics and mathematical modelling of a non-linear system. | 2 |
| 1.2 | Classification of equilibrium points, Stability of a nonlinear system based on equilibrium points. | 2 |
| 1.3 | Bifurcation (construction not included), Phase plane analysis of nonlinear systems. | 3 |
| **2** | **Nonlinear characteristics (8 hours)** | |
| 2.1 | Periodic solution of nonlinear systems and existence of limit cycles | 2 |
| 2.2 | Open sets, closed sets, connected sets, Invariant set theorem, Bendixson's theorem and Poincare-Bendixson criteria | 4 |
| 2.3 | Existence and uniqueness of solutions to nonlinear differential equations (Proofs not required), Lipschitz condition. | 2 |
| **3** | **Stability Analysis (7 hours)** | |
| 3.1 | Lyapunov stability theorems (Proofs not required)- local stability - local linearization and stability in the small- region of attraction | 2 |
| 3.2 | The direct method of Lyapunov | 2 |
| 3.3 | Construction of Lyapunov functions, La Salles's invariance principle. | 3 |
| **4** | **Analysis of feedback systems (8 hours)** | |
| 4.1 | Passivity and loop transformations | 2 |

| | | |
|---|---|---|
| 4.2 | KYP Lemma (Proof not required), Absolute stability | 2 |
| 4.3 | Circle Criterion | 2 |
| 4.4 | Popov Criterion | 2 |
| **5** | **Nonlinear control systems design (8 hours)** | |
| 5.1 | Feedback linearization | 2 |
| 5.2 | Input state linearization method | 2 |
| 5.3 | Input-output linearization method | 2 |
| 5.4 | Stabilization - regulation via integral control- gain scheduling | 2 |

**Text Book:**

1. Khalil H. K, Nonlinear Systems, 3/e, Pearson
2. Gibson J.E. Nonlinear Automatic Control, Mc Graw Hill.
3. Slotine J. E and Weiping Li, Applied Nonlinear Control, Prentice-Hall,

**References:**


1. Alberto Isidori, “Nonlinear Control Systems: An Introduction”, Springer-Verlag, 1985.
2. M. Vidyasagar, “Nonlinear Systems Analysis”, Prentice-Hall, India, 1991.
3. Shankar Sastry, “Nonlinear System Analysis, Stability and Control”, Springer, 1999.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| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| **22EEE803.2** | **SPECIAL ELECTRICAL MACHINES** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble:** This course gives an overview of special electrical machines for control and industrial applications.

**Prerequisite: EET202 DC Machines and Transformers**

**EET307 Synchronous and Induction Machines**

**Course Outcomes:** After the completion of the course, the student will be able to:

| | |
|---|---|
| **CO 1** | Analyse the performance of different types of permanent magnet motors. |
| **CO 2** | Analyse the performance of a stepper motor. |
| **CO 3** | Analyse the performance of different types of reluctance motors. |
| **CO 4** | Explain the construction and principle of operation of servo motors, single phase motors and linear motors. |
| **CO 5** | Analyse the performance of linear induction motors. |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | - | - | - | 2 | - | - | - | - | - | 2 |
| **CO 2** | 3 | 2 | - | - | - | 2 | - | - | - | - | - | 2 |
| **CO 3** | 3 | 2 | - | - | - | 2 | - | - | - | - | - | 2 |
| **CO 4** | 3 | 2 | - | - | - | 2 | - | - | - | - | - | 2 |
| **CO 5** | 3 | 2 | - | - | - | 2 | - | - | - | - | - | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 15 | 15 | 30 |
| Understand | 25 | 25 | 50 |
| Apply | 10 | 10 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

**Part A:** 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the principle of operation of any motor.[K1, PO1]
2. List the permanent magnets used in motors and explain their magnetization characteristics. [K1, PO1]
3. Problems based on emf and torque of PMBLDC motor and PMSM. [K2, PO2]

**Course Outcome 2 (CO2):**

1. Explain the working of any type of stepper motor with a neat diagram. [K1, PO1]
2. Explain the different configurations for switching the phases of a stepper motor. [K2, PO1]
3. Numerical problems from stepper motors. [K2, PO2]

**Course Outcome 3(CO3):**

1. Derive the torque equation of any motor. [K2, PO1]
2. Draw the phasor diagram of a synchronous reluctance motor. [K1, PO1]
3. Explain any two power converter circuits used for the control of SRM. [K1, PO1]

**Course Outcome 4 (CO4):**

1. Explain the constructional details of any servo motor. [K1, PO1]
2. Discuss the role of servo motors in automation systems. [K2, PO12]
5. Explain the constructional details and working principle of any motor. [K1, PO1]

**Course Outcome 5 (CO5):**

1. Explain the principle of operation of a LIM. [K1, PO1]
2. What are the different types of Linear motors?. [K1, PO1]
3. Derive the thrust equation of a LIM. [K2, PO1]

Model Question paper

QP CODE: PAGES:

Reg. No:______________

Name:______________

**TKM COLLEGE OF ENGINEERING**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEE803.2**

**Course Name: SPECIAL ELECTRICAL MACHINES**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain the constructional details of PMBLDC Motor.
2. Explain the sensor less control of PMSM.
3. Define the following terms as applied to stepper motors (i) Holding Torque (ii) Step accuracy (iii) Detent position.
4. What is meant by micro stepping in stepper motors? What are its advantages?
5. Draw the torque -slip characteristics of a Reluctance motor and explain its shape.
6. Explain the drawbacks of a Switched Reluctance motor.
7. What are the applications of servo motors?
8. Draw and explain the performance characteristics of an ac servo motor.
9. Explain the working principle of a hysteresis motor.
10. Derive the expression for linear force in LIM.

**PART B (14 x5= 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. (a) Explain the principle of operation of the PMBLDC motor with a neat circuit diagram showing the complete drive circuit. (10 marks)
    (b) Differentiate trapezoidal and sinusoidal back emf permanent magnet motors. (4 marks)
12. (a) Explain the demagnetisation characteristics and choice of permanent magnets in a Brushless DC motor. (10 marks)
    (b) Explain the constructional details and working principle of the permanent magnet dc motor. (4 marks)

## Module 2

13. (a) With neat sketches, explain the constructional details and working principle of the variable reluctance stepper motor. (10 marks)

(b) List any four applications of stepper motors. (4 marks)

14. (a) A permanent magnet stepper motor is driven by a series of pulses of duration 20ms. It has 4 stator poles and 6 rotor poles. How long will it take for the motor to make a complete rotation? (4 marks)

(b) Compare variable reluctance, permanent magnet and hybrid stepper motors. (6 marks)

(c ) Explain monofilar and bifilar windings. (4 marks)

## Module 3

15. (a) With neat sketches explain the construction and operation of 8/6 SRM. (10 marks)

(b) Draw and explain n+1 switches and diode configuration power converter for the SRM. (4 marks)

16. (a) Derive the torque equation of a synchronous reluctance motor. ( 8 marks)

(b) Explain the basic principle of operation of a synchronous reluctance motor. (6 marks)

## Module 4

17. (a) With the help of a schematic diagram, explain the working of the field controlled d.c servomotor. (8 marks)

(b) Explain the working and applications of split field servomotors. (6 marks)

18. (a) Explain the constructional features and working principle of AC Servomotors. (10 marks)

(b) Explain the characteristic difference between AC and DC servomotors. (4 marks)

## Module 5

19. (a) Describe the properties of the materials used for the rotor construction of hysteresis motors. (5 marks)

(b) Why is compensating winding used in AC series motors? Draw a series motor with different types of compensating windings. (5 marks)

(c) What are the modifications to be made in the DC series motor to operate it in an AC supply? (4 marks)

20. (a) Develop the equivalent circuit of a LIM and describe the main factors affecting its performance. (10 marks)

(b) Explain the transverse edge effect in LIM. (4 marks)

## Syllabus

### Module 1 (8 hours)

**Permanent Magnet DC Motors** – construction – principle of operation.

**PM Brushless DC motor-** Brushless DC motor-construction - permanent magnets – different types- demagnetization characteristics – arrangement of permanent magnets – magnetization of permanent magnets – axial and parallel magnetizations- principle of operation – Control of BLDC motor - applications.

**Permanent Magnet Synchronous Motors**-construction - principle of operation –Control of PMSM - Self control - Sensor less Control– applications - Comparison with BLDC motors.

### Module 2 (7 hours)

**Stepper motors -** Basic principle - different types - variable reluctance, permanent magnet, hybrid type - principle of operation – comparison. Monofilar and bifilar windings - modes of excitation- static and dynamic characteristics- open loop and closed loop control of Stepper Motor-applications.

### Module 3 (7 hours)

**Synchronous Reluctance Motor -** Construction, principle of operation- phasor diagram - torque equation - applications.

**Switched reluctance motors -** principle of operation - torque equation – characteristics - power converter circuits - control of SRM - rotor position sensors- torque pulsations – sources of noise-noise mitigation techniques - applications.

### Module 4 (6 hours)

**DC Servo motors –** DC servo motors – construction– principle of operation - transfer function of field and armature controlled dc servo motors -permanent magnet armature controlled dc servo motor- series split field dc servo motor- applications.

**AC Servo motors -**Construction – principle of operation- performance characteristics - damped ac servo motors - Drag cup servo motors- applications.

### Module 5 (8 hours)

**Single Phase Special Electrical Machines-** AC series Motor, Repulsion Motor, Hysteresis Motor, Universal Motor- Construction - principle of operation - applications.

**Linear Electric Machines:** Linear motors – different types – linear reluctance motor- linear synchronous motors – construction – comparison.

**Linear Induction Motor** – Construction- Thrust Equation, Transverse edge and end effects- Equivalent Circuit, Thrust-Speed characteristics, Applications.

**Text Book**:

E. G. Janardhanan, '*Special Electrical Machines*' PHI Learning Private Limited.

**References:**


1. R. Krishnan, '*Permanent magnet synchronous and Brushless DC motor Drives*', CRC Press.
2. T. J. E. Miller, '*Brushless PM and Reluctance Motor Drives*', C. Larendon Press, Oxford.
3. Theodore Wildi, '*Electric Machines, Drives and Power Systems*', Prentice Hall India Ltd.
4. Veinott & Martin,' *Fractional & Sub-fractional hp Electric Motors*', McGraw Hill International Edn.
5. R. Krishnan, '*Switched Reluctance Motor Drives*', CRC Press.
6. K. Venkataratnam, '*Special Electrical Machines*', Universities Press.


**Course Contents and Lecture Schedule**

| No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Permanent Magnet DC Motors (8 hours)** | |
| 1.1 | Permanent Magnet DC Motors – construction – principle of operation. | 1 |
| 1.2 | Brushless DC motor-construction - permanent magnets – different types- demagnetization characteristics | 1 |
| 1.3 | Arrangement of permanent magnets – magnetization of permanent magnets – axial and parallel magnetizations- principle of operation | 2 |
| 1.4 | Control of BLDC motor- applications. | 1 |
| 1.6 | Permanent Magnet Synchronous Motors-construction- principle of operation | 1 |
| 1.7 | Control methods of PMSM-Self control- Sensorless Control -applications- Comparison with BLDC | 2 |
| **2** | **Stepper motors (7 hours)** | |
| 2.1 | Stepper motors – construction and principle of operation | 1 |
| 2.2 | different types - variable reluctance , permanent magnet, hybrid type - principle of operation – comparison | 2 |
| 2.3 | Windings - Monofilar and bifilar windings- modes of excitation- Full step on mode, two phase ON mode, Half step mode. | 2 |
| 2.4 | Static and dynamic characteristics | 1 |
| 2.5 | Open loop and closed loop control of Stepper Motor-applications. | 1 |
| **3** | **Reluctance motors (7 Hours)** | |
| 3.1 | Synchronous Reluctance Motor - Construction, principle of operation | 1 |
| 3.2 | Phasor diagram - torque equation- torque-slip characteristics- applications | 2 |
| 3.3 | Switched reluctance motors - principle of operation - torque equation- characteristics - power converter circuits . | 2 |
| 3.4 | Control of SRM - rotor position sensors- | 1 |

| | | |
|---|---|---|
| 3.5 | Torque pulsations – sources of noise- mitigation techniques - applications. | 1 |
| **4** | **Servo motors (6 Hours)** | |
| 4.1 | DC servo motors – construction– principle of operation - transfer function of field and armature controlled DC servomotors | 2 |
| 4.2 | Permanent magnet armature controlled - series split field DC servo motor- applications | 2 |
| 4.3 | **AC Servomotors -**Construction – principle of operation- performance characteristics | 1 |
| 4.4 | Damped AC servo motors - Drag cup servo motors- applications. | 1 |
| **5** | **Single Phase Special Electrical Machines- (8 Hours)** | |
| 5.1 | AC series Motor, Repulsion Motor, Hysteresis Motor, Universal Motor- Construction -principle of operation - applications. | 3 |
| 5.2 | **Linear Electric Machines:** Linear motors – different types | 1 |
| 5.3 | Linear reluctance motor , linear synchronous motors – construction – comparison. | 1 |
| 5.4 | Linear Induction Motor – Construction- Thrust Equation, Transverse edge and end effects | 2 |
| 5.5 | Equivalent Circuit, Thrust-Speed characteristics, Applications. | 1 |

| CODE<br><br>22EEE803.3 | POWER QUALITY | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PEC | 2 | 1 | 0 | 3 |

**Preamble:** The objective of this course is to introduce the fundamental concepts of power quality. This course covers different power quality issues and its mitigation methods.

**Prerequisite:** Nil

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Identify the sources and effects of power quality problems. |
| **CO 2** | Apply Fourier concepts for harmonic analysis. |
| **CO 3** | Explain the important aspects of power quality monitoring. |
| **CO 4** | Examine power quality mitigation techniques. |
| **CO 5** | Discuss power quality issues in grid connected renewable energy systems. |

**Mapping of course outcomes with program outcomes**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** | **PO 11** | **PO 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | - | - | - | 2 | - | 1 | - | - | - | 2 |
| **CO 2** | 3 | 3 | - | - | - | - | - | - | - | - | - | 2 |
| **CO 3** | 3 | 3 | - | - | 3 | - | - | - | - | - | - | 2 |
| **CO 4** | 3 | 3 | 2 | - | - | - | - | 1 | - | - | - | 2 |
| **CO 5** | 3 | 2 | - | - | - | - | - | - | - | - | - | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 20 | 20 | 40 |

| | | | |
|---|---|---|---|
| Understand | 20 | 20 | 40 |
| Apply | 10 | 10 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. What is meant by Power Quality? (K2, PO1, PO2, PO8)
2. Explain the sources and effects of different power quality problems. (K1, PO1, PO2, PO6, PO12)
3. Discuss the different types of power quality disturbances. (K1, PO1, PO2, PO12)

**Course Outcome 2 (CO2)**

1. Discuss the important sources of harmonics in the power network. (K1, PO1,PO2, PO12)
2. What are the effects of harmonics in the power system and other networks? (K2, PO1, PO2, PO12)
3. Conduct harmonic analysis using suitable methods. (K3, PO1, PO2)

**Course Outcome 3(CO3):**

1. Explain the important indices used to quantify harmonics in a power network? (K2, PO1, PO2)
2. Describe the key aspects of different power quality standards. (K2, PO1, PO2, PO12)
3. Discuss the objectives, features and measurement issues of different monitoring instruments. (K2, PO1, PO2, PO5, PO12)

**Course Outcome 4 (CO4):**

1. Design passive filters for mitigating harmonic distortion. (K3, PO1, PO2, PO3, PO8, PO12)
2. Discuss the important active filters used for harmonic suppression and sag/swell correction. (K2, PO1, PO2, PO12)
3. Explain the operation of a single phase active power factor converter. (K2, PO1, PO2)

**Course Outcome 5 (CO5):**

1. Discuss the configuration and working of shunt and series-shunt power quality conditioners. (K2, PO1, PO2)
2. Identify the important power quality issues associated with grid connected renewable energy systems. (K2, PO1, PO2, PO12)
3. Explain the operating conflicts in connection with grid connected renewable energy system. (K2, PO1, PO2, PO12)
4. Discuss the problems and its solutions associated with wiring and grounding. (K2, PO1, PO2, PO12)

**Model Question paper**

**QP CODE:**

PAGES:2

Reg.No:_______________
Name:_________________

**TKM COLLEGE OF ENGINEERING**
**SEVENTH SEMESTER B.TECH DEGREE EXAMINATION,**
**MONTH& YEAR**

**Course Code: 22EEE803.3**

**Course Name: POWER QUALITY**

**Max. Marks: 100** **Duration: 3 Hrs**

**PART A**

**Answer all questions. Each Question Carries 3 marks**

1. 'Power Quality is voltage quality'. Comment.
2. Differentiate between impulsive and oscillatory transients.
3. What do you mean by triplen harmonics and what are its effects in the power system?
4. Explain the generation of harmonics in the presence of non-linear loads.
5. Write short note on IEEE 519 standard.
6. Discuss the objectives of power quality monitoring.
7. List the merits and demerits of passive filters to reduce harmonic distortion.
8. Define Telephone Interference Factor.
9. What is meant by islanding? List the problems caused by it.
10. Describe the term Ground Loops. List solutions for mitigating this problem.

**PART B**

**Answer any one full question from each module. Each question carries 14 marks.**

**Module 1**

11. a) Explain the sources of voltage sag in a power network. (6)

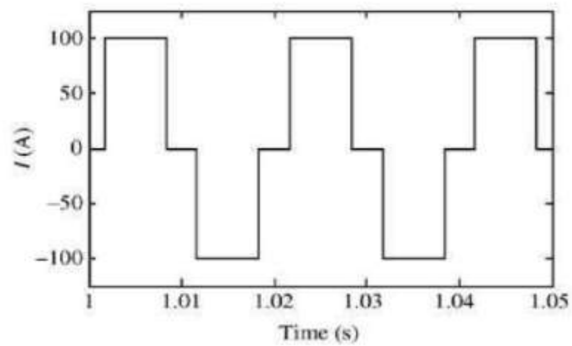
b) Discuss any four effects of power quality problems. (8)

12. What is meant by waveform distortions? Using neat diagrams, explain the five primary types of waveform distortion. (14)

**Module 2**

13. Explain the effects of power system harmonics on different components of power systems. (14)

14. For a quasi-square wave of (120° pulse width) of current with an amplitude I of 100A (shown in Fig), calculate (a) crest factor (CF), (b) distortion factor (DF), and (c) total harmonic distortion. (14)




**Module 3**

15. a) Define total harmonic distortion, distortion factor, total demand distortion and telephone influence factor. (8)

b) Derive the relationship between total power factor, distortion factor and displacement factor. (6)

16. a) How is RMS value computed by a power quality monitoring instrument? (7)

b) Describe the functionalities offered by a power quality analyzer. (7)

**Module 4**

17. a) Explain the working principle of DVR for sag and swell correction. (6)

b) A single-phase fully controlled bridge converter is fed from a supply of 230V at 50 Hz at a thyristor firing angle of 60°. Consider continuous load current of 200 A. Design a shunt passive filter with third, fifth, seventh and a ninth passive tuned filters. (8)

18. Draw the configuration of a unified power quality conditioner and show that it offers a single solution for mitigating multiple power quality problems. (14)

**Module 5**

19. Explain the operation of a PWM power factor correction circuit. Using a block diagram, explain the control logic of the same. (14)

20. Discuss the important solutions to wiring and grounding problems. (14)

## Syllabus (35 Hours)

**Module 1** **(7 hours)**

Power quality phenomenon - Sources and effects of power quality problems, Need for concern of Power quality, types of power quality disturbances –Transients – classification and origin, Short duration voltage variation – interruption, sag, swell, Long duration voltage variation, voltage unbalance, waveform distortion - notching, harmonics and voltage flicker

**Module 2** **(8 hours)**

Harmonics - mechanism of harmonic generation, Triplen harmonics, Harmonic sources – switching devices, arcing devices and saturable devices, Effects of harmonics on power system equipment and loads – transformers, capacitor banks, motors and telecommunication systems, Effect of triplen harmonics on neutral current, line and phase voltages.

Harmonic analysis using Fourier series and Fourier transforms – simple numerical problems

**Module 3** **(7 hours)**

Harmonic indices (CF, DF, THD, TDD, TIF, DIN, C – message weights), Displacement and total power factor

Overview of power quality standards: IEEE 519, IEEE 1433 and IEC 61000

Power quality Monitoring: Objectives and measurement issues, different monitoring instruments – Power quality analyzer, harmonic spectrum analyzer, flicker meters

**Module 4** **(7 hours)**

Mitigation of Power quality problems - Harmonic elimination - Design simple problems and analysis of passive filters to reduce harmonic distortion – demerits of passive filters –description of active filters - shunt, series, hybrid filters, sag and swell correction using DVR

Power quality conditioners - DSTATCOM and UPQC - Configuration and working

**Module 5** **(6 hours)**

Power factor correction – Single phase active power factor converter – circuit schematic and control block diagram

Power Quality issues of Grid connected Renewable Energy Systems – operating conflicts

Grounding and wiring– reasons for grounding – wiring and grounding problems - solutions to these problems

**Note:** It is encouraged to conduct assignments involving case studies to get hands-on experience of use of power quality instruments for power quality monitoring.

**Reference Books**

1.R. C. Dugan, M. F. Me Granaghen, H. W. Beaty, *‘Electrical Power System Quality’,* McGraw-Hill, 2012
2. Angelo Baggini (Ed.) *Handbook of Power Quality*, Wiley, 2008
3. C. Sankaran, *'Power Quality'*, CRC Press, 2002
4. G. T. Heydt, *‘Power Quality',* Stars in circle publication, Indiana, 1991
5. Jose Arillaga, Neville R. Watson, *‘Power System Harmonics',* Wiley, 1997
6. Math H. Bollen, ‘Understanding Power Quality Problems’ Wiley-IEEE Press, 1999
7. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, “Power Quality problems and mitigation techniques”, John Wiley and Sons Ltd, 2015.
8. Surajit Chattopadhyay, ‘Electric power quality’ – Springer, 2011

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures<br>**(35 Hours)** |
|---|---|---|
| 1 | **Power quality phenomenon** | **7** |
| 1.1 | Sources and effects of power quality problems | 2 |
| 1.2 | Need for concern of Power quality | 1 |
| 1.3 | Types of power quality disturbances – Transients – classification and origin | 1 |
| 1.4 | Short duration voltage variation – interruption, sag, swell | 1 |
| 1.5 | Long duration voltage variation, voltage unbalance | 1 |
| 1.6 | Waveform distortion - notching, harmonics and voltage flicker | 1 |
| 2 | **Harmonics** | **8** |
| 2.1 | Mechanism of harmonic generation | 1 |
| 2.2 | Harmonic sources – switching devices, arcing devices and saturable devices | 1 |
| 2.3 | Effects of harmonics on power system equipment and loads – transformers, capacitor banks, motors and telecommunication systems | 2 |
| 2.4 | Effect of triplen harmonics on neutral current, line and phase voltages. | 1 |

| | | |
|---|---|---|
| 2.5 | Harmonic analysis using Fourier series and Fourier transforms simple numerical problems | 3 |
| 3 | **Harmonic indices, PQ standard and monitoring** | **7** |
| 3.1 | Harmonic indices - CF, DF, THD, TDD, TIF | 1 |
| 3.2 | Harmonic indices - DIN, C – message weights, Displacement and total power factor | 1 |
| 3.3 | Overview of power quality standards: IEEE 519, IEEE 1433 and IEC 61000 | 2 |
| 3.4 | Power quality Monitoring: Objectives and measurement issues | 1 |
| 3.5 | Different monitoring instruments – Power quality analyzer, harmonic spectrum analyzer, flicker meters | 2 |
| 4 | **Mitigation of Power quality problems and Power factor correction** | **7** |
| 4.1 | Harmonic elimination – Design of passive filters simple problems | 1 |
| 4.2 | Analysis of passive filters | 1 |
| 4.3 | Demerits of passive filters –description of active filters - shunt, series, hybrid filters | 2 |
| 4.4 | Sag and swell correction using DVR | 1 |
| 4.5 | DSTATCOM and UPQC - Configuration and working | 2 |
| 5 | **Power quality conditioners, PQ in Grid connected RE systems, Grounding & Wiring** | **6** |
| 5.1 | Power factor correction – Single phase active power factor converter – circuit schematic and control block diagram | 1 |
| 5.2 | Power Quality issues of Grid connected Renewable Energy Systems | 1 |
| 5.3 | Operating conflicts | 1 |
| 5.4 | Grounding and wiring– reasons for grounding | 1 |
| 5.5 | Wiring and grounding problems - solutions to these problems | 2 |

| 22EEE803.4 | COMPUTER NETWORKS | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PEC | 2 | 1 | 0 | 3 |

**Preamble:** The course introduces main concepts of networking; application areas; classification; reference models; transmission environment; technologies; routing algorithms; OSI and TCP/IP protocols; Functions and purposes of various layers in networking: reliable data transferring methods; application protocols; network security; management systems; perspectives of communication networks.

**Prerequisite:** Nil

**Course Outcomes:** After the completion of the course, the student will be able to

| CO# | CO |
|---|---|
| 1 | Explain the computer networks, layered architecture, protocols and physical media used for setting up a network. |
| 2 | Identify the role of Data link layer, role of the MAC sub layer and networking devices in Ethernets and wireless LANs |
| 3 | Explain routing algorithms and congestion control algorithms and ways to achieve good quality of service. |
| 4 | Illustrate the IP address classes, ICMP protocols and other external routing protocols. |
| 5 | Explain the services provided by the transport layer and application layer. |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | | | | | | | | | | | |
| **CO2** | 2 | 1 | | | | | | | | | | |
| **CO3** | 2 | 1 | | | | | | | | | | |
| **CO4** | 2 | | | | | | | | | | | |
| **CO5** | 2 | | | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 15 | 15 | 30 |
| Understand | 25 | 25 | 50 |
| Apply | 10 | 10 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark Distribution**

| Total Marks | CIE Marks | ESE Marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test : 25 marks

Continuous Assessment Assignment : 15 marks

**End Semester Examination Pattern:**

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

## Course Level Assessment Questions

**Course outcome 1 (CO1) :**

1. Compare the OSI and TCP/IP reference model (K2, PO1).
2. Distinguish between Connection oriented and connectionless service (K3, PO1).
3. Explain various performance indicators of computer networks. (K2,PO1)

**Course outcome 2 (CO2) :**

1. Explain the role of the Data link layer in computer networks. (K2, PO1)
2. Discuss the sliding window protocol for error detection and correction (K2, PO1, PO2).
3. Explain the use of Switches, Routers and Gateways (K2,PO1).

**Course outcome 3 (CO3) :**

1. What is flooding? (K1, PO1)
2. Explain various routing algorithms (Any one algorithm may be asked) (K2, PO1,PO2)
3. Discuss how congestion control is done in computer networks. (K2, PO1, PO2)
4. What is meant by Quality of service? How can it be improved? (K1, PO1)
5. Compare the performance of various routing algorithms (K3,PO1).

**Course outcome 4 (CO4) :**

1. Describe the format of IPv4/IPv6 datagram with the help of a diagram, highlighting the significance of each field. (any one may be asked only). (K2, PO1)
2. Explain Subnetting with an example. (K2, PO1)
3. What is the advantage of using DHCP? (K1, PO1)
4. Explain Open Shortest Path First (OSPF) Protocol and Border Gateway Protocol (BGP). (Any one may be asked as a part question) (K2,PO1)

**Course outcome 5 (CO5) :**

1. Explain the UDP/TCP protocol. (K2,PO1)
2. What is RPC? (K1,PO1)
3. What is the use of DNS? (K1,PO1)
4. Explain how message transfer is done using SMTP. (K2,PO1)
5. Discuss the security issues of FTP. How can it be improved? (K2,PO1)

**Model Question Paper**

**QP CODE:** **PAGES: ___**

**Reg No:_______________**

**Name:_________________**

**TKM COLLEGE OF ENGINEERING**

**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEE803.4**

**Course Name : Computer Networks**

**Max Marks: 100** **Duration: 3 Hours**

**PART-A**

**(Answer All Questions. Each question carries 3 marks)**

| | | |
|---|---|---|
| **1.** | What is a VPN? | |
| **2.** | Discuss why fiber optic is preferred over copper wires, when you want to get higher bandwidth in the range of 100Mbps or higher. | |
| **3.** | What is the need for framing? | |
| **4.** | What is piggybacking? | |
| **5.** | Compare adaptive routing algorithms with the non-adaptive type. | |
| **6.** | What is jitter and discuss how it can affect various data transfer applications. | |
| **7.** | What is the urgent need for migrating to IPv6 from IPv4? | |
| **8.** | Discuss ARP. | |
| **9.** | What is the use of DNS? | |
| **10.** | What is FTP and discuss its security concerns. | **(10x3=<br>30 Marks)** |
| | **PART-B**<br>**(Answer any one Question. Each question carries 14 marks)** | |

| | | | |
|---|---|---|---|
| **11.** | | "Most networks are organized as a stack of layers or levels, each one built upon the one below it". Comment on why a layered approach is adopted with reference to the OSI and TCP/IP reference models. | |
| | **OR** | | |
| **12.** | a | Distinguish between Connection-Oriented and Connectionless Service | |
| | b | Explain the terms Bandwidth, Throughput, Latency, Bandwidth–Delay product. | |
| **13.** | | Suppose your organization is spread over 5 buildings in a 100 acre campus, and you are asked to set up an intranet with net connectivity. Discuss how you will set up the network highlighting the use of suitable physical media and various networking devices. A rough architecture diagram is expected. | |
| **OR** | | | |
| **14.** | | Explain CSMA/CD with reference to classic Ethernet LAN, | |
| **15.** | | Explain Link state routing. | |
| **OR** | | | |
| **16.** | | Discuss the various means by which congestion control can be achieved. | |
| **17.** | | Describe the format of IPv4 datagram with the help of a diagram, highlighting the significance of each field. | |
| **OR** | | | |
| **18.** | | Define Subnetting. What are the advantages of Subnetting? Explain with an example | |
| **19.** | | Compare TCP with UDP. | |
| **OR** | | | |
| **20.** | | Explain how message transfer is done using SMTP. | |

## Syllabus

**Module - 1 (Introduction and Physical Layer)**

Introduction – Uses of computer networks, Network hardware, Network software - Protocol hierarchies – Design issues for the layers – Connection oriented versus connectionless service. Reference models – The OSI reference model, The TCP/IP reference model, Comparison of OSI and TCP/IP reference models.

Physical Layer –Transmission media overview – Twisted pair and fiber optics. Performance indicators – Bandwidth, Throughput, Latency, Bandwidth–Delay product.

**Module - 2 (Data Link Layer)**

Data link layer - Data link layer design issues, Error detection and correction, Sliding window protocols.

Medium Access Control (MAC) sublayer, Channel allocation problem, Multiple access protocols – CSMA, Collision free protocols.

Ethernet – Switched Ethernet, fast Ethernet and gigabit Ethernet.

Wireless LANs - 802.11 – Architecture and protocol stack, Use of Bridges, Repeaters, Hubs, Switches, Routers and Gateways.

**Module - 3 (Network Layer)**

Network layer design issues. Routing algorithms - The Optimality Principle, Shortest path routing, Flooding, Distance Vector Routing, Link State Routing, Routing for mobile hosts.

Congestion control algorithms – Approaches to congestion control (Details not required).

Quality of Service (QoS) - Requirements, Techniques for achieving good QoS – Traffic shaping, Packet scheduling.

**Module - 4 (Network Layer in the Internet)**

IPv4 protocol, IP addresses, IPv6, Internet Control Protocols - Internet Control Message Protocol

(ICMP), Address Resolution Protocol (ARP), Dynamic Host Configuration Protocol (DHCP). Open Shortest Path First (OSPF) Protocol, Border Gateway Protocol (BGP), Internet multicasting.

**Module – 5 (Transport Layer and Application Layer)**

Transport service – Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP) – Introduction, Remote procedure call.

Transmission Control Protocol (TCP) – Introduction, TCP service model, TCP protocol, TCP segment header, Connection establishment & release.

Application Layer –Domain Name System (DNS) – overview of DNS name space and Name servers, Electronic mail – Architecture and services- SMTP – IMAP - POP3, World Wide Web (WWW) - Architectural overview, HTTP, File Transfer Protocol (FTP).

**Text Book**

1. Andrew S. Tanenbaum, Computer Networks, 5/e, Pearson Education India.
2. Behrouz A Forouzan, Data Communication and Networking, 5/e, McGraw Hill Education

**Reference Books**

1. Larry L Peterson and Bruce S Dave, Computer Networks – A Systems Approach, 5/e, Morgan Kaufmann.
2. Fred Halsall, Computer Networking and the Internet, 5/e.
3. James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 6/e.
4. Keshav, An Engineering Approach to Computer Networks, Addison Wesley, 1998.
5. W. Richard Stevens. TCP/IP Illustrated Volume 1, Addison-Wesley, 2005.
6. William Stallings, Computer Networking with Internet Protocols, Prentice-Hall, 2004.

**Course Contents and Lecture Schedule**

| No | Contents | No of Lecture Hrs |
|---|---|---|
| **Module – 1 (Introduction and Physical Layer) (7 hrs)** | | |
| 1.1 | Introduction – Uses of computer networks | 1 |
| 1.2 | Uses of computer networks, Network hardware | 1 |
| 1.3 | Network software - Protocol hierarchies – Design issues for the layers – Connection oriented versus connectionless service. | 1 |
| 1.4 | Reference models – The OSI reference model, The TCP/IP reference model | 1 |
| 1.5 | Reference models, Comparison of OSI and TCP/IP reference models. | 1 |
| 1.6 | Physical Layer – Transmission media overview – Twisted pair and fiber optics. | 1 |
| 1.7 | Performance indicators – Bandwidth, Throughput, Latency, Bandwidth–Delay product. | 1 |
| **Module 2 – (Data Link Layer) (8 hrs)** | | |
| 2.1 | Data link layer - Data link layer design issues | 1 |
| 2.2 | Error detection and correction | 1 |
| 2.3 | Sliding window protocols. | 1 |
| 2.4 | Sliding window protocols, Medium Access Control (MAC) sublayer. | 1 |
| 2.5 | Channel allocation problem, Multiple access protocols – CSMA | 1 |
| 2.6 | Collision free protocols. | 1 |
| 2.7 | Ethernet – Switched Ethernet, fast Ethernet and gigabit Ethernet.<br>Wireless LANs - 802.11 – Architecture and protocol stack | 1 |
| 2.8 | Use of Bridges, Repeaters, Hubs, Switches, Routers and Gateways. | 1 |

| | | |
|---|---|---|
| **Module 3 - (Network Layer) (6 hrs)** | | |
| 3.1 | Network layer design issues. | 1 |
| 3.2 | Routing algorithms, The Optimality Principle, Shortest path routing, Flooding. | 1 |
| 3.3 | Distance Vector Routing. | 1 |
| 3.4 | Link State Routing. | 1 |
| 3.5 | Routing for mobile hosts, Congestion control algorithms – Approaches to congestion control (Details not required). | 1 |
| 3.6 | Quality of Service (QoS) - Requirements, Techniques for achieving good QoS – Traffic shaping, Packet scheduling. | 1 |
| **Module 4 – (Network Layer in the Internet) (7 hrs)** | | |
| 4.1 | Internet Protocol (IP) - IPv4 protocol | 1 |
| 4.2 | IP addresses. | 1 |
| 4.3 | IP addresses – part 2 | 1 |
| 4.4 | IPv6 | 1 |
| 4.5 | Internet Control Protocols - Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Dynamic Host Configuration Protocol (DHCP). | 1 |
| 4.6 | Open Shortest Path First (OSPF) Protocol. | 1 |
| 4.7 | Border Gateway Protocol (BGP), Internet multicasting. | 1 |
| **Module 5 - ( Transport Layer and Application Layer) (7 hrs)** | | |
| 5.1 | Transport service – Services provided to the upper layers Transport service primitives. | 1 |
| 5.2 | User Datagram Protocol (UDP) – Introduction, Remote procedure call. | 1 |
| 5.3 | Transmission Control Protocol (TCP) – Introduction, TCP service model, TCP protocol | 1 |
| 5.4 | TCP segment header, Connection establishment & release. | 1 |

| | | |
|---|---|---|
| 5.5 | Application Layer –Domain Name System (DNS) – overview of DNS name space and Name servers | 1 |
| 5.6 | Electronic mail – Architecture and services- SMTP – IMAP - POP3 | 1 |
| 5.7 | World Wide Web (WWW) - Architectural overview, HTTP, File Transfer Protocol (FTP). | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEE803.5** | **Design of Power Electronic Systems** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble** : To impart knowledge about the design and protection of power electronic systems.

**Prerequisite** : EET306 Power Electronics

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Design gate drive circuits for various power semiconductor switches. |
| **CO 2** | Design protection circuits for various semiconductor devices. |
| **CO 3** | Select appropriate passive components for power electronic circuits. |
| **CO 4** | Design the magnetic components for power electronic circuits. |
| **CO 5** | Design signal conditioning circuits and passive filters for converters. |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | 2 |
| **CO 2** | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | 2 |
| **CO 3** | 3 | 3 | - | - | - | - | - | - | - | - | - | 2 |
| **CO 4** | 3 | 3 | 3 | 2 | - | - | - | - | - | - | - | 2 |
| **CO 5** | 3 | 2 | 3 | 2 | - | - | - | - | - | - | - | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 10 | 10 | 20 |
| Apply (K3) | 20 | 20 | 50 |
| Analyse (K4) | 10 | 10 | 10 |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Design a gate/base drive using totem pole arrangement (K1, K3, PO1, PO2, PO4)
2. Design a gate drive using a non-isolated circuit (K1, K3, PO1, PO2, PO4)
3. Design high side and low side switch drives using isolated gate drivers (K1, K3, PO1, PO2, PO4)
4. Explain the boot-strap technique for gate drives using gate drive IC IR 2110 (K1, K2, PO1)

**Course Outcome 2 (CO2):**

1. Design a turn-off and turn-on snubber circuit for SCR (K1, K3, PO1, PO2, PO4)
2. Design a Snubber circuit for a buck converter (K1, K3, PO1, PO2, PO4)
3. Describe the thermal protection, short-circuit and over-current protection in IGBTs (K1, K2, PO1)
4. Explain the steps for the design of heat sinks (K1, K2, PO1)

**Course Outcome 3 (CO3):**

1. Explain the different types of inductor and transformer assembly (K1, PO1)
2. Explain the types of capacitors used in power electronic circuits and their selection (K1, K2, PO1)
3. Explain the effect of equivalent series resistance and equivalent series Inductance of capacitors in converter operation (K4, PO1)
4. Explain the filter design for single phase and three phase inverters (K3, PO1, PO2)
5. Describe the various types of power resistors used in power electronic circuits (K1, PO1)

**Course Outcome 4 (CO4):**

1. Describe the selection of amorphous, ferrite and iron cores used in power electronic circuits. (K1, K2)
2. Explain the Inductor design in power electronics circuits (K3)
3. Explain the transformer design in power electronics circuits (K3)
4. Explain the wire selection and skin effect in power electronics circuits (K1, K2)

**Course Outcome 5 (CO5):**

1. Explain the design of current transformers, resistive shunts, hall-effect based voltage and current sensors for power electronics circuits (K2, K3, PO1)
2. Design input and output filters for single phase and three phase inverters (K3, PO1, PO2, PO4)
3. Explain the corner frequency selection and harmonic filtering performance in inverter circuits (K2, K4, PO1)
4. Explain the various components in an Intelligent Power Module (K1, K2, PO1)

**Model Question paper**

**QP CODE:**

PAGES:2

Reg.No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,**
**MONTH & YEAR**
**Course Code: 22EEE803.5**

**Course Name: DESIGN OF POWER ELECTRONIC SYSTEMS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. A MOSFET has an input capacitance Ciss = 800 pF. A gate resistance of 250 Ω is used along with a gate drive voltage peak of 12 V. If the threshold gate voltage is Vgs(th) = 4 V, how long will it take this gate signal to turn on the MOSFET?
2. Design a gate drive using non-isolated and isolated circuits.
3. Design a turn-off and turn-on snubber circuit for SCR.
4. Design a Snubber circuit for a buck converter.
5. Explain the different types of inductor and transformer assembly.
6. Explain the types of capacitors used in power electronic circuits and their selection.
7. Describe the selection of amorphous, ferrite and iron cores used in power electronic circuits.
8. Explain the Inductor design in power electronics circuits.
9. Design current transformers, resistive shunts, hall-effect based voltage and current sensors for power electronics applications.
10. Design input and output filters for single phase and three phase inverters.

**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a) Design high side switch drive using isolated gate drivers. **(6)**

    b) Design low side switch drive using isolated gate drivers. **(8)**

12. a) Explain the boot-strap technique for gate drive design using gate drive IC IR 2110 **(8)**

    b) Design a gate drive circuit for IGBT **(6)**

## Module 2

13. a) Describe the thermal protection in IGBTs. **(10)**
    b) Explain the steps for the design of heat sinks. **(4)**

14. a) Describe the short-circuit protection in IGBTs **(7)**
    b) Describe the over-current protection in IGBTs **(7)**

## Module 3

15. a) Two capacitor values are made by a manufacturer. The two have similar size, and each has an ESL of 20 nH, and tan δ=0.2. One is 1000 µF and the other is 100 µF. Evaluate their ESRs and resonant frequencies. If 10 numbers of 100 µF capacitors are paralleled to make 1000 µF, evaluate the ESR, ESL and the resonant frequency of the paralleled combination. Which (a single 1000 µF or a parallel combination of 10 numbers of 100 µF), is better in terms of operating frequency? (**10)**
    b) Explain the filter design for single phase and three phase inverters. **(4)**

16. a) Describe the various types of power resistors used in power electronic circuits. **(6)**
    b) Explain the effect of equivalent series resistance of capacitor **(8)**

## Module 4

17. a) Design high frequency transformer in power electronics circuits. **(8)**
    b) Explain the wire selection in power electronics circuits. **(6)**

18. a) A 2 mH inductor design for dc applications is as follows, for a maximum current of 0.5A: Core: 26x19; Aw = 40mm2, AC = 90mm2; N=37; aw = 0.29mm2 (23 SWG). For the above core and windings and N, evaluate the peak flux density, peak current density, window space factor (kw), and the inductance value, for air gap values of 0.08mm and 1mm. **(10)**
    b) Explain the thermal considerations in power electronic circuits. **(4)**

## Module 5

19. a) Explain the corner frequency selection in inverter circuits **(8)**
    b) Explain the various components in an Intelligent Power Module **(6)**

20. a) Explain the harmonic filtering performance in inverter circuits **(8)**
    b) Explain the methods for reducing stray inductance in power electronic circuits **(6)**

## Syllabus

**Module 1 (8 hours)**

**Gate and base drive design**: Gate drive requirements and gate/base drive design for SCRs, BJTs, MOSFETs, IGBTs-Gate drive design using discrete components - open collector, totem pole, non-isolated and isolated- optocoupler, pulse transformer based, use of ICs such as DS0026, TLP250- High side and low side switch driving using isolated gate drivers. Boot-strap technique for gate drives using gate drive IC IR 2110.

Major references: Ref.1, Ref.2, Ref.3

**Module 2 (7 hours)**

**Design of protection elements**: Snubber circuits: Function and types of Snubber circuits, design of turn -off and turn-on snubber. Snubber design for step-down converter. Short-circuit and over-current protection in IGBTs, desaturation protection. Thermal protection, cooling, design and selection of heat sinks (natural cooling only).

Major references: Ref.1, Ref.2,

**Module 3 (7 hours)**

**Passive elements in Power electronics**: Inductors: types of inductors and transformer assembly-. Capacitors: types of capacitors used in power electronic circuits, selection of capacitors, dc link capacitors in inverters, filter capacitors in dc-dc and inverter circuits, equivalent series resistance and equivalent series Inductance of capacitors and their effects in converter operation. Design of filters - input and output filters - typical filter design for single phase and three phase inverters - LC filter - corner frequency selection - harmonic filtering performance – design constraints. Resistors: power resistors, use in snubbers. Resistors for special purpose: high voltage resistors and current shunts.

Major references: Ref.1, Ref.4,

**Module 4 (7 hours)**

**Magnetics design**: Magnetic materials and cores: amorphous, ferrite and iron cores-Inductor and transformer design based on area-product approach. Magnetic characteristics and selection based on loss performance and size, eddy current and hysteresis loss. Thermal considerations, leakage inductance, comparison of sizes of transformer and inductor, wire selection and skin effect.

Major References: Ref.1,2,3,5,6

**Module 5 (7 hours)**

**Measurements and signal conditioning:** Design of current transformers for power electronic applications, resistive shunts, hall-effect based voltage and current sensors, typical design based on hall-effect sensors, signal conditioning circuits- level shifters, anti-aliasing filters. Minimizing stray inductance in drive circuit, shielding and portioning of drive circuit, reduction of stray inductance in bus bar. Introduction to Intelligent Power Module.

Major References: Ref.6

**Assignments/ course projects may be given based on the topic: Demonstrative design of a converter such as Buck converter/ Flyback converter.**

**References:**


1. Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters, Applications & Design, Wiley-India, 2002.
2. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India, 2009.
3. V. Ramanarayanan, Course material on 'Switched mode power conversion' 2007.
4. Daniel W. Hart, Power Electronics, Tata McGraw-Hill Education, 2011.
5. Erickson, Robert W., and Maksimovic, Dragan, Fundamentals of Power Electronics, 1997.
6. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
7. Joseph Vithayathil, Power Electronics: Principles and Applications, McGraw-Hill College; International edition, 1995.

Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.

Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education, 2014.

10. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 1990.


**Course Contents and Lecture Schedule:**

| **No.** | **Topic** | **No. of Lectures** |
|---|---|---|
| **1** | **Design of gate and base drive circuits (8 hours)** | |
| 1.1 | Gate drive requirements and gate drive design for SCRs, BJTs, MOSFETs, IGBTs. | 3 |
| 1.2 | Gate drive design using discrete components. | 3 |
| 1.3 | High side and low side switch driving using isolated gate drivers. | 1 |
| 1.4 | Boot-strap technique for gate drives using gate drive IC IR 2110. | 1 |
| **2** | **Design of protection elements (7 hours)** | |
| 2.1 | Snubber circuits: Function and types of Snubber circuits, design of turn off and turn-on snubber. | 2 |
| 2.2 | Snubber design for step-down converter. | 2 |
| 2.3 | Short-circuit and over-current protection in IGBTs, desaturation protection. | 1 |
| 2.4 | Thermal protection, cooling, design and selection of heat sink (natural cooling only). | 2 |
| **3** | **Passive elements in Power electronics (7 hours)** | |

| | | |
|---|---|---|
| 3.1 | Inductors: types of inductors and transformer assembly. | 1 |
| 3.2 | Capacitors: types of capacitors used in power electronic circuits, selection of capacitors. | 1 |
| 3.3 | DC link capacitors in inverters, filter capacitors in dc-dc and inverter circuits, equivalent series resistance and equivalent series Inductance of capacitors and their effects in converter operation. | 2 |
| 3.4 | Design of filters: input and output filters - typical filter design for single phase and three phase inverters - LC filter - corner frequency selection - harmonic filtering performance – design constraints. | 2 |
| 3.5 | Resistors: power resistors, their use in snubbers. Resistors for special purpose: high voltage resistors and current shunts. | 1 |
| **4** | **Magnetics design (7 hours)** | |
| 4.1 | Magnetic materials and cores: amorphous, ferrite and iron cores. | 1 |
| 4.2 | Inductor and transformer design based on area-product approach. | 3 |
| 4.3 | Magnetic characteristics and selection based on loss performance and size, eddy current and hysteresis loss. | 1 |
| 4.4 | Thermal considerations, leakage inductance, comparison of sizes of transformer and inductor, wire selection and skin effect. | 2 |
| **5** | **Measurements and signal conditioning (7 hours)** | |
| 5.1 | Design of current transformers for power electronic applications, resistive shunts. | 2 |
| 5.2 | Hall-effect based voltage and current sensors, typical design based on hall-effect sensors. | 1 |
| 5.3 | Signal conditioning circuits- level shifters, anti-aliasing filters. | 2 |
| 5.4 | Minimizing stray inductance in drive circuit, shielding and portioning of drive circuit, reduction of stray inductance in bus bar. | 1 |
| 5.5 | Introduction to Intelligent Power Module. | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEE803.6** | **HVDC AND FACTS** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble** : This course introduces HVDC concepts and analysis of HVDC systems. It also provides a detailed study of FACTS devices.

**Prerequisite** : **Nil**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Analyse current source and voltage source converters for HVDC systems |
| **CO 2** | Describe the control schemes for HVDC systems |
| **CO 3** | Explain the need for FACTS devices |
| **CO 4** | Classify reactive power compensators in power system |
| **CO 5** | Interpret series and shunt connected FACTS devices for power system applications |
| **CO 6** | Explain the dynamic interconnection mechanisms of FACTS devices |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | 2 | | | | | | | |
| **CO 2** | 3 | 3 | | | 2 | | | | | | | |
| **CO 3** | 3 | 3 | | | 2 | | | | | | | |
| **CO 4** | 3 | 3 | | | 2 | | | | | | | |
| **CO 5** | 3 | 3 | | | 2 | | | | | | | |
| **CO 6** | 3 | 3 | | | 2 | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 20 | 20 | 40 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 10 | 10 | 20 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**Mark Distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Discuss the advantages of HVDC over HVAC (K2, PO1)
2. Explain various types of HVDC system (K2, PO1)
3. Explain various converters in HVDC system(K2, PO2)

**Course Outcome 2 (CO2):**

1. Discuss the control basics of two terminal link (K2, PO1)
2. Explain static $V_d$-$I_d$ characteristics of a HVDC system (K2, PO1)
3. Derive equivalent circuit of a two terminal HVDC link (K3, PO2)

**Course Outcome 3 (CO3):**

1. What is meant by voltage regulation? (K1,PO1, PO2)
2. With neat diagrams explain the effect of phase angle compensation (K2,PO1,PO2)

**Course Outcome 4 (CO4):**

1. Explain the principle of TSC. Also explain the effect of initial charge of the capacitor in TSC. (K2, PO1, PO2)
2. Explain the principle and operation of STATCOM(K2, PO1, PO2)

**Course Outcome 5 (CO5):**

1. Explain with a neat circuit and necessary waveforms, the operation of IPFC. (K2, PO1,PO2)
2. Explain the applications UPFC (K2, PO1)

**Model Question paper**

**QP CODE:**

PAGES: 2

Reg. .No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**EIGHTH SEMESTER B. TECH DEGREE EXAMINATION,**
**MONTH & YEAR**

**Course Code: 22EEE803.6**

**Course Name: HVDC AND FACTS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain the advantages of HVDC transmission system over HVAC.
2. What will be the effect on the Short Circuit MVA of a bus if an additional HVDC line is connected to that bus?
3. Enumerate the functions of HVDC control.
4. Discuss any one method for extinction angle control in HVDC.
5. Why are FACTS controllers needed in AC power transmission systems?
6. Explain the effect of series compensation
7. Explain TSR controller with necessary waveforms
8. Explain with neat circuit and necessary waveforms, the operation of TSSC
9. Give the comparisons between UPFC and IPFC
10. Explain the working principle of Thyristor Controlled phase angle Regulator

**PART B (14 x 5 = 70 Marks)**
**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a) Derive average output voltage of a 6 pulse converter with overlap **(10)**
 b) Compare CSC and VSC. **(4)**
12. a) Explain VSC with AC voltage control with the help of schematic. **(10)**
 b) Discuss the effect of delay angle in the reactive power requirement, in a HVDC system. **(4)**

## Module 2

13. a) Derive equivalent circuit of a two terminal HVDC link **(10)**

b) Explain the hierarchy of controls in HVDC system. **(4)**

14. a) Explain static $V_d$-$I_d$ characteristics of a HVDC system. **(10)**

b) Draw the schematic of current control at the rectifier end. **(4)**

## Module 3

15. a) Explain the effect of shunt compensation with neat diagrams **(8)**

b) Give the comparisons between series and shunt compensators **(6)**

16. a) What is meant by power quality and voltage regulation? Explain its significance in power systems **(10)**

b) List out different types of FACTS controllers. **(4)**

## Module 4

17. Explain TCR controller. What are the different methods to eliminate harmonics? **(14)**

18. (a)Explain the principle and operation of SSSC compensation **(4)**

(b)Explain with diagrams, the different modes of TCSC controller **(10)**

## Module 5

19. a) With neat diagram, explain the modes of operation of UPFC **(8)**

b)Explain with neat circuit, the operation of IPFC **(6)**

20. a) Explain the working principle of Thyristor Controlled Voltage e Regulator **(4)**

b) Explain the independent reactive power flow control (P&Q) characteristic of UPFC (**10)**

## Syllabus

### Module 1

### Introduction to HVDC System

Comparison of AC and DC Transmission - Types of HVDC system - Current Source Converters - Analysis without and with overlap period. Voltage Source Converters (VSC) - VSC with AC current control and VSC with AC voltage control

### Module 2

HVDC Controls - Functions of HVDC Controls - Equivalent circuit for a two terminal DC Link - Control Basics for a two terminal DC Link - Current Margin Control Method - Current Control at the Rectifier - Inverter Extinction Angle Control - Hierarchy of Controls

### Module 3

### Introduction to FACTS

Power flow in Power Systems – Voltage regulation and reactive power flow control in Power Systems - Power flow control -Constraints of maximum transmission line loading - Needs and emergence of FACTS - Types of FACTS controllers-Advantages and disadvantages

Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control.

### Module 4

### Shunt and Series Facts Devices

Static shunt Compensator - Objectives of shunt compensations - Variable impedance type VAR Generators -TCR, TSR, TSC, FC-TCR (Principle of operation and schematic) and -STATCOM (Principle of operation and schematic).

Static Series compensator - Objectives of series compensations-Variable impedance type series compensators - GCSC. TCSC, TSSC (Principle of operation and schematic)

Switching converter type Series Compensators-(SSSC) (Principle of operation and schematic)

### Module 5

### UPFC AND IPFC

Unified Power Flow Controller: Circuit Arrangement, Operation of UPFC- Basic principle of P and Q control- independent real and reactive power flow control- Applications

Introduction to interline power flow controller (IPFC) (Principle of operation and schematic)

Thyristor controlled Voltage and Phase angle Regulators (Principle of operation and schematic)

*Note: Simulation assignments may be given in MATLAB, SCILAB, PSAT, ETAP, PSCAD, etc.*

**Text Books**

1. Vijay K Sood, “HVDC and FACTS Controllers”, Springer, 2004
2. N.G. Hingorani and L.Gyugyi, “Understanding FACTS”, IEEE Press 2000

**References:**

1. K.R.Padiyar, “High Voltage DC Transmission”, Wiley 1993
2. Y.H. Song and A.T.Jones, “Flexible AC Transmission systems (FACTS)”, IEEE Press 1999.
3. K.R.Padiyar, “FACTS Controllers in Power Transmission and distribution”, New age international Publishers 2007.
4. T.J.E. Miller, “Reactive Power control in Power systems”, John Wiley 1982.
5. C.L.Wadhwa, “Electric Power Systems”, New Academic Science Limited, 1992

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **HVDC Converters(6 hours)** | |
| 1.1 | Comparison of AC and DC Transmission Systems - Costs, Technical considerations and reliability | 1 |
| 1.2 | Types of HVDC Links | 1 |
| 1.3 | Current Source Converters | 2 |
| 1.4 | Voltage Source Converters | 2 |
| **2** | **HVDC Controls (7hours)** | |
| 2.1 | Function of HVDC Controls | 1 |
| 2.2 | Control Basics of two terminal DC Link | 2 |
| 2.3 | Current Margin Control Method | 1 |
| 2.4 | Current Control at the rectifier | 1 |
| 2.5 | Inverter Extinction Angle Control | 1 |
| 2.6 | Hierarchy of Controls | 1 |
| **3** | **Introduction to FACTS (6 hours)** | |

| | | |
|---|---|---|
| 3.1 | Power flow in Power Systems – Voltage regulation and reactive power flow control in Power Systems - Power flow control -Constraints of maximum transmission line loading | 2 |
| 3.2 | Needs, emergence of FACTS- Types of FACTS controllers-Advantages and disadvantages | 2 |
| 3.3 | Transmission line compensation- Uncompensated line shunt compensation - Series compensation -Phase angle control. (line diagram, vector diagram and expression for P and Q) | 2 |
| **4** | **Shunt and Series Facts Devices (8 Hours)** | |
| 4.1 | Static shunt Compensator - Objectives of shunt compensations, | 1 |
| 4.2 | Variable impedance type VAR Generators -TCR , TSR, TSC, FC-TCR (Principle of operation and schematic) | 2 |
| 4.3 | STATCOM- Principle of operation-and schematic | 1 |
| 4.4 | Static Series compensator - Objectives of series compensations | 1 |
| 4.5 | Variable impedance type series compensators - GCSC. TCSC, TSSC - Principle of operation and schematic | 2 |
| 4.6 | Switching converter type Series Compensators-(SSSC)- Principle of operation and schematic | 1 |
| **5** | **UPFC AND IPFC (7 Hours)** | |
| 5.1 | Unified Power Flow Controller: Circuit Arrangement, Operation of UPFC- | 2 |
| 5.2 | Basic principle of P and Q control- independent real and reactive power flow control- Applications | 2 |
| 5.3 | Introduction to interline power flow controller (IPFC). | 1 |
| 5.4 | Thyristor controlled Voltage and Phase angle Regulators -Principle of operation | 2 |

| CODE<br><br>22EEE803.7 | ADVANCED ELECTRONIC DESIGN | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PEC | 2 | 1 | 0 | 3 |

**Preamble:** This course makes a student capable to design a system that senses a physical quantity, condition the sensed signal and digitally measure it.

**Prerequisite: EET205 (Analog Electronics), EET303 (Microprocessors and microcontrollers)**

**Course Outcomes:** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Analyse the frequency response characteristics of op-amps along with its circuit properties. |
| **CO 2** | Develop advanced op-amp circuits which serve as building blocks to more complex digital and analog circuits. |
| **CO 3** | Design active filters as per situational and system demands. |
| **CO 4** | Develop sensor circuits for physical quantity measurements. |
| **CO 5** | Design the microcontroller interfacing with analog domain for real world applications. |

**Mapping of course outcomes with program outcomes**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** | **PO 11** | **PO 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 2 | | 1 | | | | | | | |
| **CO 2** | 3 | 2 | 2 | 1 | 1 | | | | | | | |
| **CO 3** | 3 | 2 | 2 | 1 | 1 | | | | | | | |
| **CO 4** | 3 | 2 | 2 | 1 | 1 | | | | | | | |
| **CO 5** | 3 | 2 | 2 | 1 | 1 | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember | 10 | 10 | 20 |
| Understand | 20 | 20 | 40 |
| Apply | 20 | 20 | 40 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the frequency response characteristics of an op-amp. (K1, K2, PO1, PO2)

2. Examine the gain frequency relationships of an op-amp. (K1, K2, PO1, PO2)

3. List the non idealities in frequency response resulting in circuit applications. (K1, K2, PO1, PO4)

**Course Outcome 2 (CO2)**

1. Design precision rectifier circuit and voltage to current conversion circuit after mentioning the assumptions made with respect to inputs and outputs. (K3, PO1, PO2, PO4)

2. Illustrate the working of a PLL using a block diagram. (K2, PO1)

3. List the criteria you consider for designing a sample and hold circuit. (K2, PO1, PO2, PO4)

**Course Outcome 3(CO3):**

1. List out the benefits of an active filter over a passive filter. (K2, PO1)

2. List out the factors considered for selecting the filter order. (K2, PO1)

3. List out a set of assumptions and design a Butterworth based on your assumptions for the assumed application. (K2, PO1, PO2, PO4).

**Course Outcome 4 (CO4):**

1. List out the parameters you may consider for selecting a sensor for a particular application (K2, PO1, PO2, PO4).

2. Design a sensor circuit for pressure measurement with proper assumptions (K3, PO1, PO2, PO4).

3. Hall effect sensor can be termed as an isolated sensor, explain why? (K2, PO1, PO2, PO4)

**Course Outcome 5 (CO5):**

1. Illustrate how an LM 35 temperature sensor is interfaced with Atmega 32 with a block diagram and required coding. (K3, PO1, PO2, PO3, PO4)

2. Conduct a study on parallel vs serial ADC and list out the pros and cons. (K2, PO1, PO4).

3. Analyse the importance of conversion time of an ADC in an embedded system design. (K2, PO1, PO4).

**Model Question paper**

**TKM COLLEGE OF ENGINEERING**

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH AND YEAR

**Course Code: 22EEE803.7**

**Course Name: Advanced Electronic Design**

Max. Marks: 100 Duration: 3 Hours

***Note: Certified IC data sheets of relevant ICs may be permitted inside the examination hall. <u>However, application notes of ICs are NOT permitted</u>.***

## PART A

***Answer all questions, each carries 3 marks.*** Marks

| | | |
|---|---|---|
| 1 | List the effects of Op-amp slew-rate in practical circuits. | (3) |
| 2 | Draw the high frequency equivalent circuit of an op-amp. | (3) |
| 3 | A randomly varying signal whose peak voltage was expected to be in the range -20 V to 35 V. Draw a peak detector circuit that gives the peak voltage value of the signal. What would be the nominal voltage ratings of the components used? Assume a suitable safety factor. | (3) |
| 4 | In a classical sample and hold circuit design explain the relevance of acquisition time. | (3) |

5 How will the loading effect be affected if you replace a passive filter with an active filter in a measuring circuit? Give proper reasoning for your answer. (3)

6 How closely is the roll-off rate requirement associated with the order of an active filter? (3)

7 Mr X has designed a current measurement circuit based on hall effect sensor and the design had transient voltage suppressors for surge protection, active filters for noise separation and an isolation transformer for the purpose of isolating the measuring system from high power circuit. If given an opportunity, what corrections will you suggest without changing the sensor and why? (3)

8 List out the relevance of signal conditioning in a circuit that uses MPX2010 pressure sensor. (3)

9 List out any three characteristics of ADC in Atmega 32. (3)

10 What do you understand by the term conversion time in an ADC? (3)

## PART B

***Answer any two full questions, each question carries 14 marks.***

11 a) Explain the relevance of unity gain bandwidth for an op-amp. (4)

b) Derive the open loop voltage gain of an op-amp as a function of frequency. (10)

OR

12 a) An inverting amplifier with closed loop gain, $A_o$ = -2 V/V is driven with a square wave of peak values $\pm V_m$ and frequency f. With $V_m$ = 2.5 V. It is observed that the output turns from trapezoidal to triangular when f is raised to 250 kHz. With f = 100 kHz, it is found that slew-rate limiting ceases when $V_m$ is lowered to 0.4 V. If the input is changed to a 3.5 V (rms) ac signal, what is the useful bandwidth of the circuit? (8)

b) How does the frequency response of non-compensated Op-amps differ from compensated Op-amps? (6)

13 a) Describe the operation of a frequency-to-voltage converter with circuit diagrams and waveforms. (7)

b) With a block-diagram, explain how a PLL can be used to implement a frequency multiplier. Use a multiplication factor of 2 for the illustration. (7)

OR

14 (a) For a particular application we need to generate multiple copies of a reference current source. Describe an Op-amp circuit that generates mirror images of the current source which can serve the said purpose. (7)

(b) It is required to design an amplifier for the current signal delivered by a photodetector. Use an Op-amp powered from ±15 V power supply to deliver an output voltage in the range -5 V to +5 V for an input current in the range 0 to 1 A. (7)

15 (a) Design a unity gain second-order low-pass Butterworth filter with a -3 dB frequency of 10 kHz. If input, $V_i(t) = 10 \cos(4\pi\, 10^4 t - 90°)$ V, find output $V_o(t)$. (8)

(b) Derive an expression to find the cutoff frequency of a second order low pass Sallen-Key filter. (6)

OR

16 a) Explain the relevance of corner frequencies in filter characteristics. (5)

b) Design a second order Sallen-Key high pass filter with a cutoff frequency of 10 kHz and Q of 1. Assume both resistors to be of equal value and both capacitors to be equal. (9)

17 a) Explain a temperature sensor circuit using the sensor AD590. (6)

b) Design a differential pressure measuring circuit using MPX2010 pressure sensor with switching output. The output should switch at 5 kPa pressure difference. Assume zero offset of the sensor. Assume operating voltage of 10 V, temperature of measurement as 25°C and $P_1 > P_2$. *Hint: use a comparator at the output.* (8)

OR

18 a) To calibrate ADXL202E, the accelerometer's measurement axis is pointed directly at the earth. The 1g reading is saved and the sensor is turned 180° to measure -1g. Let A = accelerometer output with axis oriented to +1g = 55% duty cycle and B = accelerometer output with axis (8)

oriented to -1g = 32% duty cycle. What is the sensitivity of the accelerometer?

b) When two or more sensors are mounted close to each other, acoustic interference is possible. Describe the ways in which multiple ultrasonic sensors 873P can be connected. Give the connections for both the analog current and the analog voltage outputs. Assume that the sensors are connected away from an amplifier. (6)

19 a) Differentiate between serial and parallel ADC. (7)

b) What is the relevance of a stable regulated supply voltage in an ADC. List the sampling requirements for successful reproduction in an ADC. (7)

OR

20 It is required to interface the temperature sensor LM35 with Atmega32 for measuring the temperature of an element that varies in the range $0^o$ C to $120^o$C. Draw the interfacing diagram with proper labelling of the Atmega 32 ports. Write an appropriately commented code for the same. (14)

****

## Syllabus

**Module 1: Op-amp Frequency response**-compensating networks, frequency response of internally compensated Op-Amps, frequency response of non compensated Op-Amps, High-frequency Op-amp equivalent circuit, open loop voltage gain as a function of frequency, closed loop frequency response, circuit stability, slew rate, slew rate equation, effect of slew rate.

**Module 2: Advanced Op-amp applications-** Precision rectifier, peak detector and log-converter , antilog amplifier, current mirror, voltage-to-current converters, current-to-voltage converters, voltage-to-frequency and frequency-to-voltage converters, Sample and hold circuit-Basic Circuits, practical sample and hold circuits, performance characteristics. Phase Locked Loop ( PLL)- Operating principles, block diagrams, monolithic PLL, IC 565 - PLL applications.

**Module 3: Filters-** Introduction to basic theory of filters: Filter responses - Active vs passive filters, Low pass, Band-pass, high-pass, band-stop filters and their characteristics - first order vs higher order filters - Realisation of Active filters - Transfer function synthesis, Sallen Key based (VCVS) filters - First order low pass butterworth filter design and frequency scaling, second order low pass butterworth filter design.

**Module 4: IC Sensors**- IC sensors for different energy forms, thermal energy sensors, mechanical energy sensors, radiant energy sensors, magnetic energy sensors, chemical energy sensors. MEMS-typical IC sensors, temperature energy sensors- LM35 and AD590, pressure sensors-MPX2010, accelerometer-ADXL202E, ultrasonic sensor-873P, infrared thermometer modules-MLX90601 family, Hall effect direction detection sensor-A3422xka

**Module 5: ADC, DAC and sensor interfacing to a typical Microcontroller**-Review of ADC and ADC characteristics-resolution, conversion time, parallel versus serial ADC with ADC0848 and MAX1112 examples, sampling requirements, ADC programming / interfacing in Atmega 32, interfacing temperature sensor LM35 with Atmega32, DAC 0808 interfacing with Atmega 32

**Text Books**


1. L. K. Maheswari, M.M.S Anand, "Analog Electronics", Prentice Hall India Learning Private Limited, 2005.

2. Muhammad Ali Mazidi,Sarmad Naimi, Sepehr Naimi, "The AVR Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education India, 1st Edition, 2013


**References**


1. Ramakant A Gayakwad, "Op-amps and Linear Integrated Circuits", Pearson Education; Fourth edition, 2015

2. D Roy Choudhury, "Linear Integrated Circuits", New Age International Publishers; Fifth edition, 2018

3. Sergio Franco, "Design with operational amplifier and analog circuits" Third Edition, Mc Graw Hill, 2001

4. Elliot Williams,“Make: AVR Programming-Learning to write software for hardware”, First edition, Shroff/Maker Media, 2014.

5. Data sheets and application notes of relevant ICs mentioned in the syllabus

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Module 1: Op-amp frequency response (8 hrs)** | |
| 1.1 | Compensating networks,frequency response of internally compensated Op-Amps, frequency response of non compensated Op-Amps, | 3 hrs |
| 1.2 | High-frequency Op-amp equivalent circuit,. | 1 hr |
| 1.3 | Open loop voltage gain as a function of frequency, closed loop frequency response, circuit stability, | 2 hrs |
| 1.4 | Slew rate, slew rate equation, effect of slew rate | 2 hrs |
| 2 | **Module 2: Advanced Op-amp applications (8 hrs)** | |
| 2.1 | Precision rectifier, peak detector and log-converter , antilog amplifier, current mirror, voltage-to-current converters, current-to-voltage converters, voltage-to-frequency and frequency-to-voltage converters, | 4 hrs |
| 2.2 | Sample and hold circuit- Basic Circuits, practical sample and hold circuits, performance characteristics. | 2 hrs |
| 2.3 | Phase Locked Loop ( PLL)- Operating principles, block diagrams, monolithic PLL, IC 565 PLL applications. | 2 hrs |
| 3 | **Module 3: Filters (6 hrs)** | |
| 3.1 | Introduction to basic theory of filters: Filter responses - Active vs passive filters, Low pass, Band-pass, high-pass, band-stop filters and their characteristics - first order vs higher order filters | 2 hr |

| | | |
|---|---|---|
| 3.2 | Realisation of Active filters - Transfer function synthesis, Sallen Key based (VCVS) filters | 2 hr |
| 3.3 | First order low pass butterworth filter design and frequency scaling, second order low pass butterworth filter design. | 2 hrs |
| 4 | **Module 4: IC Sensors (7 hrs)** | |
| 4.1 | IC sensors for different energy forms, thermal energy sensors, mechanical energy sensors, radiant energy sensors, magnetic energy sensors, chemical energy sensors. | 2 hrs |
| 4.2 | MEMS-typical IC sensors, temperature energy sensors- LM35 and AD590, pressure sensors-MPX2010, accelerometer-ADXL202E, ultrasonic sensor-873P, infrared thermometer modules-MLX90601 family, Hall effect direction detection sensor-A3422xka | 5 hrs |
| 5 | **Module 5: ADC, DAC and sensor interfacing to a typical Microcontroller (7 hrs)** | |
| 5.1 | Review of ADC and ADC characteristics-resolution, conversion time, parallel versus serial ADC with ADC0848 and MAX1112 examples, Sampling requirements | 4 hrs |
| 5.2 | ADC programming / interfacing in Atmega 32, interfacing temperature sensor LM35 with Atmega32, DAC 0808 interfacing with Atmega 32 | 3 hrs |

# SEMESTER VIII
# (PROGRAM ELECTIVE V)

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEE804.1** | **ELECTRIC & HYBRID VEHICLES** | **PEC** | **2** | **1** | **0** | **3** |

e

**: Electric and Hybrid vehicles are gaining popularity globally. This course introduces the fundamental concepts of electric, hybrid and autonomous vehicles, drive trains, electrical machines used, energy storage devices, charging systems and different communication protocols.**

**Prerequisite** **:** EET 202 -DC Machines and Transformers, EET 307-Synchronous and Induction machines, EET 302-Power Electronics

**Course Outcomes** **:** After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Explain the basic concepts of Conventional, Electric, Hybrid EV and Autonomous Vehicles |
| **CO 2** | Describe different configurations of electric and hybrid electric drive trains |
| **CO 3** | Discuss the propulsion unit for electric and hybrid vehicles |
| **CO 4** | Compare various energy storage and EV charging systems |
| **CO 5** | Select drive systems and various communication protocols for EV |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | | | | | 2 | | | | | |
| **CO 2** | 3 | 2 | | | | | | | | | | |
| **CO 3** | 3 | 2 | | | | | | | | | | |
| **CO 4** | 3 | 3 | 2 | | | | | | | | | |
| **CO 5** | 3 | 1 | 2 | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 20 | 20 | 40 |

| | | | |
|---|---|---|---|
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 10 | 10 | 20 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| **150** | **50** | **100** | **3 hours** |

**Continuous Internal Evaluation Pattern:**

**Attendance : 10 marks**

**Continuous Assessment Test (2 numbers) : 25 marks**

**Assignment/Quiz/Course project : 15 marks**

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Give questions indicating bloom's taxonomy level under each CO**

**Course Outcome 1 (CO1):**

1. Which are the resistive forces that retard the motion of a four wheel vehicle?(PO1,K1)
2. Explain briefly the performance parameters of the vehicle.(PO1, PO2,K1)
3. What are the social and environmental importance of EV.(PO7, K1)

**Course Outcome 2 (CO2):**

1. Architecture and power flow control of hybrid electric vehicle.(PO2, K2)
2. Subsystems of an electric vehicle.(PO1, K1)
3. What is regenerative braking?(PO1, K1)

**Course Outcome 3 (CO3):**

1. Electric components of an electric vehicle. (PO1, K1)
2. Control of orthogonal flux and torque in a separately excited DC motor(PO2, K2)
3. FOC control concept in PMSM motors.(PO1, PO2,K2)

**Course Outcome 4 (CO4):**

1. Battery management supporting system for hybrid vehicle.(PO1, K2)
2. Numerical problems in sizing and selection of batteries (PO3, K3)
3. Pin diagrams and differences of various connectors used for EV charging.(PO2,K2)

**Course Outcome 5 (CO5):**

1. Torque - speed envelope curves of drive train motors (PO2,K1)
2. Numerical Problems in sizing of drive systems (PO3,K3)
3. Different communication protocols used in EV (PO1, K2)

**Model Question Paper**

**QP CODE:** **Pages:**

**Reg No.:_______________**

**Name:_________________**

**TKM COLLEGE OF ENGINEERING**

**FIRST SEMESTER B. TECH DEGREE EXAMINATION,**

**MONTH & YEAR**

**Course Code: 22EEE804.1**

**Course Name: ELECTRIC AND HYBRID VEHICLES**

**Max. Marks: 100** **Duration: 3 hours**

**PART A**

**Answer all questions; each question carries 3 marks.**

| | | |
|---|---|---|
| 1. | Explain rolling resistance and aerodynamic drag in vehicles. | (3) |
| 2. | Write short notes on gradeability of the automobile system | (3) |
| 3. | With the help of a block diagram, explain the major components of an electric vehicle. | (3) |
| 4. | What is axial balancing? | (3) |
| 5. | What are the electric components used in the propulsion unit of EV/HEV? | (3) |
| 6. | List the advantages of PMSM motors over DC and induction motors. | (3) |
| 7. | Explain the terms specific energy and energy density as applied to batteries. | (3) |
| 8. | Explain the V2G concept. | (3) |
| 9. | What is meant by Constant Power Speed Ratio as applied to an electric motor? | (3) |

| | | | |
|---|---|---|---|
| 10. | | What is the significance of a communication network in electric/hybrid vehicles? | (3) |

**PART B**

**Answer any one complete question from each section; each question carries 14 marks**

| | | | |
|---|---|---|---|
| 11 | (a) | Draw and explain ideal traction power plant characteristics of various power plants and various power source characteristics used in electric and hybrid electric vehicles. | (8) |
| | (b) | Why is a gear system needed for an ICE? Explain with relevant characteristic curves. | (6) |

OR

| | | | |
|---|---|---|---|
| 12 | (a) | Explain the levels of automation and its significance in autonomous vehicles (5 marks) | |
| | (b) | What are the resistive forces acting on the vehicle movement? Obtain the dynamic equation of the vehicle movement. | |
| 13 | (a) | Draw and explain different classification of electric vehicles based on power source configurations. | (7) |
| | (b) | Explain the different power flow control modes of a typical parallel hybrid system with the help of block diagrams. | (7) |

OR

| | | | |
|---|---|---|---|
| 14 | (a) | Explain in detail the EV drivetrain alternatives based on drivetrain configurations | (6) |
| | (b) | Explain the different power flow control modes of a typical ICE dominated series-parallel hybrid system with the help of block diagrams | (8) |
| 15 | (a) | Explain the Permanent Magnet Synchronous Motor control for application in EV. | (10) |
| | (b) | Describe the advantages of independent control of flux and torque in SEDC Motor | (4) |

OR

16 (a) Discuss in detail the various electrical components used in HEV. (10)

(b) List the advantages of FOC control. (4)

17 (a) What is meant by the C rating of a battery? Explain with an example. (4)

(b) Explain the operation, advantages and disadvantages of Fuel cells used in EV. (10)

OR

18 (a) Explain briefly the different charging systems used for charging of EV. (8)

(b) With pin diagrams, describe the CCS Type 2 connectors used for EV charging. (6)

19 (a) A hybrid electric vehicle has two sources- an ICE with output power of 80kW and battery storage. The battery storage is a 150 Ah, C10 battery at 120V. (i).Calculate the battery energy capacity (ii). Without de-rating the Ahr capacity,what is the maximum power that can be supported by the battery? (iii). What is the electrical motor power output if the total efficiency of power converter and motor combination is 98%? (iv). What is the maximum power that can be transmitted to the wheels if the transmission efficiency is 95%? (8)

(b) Explain briefly the factors to be considered while sizing the electric motor for EV. (6)

OR

20 (a) What does CP and PP pins denote in connectors and explain its functions (5)

(b) Draw and explain the FLEXRAY communication systems used in EV. (9)

## Syllabus

**Module 1 - 8 hrs**

**Introduction to Hybrid Electric Vehicles**: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. (2 hrs)

**Conventional Vehicles**: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. (5 hrs)

**Autonomous Vehicles:** Levels of automation, significance & effects of automation in vehicles (1 hr)

**Module 2 - 7 hrs**

**Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. (4 hrs)

**Electric Drive-trains:** Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.(3 hrs)

**Module 3 - 7 hrs**

**Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles (2 hrs)

**DC Drives:** Review of Separately excited DC Motor control – Speed and torque equations - Independent control of orthogonal flux and torque - Closed loop control of speed and torque (block diagram only) (2 hrs)

**PMSM Drives:** PMSM motor basics – Independent control of orthogonal flux and torque (concept only)- Field Oriented Control (FOC) – Sensored and sensorless control (block diagram only) (3 hrs)

**Module 4 - 7 hrs**

**Energy Storage:** Introduction to energy storage requirements in Hybrid and Electric Vehicles-Battery based energy storage systems,Battery Management System, Types of battery- Fuel Cell based energy storage systems- Supercapacitors-Hybridization of different energy storage devices (3 hrs)

**Overview of Electric Vehicle Battery Chargers** - On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams – Types of charging stations - AC Level 1 & 2, DC - Level 3 –V2G concept-Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences (4hrs)

**Module 5 - 5 hrs**

**Sizing the drive system:** Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics (3 hrs)

**Vehicle Communication protocols** : Need & requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins, Communication Protocols - CAN, LIN, FLEXRAY (Basics only)- Power line communication (PLC) in EV (2 hrs)

**Text Books**

Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

**References:**


1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. Chris Mi, M A Masrur, D W Gao, " Hybrid Electric Vehicles – Principles and applications with practical perspectives," Wiley, 2011
4. Anderson JM, Nidhi K, Stanley KD, Sorensen P, Samaras C, Oluwatola OA, Autonomous vehicle technology: A guide for policymakers, Rand Corporation,2014


**Online Resources:**

1. NPTEL courses/Materials (IITG, IITM,IITD) – Electric and Hybrid vehicles
   https://nptel.ac.in/courses/108/103/108103009/ (IIT Guwahati)
   https://nptel.ac.in/courses/108/102/108102121/ (IIT Delhi)
   https://nptel.ac.in/courses/108/106/108106170/ (IIT Madras)
2. FOC Control - video lecture by Texas Instruments
   https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors
3. Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
   https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
   https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html
4. Electric Vehicle Conductive AC Charging System
   https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf
   Electric Vehicle Conductive AC Charging System

**Course Contents and Lecture Schedule:**

| No. | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to hybrid/electric, conventional & autonomous vehicles (8 hours)** | |
| 1.1 | Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles | 1 |
| 1.2 | Impact of modern drive-trains on energy supplies | 1 |
| 1.3 | Conventional Vehicles: Basics of vehicle performance | 1 |
| 1.4 | Vehicle power source characterization, transmission characteristics | 2 |
| 1.6 | Mathematical models to describe vehicle performance | 2 |
| 1.7 | Autonomous Vehicles: Levels of automation, significance & effects of automation in vehicles | 1 |
| **2** | **Hybrid & Electric drive-trains (7 hours)** | |
| 2.1 | Hybrid Electric Drive-trains: Basic concept of hybrid traction | 1 |
| 2.2 | Introduction to various hybrid drive-train topologies | 1 |
| 2.3 | Power flow control in hybrid drive-train topologies, fuel efficiency analysis. | 2 |
| 2.4 | Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies | 1 |
| 2.5 | Power flow control in electric drive-train topologies, hub motors, fuel efficiency analysis. | 2 |
| **3** | **Electric Propulsion System (7 Hours)** | |
| 3.1 | Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles | 2 |
| 3.2 | DC Drives: Review of Separately excited DC Motor control – Speed and torque equations - Independent control of orthogonal flux and torque – Closed loop control of speed and torque (block diagram only) | 2 |
| 3.3 | PMSM Drives: PMSM motor basics – Independent control of orthogonal flux and torque (concept only) | 2 |
| 3.4 | Field Oriented Control (FOC) of Permanent Magnet Synchronous Motor – Sensored and sensorless control (block diagram only) | 1 |

| | | |
|---|---|---|
| **4** | **Energy Storage (7 Hours)** | |
| 4.1 | Energy Storage: Introduction to energy storage requirements in Hybrid and Electric Vehicles- Battery based energy storage systems, Battery Management System | 1 |
| 4.2 | Types of battery-Lithium ion, Lead acid | 1 |
| 4.3 | Fuel Cell based energy storage systems- Supercapacitors-Hybridization of different energy storage devices | 1 |
| 4.4 | Overview of Electric Vehicle Battery Chargers – On-board chargers, Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams | 2 |
| 4.5 | Types of charging stations - AC Level 1 & 2, DC - Level 3 | 1 |
| 4.6 | V2G concept-Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences | 1 |
| **5** | **Sizing the drive system (5 Hours)** | |
| 5.1 | Sizing the drive system **:**Matching the electric machine and the internal combustion engine (ICE) | 1 |
| 5.2 | Sizing the propulsion motor | 1 |
| 5.3 | Sizing the power electronics | 1 |
| 5.4 | Vehicle Communication protocols : Need and requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins | 1 |
| 5.5 | Communication Protocols - CAN, LIN, FLEXRAY(Basics only) –Power Line Communication (PLC) in EV | 1 |

| 22EEE804.2 | INTERNET OF THINGS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PEC | 2 | 1 | 0 | 3 |

**Preamble:** This elective course is designed for state-of-the-art features to students and enable them to work in the industry where IoT is applied to a great extent**.** Students will also be introduced to the programming of embedded devices used in different levels of IoT application. Moreover, they will get exposed to sensor interfacing and uploading data to cloud services provided by different firms.

**Prerequisite:**

Experience in high level language programming and system design concepts with microcontrollers are required.

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Explain the role of computer networks in IoT. (K1) |
| **CO 2** | Select the appropriate communication standard for their IoT application. (K2) |
| **CO 3** | Use the appropriate sensors and embedded devices to get the data from the "things" and upload to cloud (K2) |
| **CO 4** | Develop programs for IoT devices using micropython language. (K3) |
| **CO 5** | Utilize the learned information to find an IoT based solution for the problem at hand. (K3) |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | | | | | | | | | | |
| **CO 2** | 2 | | | | | | | | | | | |
| **CO 3** | 2 | 2 | | | 2 | | | | | | | |
| **CO 4** | 2 | 3 | 3 | 1 | 2 | | | | 1 | | | 1 |
| **CO 5** | 2 | 3 | 3 | 1 | 2 | 2 | 1 | | 1 | | | 1 |
| **CO 6** | | | | | | | | | | | | |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 20 |
| Understand | 25 | 25 | 50 |
| Apply | 15 | 15 | 30 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Draw and explain the functional block diagram of IoT system.

2. Define the terms a) IP address b) Access point c) Station d) Router e) gateway

3. Explain the enabling technologies of IoT

**Course Outcome 2 (CO2)**

1. Explain the Wireless Sensor Network (WSN) technology.

2. How the data sensed from things uploaded to cloud?

3. Briefly explain the communication standards in use for connection to cloud service.

**Course Outcome 3(CO3):**

1. Explain the main features of Raspberry Pi 4 B computer

2. How ESP32 can be used as an embedded device in IoT applications?

3. Briefly explain the use ARM EMBED in IoT application.

**Course Outcome 4 (CO4):**

Prepare a micropython program to enable ESP32 module as an access point.

2. Prepare a micropython program to read analog data using raspberry pi and setup a server.

3. Explain the features of ARM EMBED IoT platform.

**Course Outcome 5 (CO5):**

Explain the application of IoT with suitable block diagram for smart metering of electricty

2. Detail the data sensing and prediction based on IoT applications in smart farming.

3. Detail the features of Industrial IoT with suitable block diagram.

**Model Question paper**

**TKM COLLEGE OF ENGINEERING**

**FIRST SEMESTER B. TECH DEGREE EXAMINATION,**

**MONTH & YEAR**

**Course Code: 22EEE804.2**
**Course Name: Internet of Things**

Max. Marks: 100 Duration: 3 Hours

**PART A**
***Answer all questions, each carries 5 marks.***

| | | | Marks |
|---|---|---|---|
| 1 | | What is the conceptual framework of Internet of Things? | (5) |
| 2 | | Explain the features of MQTT protocol. | (5) |
| 3 | | What are the various phases of data analytics? | (5) |
| 4 | | List few weather monitoring sensors. | (5) |
| 5 | | Write the features of Raspberry Pi 4 Model B+. | (5) |
| 6 | | Write a micro python-based program to set up ESP 32 as a station | (5) |
| 7 | | Write examples for the customer monitoring and product monitoring using IoT. | (5) |
| 8 | | How energy meter can be made smart using IoT? | (5) |

**PART B**
***Answer any two full questions, each carries 10 marks.***

| | | | |
|---|---|---|---|
| 9 | a) | Explain the major components of Internet of Things. | (6) |
| | b) | Explain the various levels of TCP/IP protocol | (4) |
| 10 | a) | Explain the concept of Zig-Bee network interconnected with Internet of Things. | (5) |
| | b) | Draw the M2M architecture. | (5) |
| 11 | a) | How does the Internet of Things database management work? | (6) |
| | b) | Explain the IPv6 addressing used in Internet of Things. | (4) |

**PART C**
***Answer any two full questions, each carries 10 marks.***

| | | | |
|---|---|---|---|
| 12 | a) | What is the significance of the data validation in Internet of Things? | (4) |
| | b) | Explain the Cloud computing paradigm for data collection and computing in an IoT environment. | (6) |
| 13 | a) | Explain the basics of Industrial Internet of Things. What are the application areas of IIoT? | (4) |
| | b) | What are the components needed in a system for smart grid IoT applications . | (5) |
| 14 | a) | What are the various methods used to sense images for smart faming? | (4) |
| | b) | Explain the automotive IoT application for Predictive and Preventive maintenances of automobiles. | (6) |

## PART D

***Answer any two full questions, each carries 10 marks.***

| | | | |
|---|---|---|---|
| 15 | a) | How is embedded-device platform hardware selected for M2M applications? | (4) |
| | b) | Give the programming structure of Micropython | (6) |
| 16 | a) | Explain ESP32 target board for Internet Of Things application. | (4) |
| | b) | Explain the process of programming embedded devices using Micropython . | (6) |
| 17 | a) | Explain the architecture reference model for the smart grid application. | (10) |

****

## Syllabus

## EET 428: INTERNET OF THINGS

Module 1

Introduction: Definition and Characteristics of IoT, Physical Design of IoT: Things in IoT, IoT Protocols, Logical Design of IoT: IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies. Design challenges – power consumption and security issues.

Computer networks: Internet-protocols and standards-OSI model- TCP/IP protocol suite. IP addressing – IPv4 and IPv6, Physical layer components- Switch, Router, Access point, station, Server, Client, Port, Gateway. Sizing of network- LAN, MAN, WAN .
**(8 hrs)**

Module 2

IoT and M2M Communications: Introduction, M2M, M2M applications, Differences between M2M and IoT, M2M standards- Bluetooth-LE, Zigbee, NFC, Wifi and LoRaWAN. Data logging and cloud services- CoAP, MQTT and JSON. Big data analytics (concepts only.)
**(6 hrs)**

Module 3

Sensor technologies for IoT- Wireless sensor network. Voltage, Current, Speed, Temperature and humidity sensors and data acquisition using embedded devices- block diagram. Data logging to cloud services- protocols and programming.
**(6 hrs.)**

Module 4

Embedded devices for IoT. Introduction to Python programming and embedded programming using micropython. Sensor interfacing and data acquisition using target boards like Raspberry Pi 4B, ARM EMBED, ESP32, Arduino boards. Programming examples for data logging to cloud using micropython. (Assignments on hardware implementation using these or similar boards may be given.) **(8hrs.)**

Module 5

IoT applications: Energy management and smart grid applications. IoT based home automation, Smart metering for electricity consumers. IoT based weather stations, Agriculture- smart farming, Automobile IoT- Electric vehicles-platform and software, Industrial IoT. **(6 hrs.)**

**Text Books**

1. Simone Cirani,” Internet of things: Architecture, protocols and standards”, Wiley, 2019

2. Charles Bell, “MicroPython for the Internet of Things: A Beginner’s Guide to Programming with Python on Microcontrollers”, Apress, 2017

3. B.K Thripathy, J Anuradha, “Internet of things (IoT) _ technologies, applications, challenges and solutions “, CRC press, 2018

4. Raj Kamal, “Internet of Things: Architecture and Design Principles”, McGraw Hill (India) Private Limited.

**Reference Books**


1. Qusay F. Hassan, ” Internet of Things A to Z,: Technologies and applications”, IEEE press,2018

2. Gary Smart, “Practical Python Programming for IoT : Build advanced IoT projects using Raspberry Pi 4, MQTT, RESTful APIs, WebSockets, and Python 3, Packt Publishing Ltd, 2020.

3. Gaston C. Hillar , “MQTT Essentials - A Lightweight IoT Protocol” , Packt Publishing Ltd, 2017.

4. Alasdair Gilchrist , “Industry 4.0 The Industrial Internet of Things”. Apress, 2016.


**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | | |
| 1.1 | Introduction to IoT, functional block | 2 |
| 1.2 | IoT communication models,Design challenges | 2 |
| 1.3 | Computer networks related topics | 4 |
| 2 | | |
| 2.1 | Introduction to M2M communications, standards | 2 |
| 2.2 | Data logging and cloud services, MQTT,json | 3 |
| 2.3 | Big data analytics ( concepts only) | 1 |
| 3 | | |
| 3.1 | Sensors and sensor networks | 1 |
| 3.2 | Voltage ,current, temperature sensors and their interfaces | 2 |
| 3.3 | Data logging to cloud services and protocols | 3 |
| 4 | | |
| 4.1 | Introduction to embedded devices like Raspberry Pi, ESP32 etc | 2 |
| 4.2 | Introduction to micropython programming | 3 |
| 4.3 | Micropython programming for data logging to cloud | 3 |
| 5 | | |
| 5.1 | IoT applications in smart grids | 3 |
| 5.2 | IoT application to other applications | 1 |
| 5.3 | IoT applications in electric vehicles and IIoT | 2 |

| 22EEE804.3 | ENERGY STORAGE SYSTEMS | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| | | PEC | 3 | 0 | 0 | 3 |

**Preamble:** This course aims to introduce the importance and application of energy storage systems and to familiarize with different energy storage technologies.

**Prerequisite:** Nil

**Course Outcomes**: After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Identify the role of energy storage in power systems |
| **CO 2** | Classify thermal, kinetic and potential storage technologies and their applications |
| **CO 3** | Compare Electrochemical, Electrostatic and Electromagnetic storage technologies |
| **CO 4** | Illustrate energy storage technology in renewable energy integration |
| **CO 5** | Summarise energy storage technology applications for smart grids) |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | | | | | | | | | | |
| **CO 2** | 3 | | | | | | | | | | | |
| **CO 3** | 3 | 2 | 1 | | | | 1 | | | | | |
| **CO 4** | 3 | 2 | 1 | | | 1 | 1 | | | | | 1 |
| **CO 5** | 3 | 1 | 1 | | | 1 | 1 | | | | | 1 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember (K1) | 15 | 15 | 30 |
| Understand (K2) | 20 | 20 | 40 |
| Apply (K3) | 15 | 15 | 30 |
| Analyse (K4) | | | |
| Evaluate (K5) | | | |
| Create (K6) | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

| | |
|---|---|
| Attendance | : 10 marks |
| Continuous Assessment Test (2 numbers) | : 25 marks |
| Assignment/Quiz/Course project | : 15 marks |

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1)**

1. What are the different parts of a complete energy storage unit? (K1, PO1)
2. Explain the Dynamic Duty of storage plant. (K2, PO1,PO2)
3. What are the different types of central store? ( K2, PO1)

**Course Outcome 2 (CO2)**

1. List the applications of thermal energy storage systems. (K1, PO1)
2. Explain hydrogen-based power utility concept.(K2,PO1)
3. What are the different storage containments of hydrogen? (K1, PO1)

**Course Outcome 3(CO3)**

1. Explain the working of fuel cell along with schematic diagram. (K2, PO1,PO2,PO7)
2. Write short notes on supercapacitors. (K2, PO1)
3. Explain the arrangement of a control and protection system for Super Conducting Magnetic Energy Storage.(K2 , PO1,PO3)

**Course Outcome 4 (CO4)**

1. Explain small-scale hydroelectric energy. (K2,PO1,PO3,PO6,PO7,PO12)
2. Write short notes on wave energy and its storage system. (K2, PO1, PO7,PO12)
3. What are the different types of renewable power sources? (K1, PO1, PO7,PO12)

**Course Outcome 5 (CO5)**

1. Explain distributed energy storage system. (K2, PO1, PO3,PO6,PO7,PO12)
2. What are the characteristics of smart grid system? (K1, PO1, PO6,PO7,PO12)
3. What is demand response? (K1, PO1, PO2)

Model Question Paper

QP CODE: Pages:

Reg No.:_______________

Name:_________________

TKM COLLEGE OF ENGINEERING

EIGHTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR

Course Code: 22EEE804.3

Course Name: ENERGY STORAGE SYSTEMS

Max. Marks: 100 Duration: 3 hours

PART A

Answer all questions; each question carries 3 marks.

| | | |
|---|---|---|
| 1. | Discuss the power transformation of energy storage system. | (3) |
| 2. | Explain the different components of energy storage system with schematic structure. | (3) |
| 3. | Define Flow equation related to thermal energy storage system. | (3) |
| 4. | Write the difference between hybrid and combined energy storage in power system. | (3) |
| 5. | Explain the chemical reaction of lead acid batteries. | (3) |
| 6. | Write down the basic principle of capacitor bank storage system. | (3) |
| 7. | Classify hydro power plants based on their rated capacity. | (3) |
| 8. | Briefly discuss small-scale hydroelectric energy system. | (3) |

9. What is distributed energy storage system? (3)

10 List the various layers of smart grid. (3)

**PART B**

**Answer any one complete question from each section; each question carries 14 marks**

11 (a) Explain static duty of energy storage plant. (8)

(b) With neat diagram explain energy and power balance in a storage unit. (6)

OR

12 (a) Explain the econometric model of energy storage. Derive the expression for annual cost of the system. (10)

(b) What are the key parameters considered for the comparison of energy storage in power system? (4)

13 (a) Discuss the working principle of compressed air energy storage system. (7)

(b) Write short note on flywheel energy storage system. (7)

OR

14 (a) Write any three industrial methods to produce hydrogen. (9)

(b) Explain ‘power to gas’ concept. (5)

15 (a) Explain the working of Li-ion batteries. (7)

(b) Describe the typical voltage–discharge profile for a battery cell. (7)

OR

16 (a) Describe basic principle and working of superconducting magnetic energy storage system. (7)

(b) With the help of a block diagram, explain the arrangement of control and protection system for superconducting magnetic energy storage system. (7)

17 (a) What are the main features of renewable energy systems? (4)

(b) Explain the role of storage systems in an integrated power system with grid-connected renewable power sources. (10)

OR

18 (a) Explain photovoltaics system. (4)

(b) Discuss the role of storage in an isolated power system with renewable power sources. (10)

19 (a) Describe the distributed energy storage system. (6)

(b) “HEV act as a distributed energy generator and storage”, justify your answer. (8)

OR

20 (a) What is demand response? (5)

(b) Draw and explain the battery SCADA system. (9)

## Syllabus

### Module 1

**Introduction to energy storage in power systems (6)**

Need and role of energy storage systems in power system, General considerations, Energy and power balance in a storage unit, Mathematical model of storage system: modelling of power transformation system (PTS)-Central store (CS) and charge–discharge control system (CDCS), Econometric model of storage system.

### Module 2

**Overview on Energy storage technologies (7)**

Thermal energy: General considerations -Storage media- Containment- Thermal energy storage in a power plant, Potential energy: Pumped hydro-Compressed Air, Kinetic energy: Mechanical- Flywheel , Power to Gas : Hydrogen - Synthetic methane

### Module 3

**Overview on Energy storage technologies (8)**

Electrochemical energy : Batteries- Battery parameters: C-rating -SoC- DoD- Specific Energy- Specific power (numerical examples), Fuel cells, Electrostatic energy (Super Capacitors), Electromagnetic energy (Super conducting Magnetic Energy Storage), Comparative analysis, Environmental impacts of different technologies.

### Module 4

**Energy storage and renewable power sources (6)**

Types of renewable energy sources: Wave - Wind – Tidal – Hydroelectric - Solar thermal technologies and Photovoltaics, Storage role in isolated power systems with renewable power sources, Storage role in an integrated power system with grid-connected renewable power sources

### Module 5

**Energy storage Applications (7)**

Smart grid, Smart microgrid, Smart house, Mobile storage system: Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G), Management and control hierarchy of storage systems - Aggregating energy storage systems and distributed generation (Virtual Power Plant Energy Management with storage systems), Battery SCADA, Hybrid energy storage systems: configurations and applications.

**Text Books**

1. A.G.Ter-Gazarian, "Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN - 978-1-84919-219-4),2011.

2. Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt," Energy Storage in Power Systems" Wiley Publication, ISBN: 978-1-118-97130-7, Mar 2016.

**Reference Books**

1. Electric Power Research Institute (USA), "Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits" (1020676), December 2010.

2. Paul Denholm, Erik Ela, Brendan Kirby and Michael Milligan, "The Role of Energy Storage with Renewable Electricity Generation", National Renewable Energy Laboratory (NREL) -a National Laboratory of the U.S. Department of Energy.

3. P. Nezamabadi and G. B. Gharehpetian, "Electrical energy management of virtual power plants in distribution networks with renewable energy resources and energy storage systems", IEEE *Power Distribution Conference*, 2011.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Introduction to energy storage for power systems: (6)** | |
| 1.1 | General considerations- different parts of energy storage unit- static duty of storage plant- dynamic duty of storage plant | 2 |
| 1.2 | Energy and power balance in a storage unit- schematic structure of energy storage | 1 |
| 1.3 | Mathematical model of storage system | 1 |
| 1.4 | Econometric model of storage- capital cost of energy storage- annual cost of storage facility | 2 |
| **2** | **Overview on Energy storage technologies: (7)** | |
| 2.1 | Principle of thermal energy storage- sensible heat storage – latent heat storage- containment- thermal energy storage in power plant application | 2 |
| 2.2 | Principle and operation of pumped hydroelectric storage (PHS)- general considerations- schematic diagram | 1 |
| 2.3 | Principle and operation of Compressed Air Energy Storage (CAES)- general considerations- basic principle-industrial application | 1 |

| | | |
|---|---|---|
| 2.4 | Principle and operation of Flywheel Energy storage System (FESS)-general considerations -applications | 1 |
| 2.5 | General considerations- synthetic storage media-Hydrogen production-Hydrogen based power utility concept- storage containment for hydrogen-Methods of extraction of methane-Block diagram Power to gas concept | 2 |
| **3** | **Overview on Energy storage technologies (8)** | |
| 3.1 | Basic concepts of conventional batteries and flow batteries- Battery parameters- C-rating-SoC- DoD- Specific Energy-Specific power (numerical examples), Fuel cell- Schematic diagram of an electrochemical fuel cell | 2 |
| 23.2 | Super conducting Magnetic Energy Storage (SMES)- basic circuit-principle-advantages | 2 |
| 3.3 | The Supercapacitor Energy Storage System- topology-principle-advantages | 2 |
| 3.4 | Comparative study of different energy storage system based on specific energy, specific power,  cycling capability and life in years | 2 |
| **4** | **Energy storage and renewable power sources (6)** | |
| 4.1 | Types of renewable power sources- brief description | 2 |
| 4.2 | Storage role in isolated power system with renewable power sources | 1 |
| 4.3 | Storage role in an integrated power system with grid-connected renewable power sources | 1 |
| 4.4 | Small scale hydroelectric energy | 1 |
| 4.5 | Solar thermal technologies and photovoltaics | 1 |
| **5** | **Energy storage Applications (7)** | |
| 5.1 | Smart grid-concepts- characteristics- Smart metering | 2 |
| 5.2 | Field of Electromobility- thyristor based battery charger and DC power supply | 1 |
| 5.3 | Vehicle to grid and grid to vehicle charging point topology | 1 |
| 5.4 | Distributed energy storage | 1 |
| 5.5 | Battery SCADA- overview | 1 |
| 5.6 | Hybrid energy storage systems: configurations and applications | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDIT |
|---|---|---|---|---|---|---|
| 22EEE804.4 | ROBUST AND ADAPTIVE CONTROL | PEC | 2 | 1 | 0 | 3 |

**Preamble:**

This course provides a mathematical introduction to the field of robust and adaptive control. The concepts in this course are considered advanced in the field of modern control theory.

**Prerequisite: EET304 Linear Control System, EET401Advanced Control System**

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| **CO 1** | Compute the norms of transfer functions and transfer function matrices. |
| **CO 2** | Interpret the robustness of the control system using Robust Stability and Robust Performance measures. |
| **CO 3** | Explain the synthesis of stabilising controllers in $H_2$ and $H_\infty$ . |
| **CO 4** | Design sliding mode controllers for a system. |
| **CO 5** | Design adaptive controllers for a system . |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 3 | | | | | | | | | | 3 |
| **CO 2** | 3 | 3 | 3 | | | | | | | | | 3 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 3** | 3 | 3 | | | | | | | | | | 3 |
| **CO 4** | 3 | 3 | 3 | | | | | | | | | 3 |
| **CO 5** | 3 | 3 | 3 | | | | | | | | | 3 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 10 | 10 | 10 |
| Understand | 20 | 20 | 20 |
| Apply | 20 | 20 | 70 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Define the various norms of a system.(K1,PO1)

2. Compute the various norms of a system.(K2,PO2)

3. Identify the properness, stabilizability and detectability of the given system.(K2,PO2)

**Course Outcome 2 (CO2)**

1. Define Robust Stability and Performance of a system. (K1,PO1)

2. Apply Robust Stability and Performance measures for a system.(K3,PO3)

3. Use additive and multiplicative uncertainty to model an uncertain system.(K3,PO2,PO3)

**Course Outcome 3(CO3):**

1. Explain the formulation of $H_2$ control. (K2,PO2)

2. Explain the formulation of $H\infty$ control. (K2,PO2)

3. Explain the formulation of controller using mu synthesis. (K2,PO2)

**Course Outcome 4 (CO4):**

1. Differentiate between variable structure control and SMC.(K2,PO2)

2. Explain the formulation of sliding mode control.(K2,PO3)

3. Explain the method of sliding surface design using pole placement method.(K3,PO3)

**Course Outcome 5 (CO5):**

1. Illustrate the block diagram of any one adaptive scheme.(K2,PO2)

2. Design a MRAC using MIT rule.(K3,PO3)

3. Distinguish adaptive versus conventional feedback system.(K2,PO2)

**Model Question paper**

**QP CODE:**

**PAGES:2**

**Reg.No:______________**

**Name:______________**

**TKM COLLEGE OF ENGINEERING**

**SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEE804.4**

**Course Name: ROBUST AND ADAPTIVE CONTROL**

**Max. Marks: 100** **Duration:3Hours**

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 marks**

1. Calculate the 2-norm and ∞-norm of the given vector $x = [1 \quad -2 \quad -3 \quad 4]^T$.
2. Define $H_2$ and $H_\infty$ norm.
3. Define Small gain theorem.
4. Explain the importance of Sensitivity function in robust control.
5. Formulate the standard LQR problem.
6. Explain the lack of Robustness of LQG control.
7. Differentiate between variable structure control and SMC.
8. What is chattering phenomenon in Sliding mode control? How does it affect the system?
9. Justify the statement "Process variations affect the performance of a system" with example.
10. List three applications of Adaptive control.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 marks**

## Module 1

1. a) What is observability and controllability grammian.

**(8)**

b) What is meant by Singular values of a transfer function matrix? What is their significance. **(6)**

2. a). How is $H_\infty$ norm computed for a SISO system? How is $H_\infty$ norm computation done for a MIMO system?

**(8)**

b) The system given by $\dot{x} = Ax + Bu\,, y = Cx, where\ A = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & -2 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}, C = [1 \quad 1 \quad 0]$ . Check the stabilizability and detectability of the system.

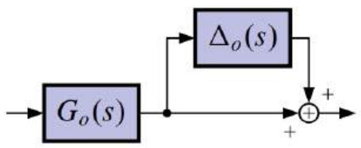
**(6)**

## Module 2

3.a) Explain the terms nominal stability, robust stability, nominal performance and robust performance. What are the conditions to be satisfied by a feedback control system for each of the above?

**(10)**

b) Identify the type of uncertainty in the given figure below. Write the mathematical model of the same.

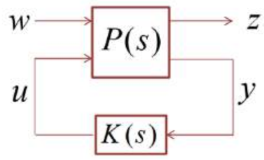



**(4)**

4. a)Explain the concept of loop shaping in achieving robustness.

**(7)**

b) Derive the LFT of the given figure below.




**(7)**

## Module 3

5. a) Determine a LQR controller for the system defined by $\dot{x} = Ax + Bu, where\ A = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix}, B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ such that the performance index $J = \int_0^\infty (x^T x + u^2)dt$ is minimised. **(8)**

b) Explain the formulation of LQG control. **(6)**

6. a) Explain the formulation of H∞ control. **(6)**

b) What is a structured singular value. Mention the steps in designing a stabilizing controller by mu synthesis. **(8)**

## Module 4

7.a) Write down the steps to be followed for designing a sliding mode controller. Also list the main features of sliding mode controllers. **(4)**

b) Design a stabilising variable structure control for a double integrator system **(10)**

8.a) Write two different reaching laws associated with sliding mode control design. Show how they assist the design to satisfy the reachability condition. **(8)**

b) In a sliding mode there exists a finite reaching time $t = t_f$ at which switching function s(t) becomes 0. Derive an expression for $t_f$ in terms of s(0). **(6)**

## Module 5

9. a) Explain the design of Self Tuning Regulator by pole placement design. **(8)**

b) Explain the least square estimation for parameter estimation. **(6)**

10. a) Design a MRAC for a first order system using MIT rule. **(8)**

b) Explain with illustration the basic blocks of a MRAS. **(6)**

**Syllabus**

**Module 1: Introduction and mathematical preliminaries( 7 hours)**

Introduction to robust control

Vector space, linear subspaces, Norm and inner product of real vectors and matrix, Hilbert Spaces , $H_2$ and $H_{inf}$ Spaces - Computing of $H_2$ and $H_{inf}$ norms(transfer function and transfer matrices) , Computing of $L_2$ and $L_{inf}$ Norms, singular value decomposition.

Proper systems, Controllability and Observability Grammians, Concept of Minimal Realisation, Stabilizability and Detectability, Packed form notation- various configurations.

**Module 2: Feedback systems and Uncertainty modelling( 9 hours)**

Single degree and two degree of freedom Robust Control Systems - System Sensitivity, Relation between Sensitivity and disturbance inputs in a feedback system, Sensitivity and Complementary Sensitivity function. Sensitivity and Complementary Sensitivity peak selection- its relation to gain and phase margin - Weighted Sensitivity and weighted complementary sensitivity.

Well-Posedness of Feedback Loop, Internal Stability.

Model Uncertainty - Classification of uncertainties -parametric, structured and unstructured-m-delta configuration- linear fractional transformation-examples.

Nominal Performance, Nominal Stability, Robust Performance and Robust Stability-Small Gain Theorem, Concept of loop shaping.

**Module 3: Robust controller design(6 hours)**

Introduction to Regulator problem, Standard LQR and LQG problem, control-Lack of Robustness , Introduction to H2 control, Hinf control, mu Synthesis.

**Module 4:Design of Sliding mode controllers (6 hours)**

Introduction to Variable Structure Systems ( VSS) - examples , Introduction to sliding mode control- -sliding surface- examples of dynamical systems with sliding modes, reaching laws-reachability condition, Invariance conditions- chattering-equivalent control, Design of sliding mode controllers using pole placement, LQR method.

**Module 5: Introduction to Adaptive Control(7 hours)**

Adaptive Control, effects of process variation - Adaptive Schemes - Adaptive Control problem - Applications – Real Time Parameter Estimation: Introduction - Regression Models - Recursive Least Squares, Self Tuning Regulators introduction, pole placement design, Model Reference Adaptive systems (MRAS) - the need for MRAS , MIT rule, MRAS for first order system.

**Text Books**

1. Sigurd Skogestad and Ian Postewaite, "Muti-variable Feedback Design" (Second Edition), John Wiley, 2005.

2. Kemin Zhou and Doyle J.C, "Essentials of Robust Control", Prentice-Hall, 1998.

3. C Edwards and Sarah Spurgeon, " Sliding Mode Control: Theory And Applications", Taylor and Francis,1998

4. K. J. Astrom and B. Wittenmark, "Adaptive Control", $2^{nd}$ Edition, Addison-Wesley, 1995

**Reference Books**

1. P C Chandrasekharan, "Robust Control of Linear Dynamical Systems", Academic Press, 1996

2. Richard C. Dorf, Robert H. Bishop, "Modern Control Systems", Pearson Education, 2008.

3. S. Sastry and M. Bodson, "Adaptive Control", Prentice-Hall, 1989

3. John C. Doyle, Bruce A. Francis, Allen R. Tannenbaum, "Feedback Control Theory" , Macmillan Pub. Co, 1992

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Introduction and mathematical preliminaries( 7 hours)** | |
| 1.1 | Introduction to robust control, Vector space, linear subspaces, Norm and inner product of real vectors and matrix, | 2 |
| 1.2 | Hilbert Spaces, $H_2$ and $H_{inf}$ Spaces - Computing of $H_2$ and $H_{inf}$ norms(transfer function and transfer matrices) , Computing of $L_2$ and $L_{inf}$ Norms, singular value decomposition. | 3 |
| 1.3 | Proper systems- various types, Review of Minimal Realisation, Stabilizability and Detectability, Packed form notation- various configuration, | 2 |

| | | |
|---|---|---|
| 2 | **Feedback systems and Uncertainty modelling( 9 hours)** | |
| 2.1 | Single degree and two degree of freedom Robust Control Systems - System Sensitivity, Relation between Sensitivity and disturbance inputs in a feedback system, Sensitivity and Complementary Sensitivity function. | 2 |
| 2.2 | Sensitivity and Complementary Sensitivity peak selection- its relation to gain and phase margin - Weighted Sensitivity and weighted complementary sensitivity.<br><br>Well-Posedness of Feedback Loop, Internal Stability. | 2 |
| 2.3 | Model Uncertainty - Classification of uncertainties -parametric, structured and unstructured-m-delta configuration- linear fractional transformation-examples. | 3 |
| 2.4 | Nominal Performance, Nominal Stability, Robust Performance and Robust Stability-Small Gain Theorem, Concept of loop shaping. | 2 |
| 3 | **Robust controller design(6 hours)** | |
| 3.1 | Introduction to Regulator problem, Standard LQR and LQG problem, control-Lack of Robustness , | 3 |
| 3.2 | Introduction to H2 control, Hinf control, mu Synthesis. | 3 |
| 4 | **Design of Sliding mode controllers (6 hours)** | |
| 4.1 | Introduction to Variable Structure Systems ( VSS)- examples , Introduction to sliding mode control- -sliding surface- examples of dynamical systems with sliding modes , reachability condition, Invariance conditions- chattering-equivalent control | 4 |

| | | |
|---|---|---|
| 4.2 | Design of sliding mode controllers using pole placement, LQR method. | 2 |
| 5 | **Introduction to Adaptive Control(7 hours)** | |
| 5.1 | Adaptive Control, effects of process variation - Adaptive Schemes - Adaptive Control problem - Applications | 1 |
| 5.2 | RealTime Parameter Estimation: Introduction - Regression Models - Recursive Least Squares, | 2 |
| 5.3 | Self Tuning Regulators introduction, pole placement design, | 2 |
| 5.4 | Model Reference Adaptive systems (MRAS) - the need for MRAS , MIT rule, MRAS for first order system. | 2 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| 22EEE804.5 | SOLAR PV SYSTEMS | PEC | 2 | 1 | 0 | 3 |

**Preamble** : This course introduces solar PV system and its grid integration aspects. It also give insight to basic knowhow for the implementation of Solar PV system utilizing modern simulation software.

**Prerequisite** : **Nil**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Explain the basics of solar energy conversion systems.(K1) |
| **CO 2** | Design a standalone PV system. (K3) |
| **CO 3** | Demonstrate the operation of a grid interactive PV system and its protection against islanding.(K2) |
| **CO4** | Utilize life cycle cost analysis in the planning of Solar PV System (K3) |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | | | | | | | | | | 1 |
| **CO 2** | 3 | 3 | 3 | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | 2 | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | 2 | 1 | 2 | | | | | | 1 | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 25 | 25 | 50 |
| Apply (K3) | 15 | 15 | 30 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain what do you mean by solar constant (K1, PO1)

2. Discuss about the different instruments used for measuring solar radiation and sun shine (K2,PO2)

**Course Outcome 2 (CO2):**

1. Design a stand alone PV system. (K3, PO1, PO2, PO3)
3. Design an off grid PV system to backup 10kW system for 3 hours and draw the block level representation of the final system. (K3, PO1, PO2, PO3)

**Course Outcome 3 (CO3):**

1. Demonstrate the operation of a grid connected PV system. (K2, PO1, PO2,PO3).
2. Summarize the protection of PV system against islanding and reverse power flow. (K2, PO1, PO2,PO3).

**Course Outcome 4 (CO4):**

1. The life cycle cost of a system is Rs. 10000/- for a life period of 20 years. The rate of interest is 8% and the inflation rate is 5%. What is the annual life cycle cost for the system? (K3, PO1, PO2,PO3)
2. Design a grid connected PV system utilizing a suitable simulation software. (K3, PO1, PO2,PO3,PO4,PO5)

**Model Question paper**

**QP CODE:**

PAGES:2

Reg. No:_______________
Name:_______________

**TKM COLLEGE OF ENGINEERING**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION,**
**MONTH & YEAR**

**Course Code: 22EEE804.5**

**Course Name: SOLAR PV SYSTEMS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain briefly what do you mean by solar azimuth angle and zenith angle.
2. Differentiate between extraterrestrial and terrestrial solar radiation.
3. Write notes on the working of a solar cooker.
4. Discuss what do you mean by a solar green house.
5. Write notes on the different materials used for making solar cells.
6. Discuss the characteristics of a solar cell.
7. Give a description on of Power Quality related IEEE standards for distributed resource grid integration
8. Differentiate SoC and DoD of storage battery .
9. Write notes on the planned and unplanned islanding .
10. Explain life-cycle cost of renewable energy system.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a.With the help of a neat diagram, explain the working of a pyrheliometer. **(7)**
b. Explain how monthly average solar radiation on inclined surfaces can be calculated. **(7)**

12. a. State the reasons for variation in the amount of solar energy reaching earth surface. **(4)**
b.With the help of a neat diagram, explain the working of a sunshine recorder. **(6)**
c. Explain the difference in the working of pyrheliometer and pyranometer. **(4)**

**Module 2**

13. a. Explain the different types of solar collectors based on the way they collect solar radiation. **(7)**

b. Explain in detail, the working of a solar air conditioning system **(7)**

14. a.With the help of a diagram, explain the function of different components of a flat plate solar collector. **(7)**

b. Design a solar water heater for domestic application. **(7)**

**Module 3**

15. a. Write notes on the efficiency of a solar cell. **(3)**

b. Discuss the effect of shadowing on the performance of solar cells. **(3)**

c. Explain how maximum power point tracking can be done using buck-boost converter. **(8)**

16. a. Compare the performance of single junction and multijunction PV modules. **(4)**

b. Write notes on packing factor of a PV module. **(3)**

c. Explain the Perturb and Observe MPPT method. Compare with incremental conductance method. **(7)**

**Module 4**

17.

a. Design an off grid PV system to backup 10kW system for 3 hours and draw the block level representation of the final system. (7)
b. Explain with a neat sketch, the working principle of a grid connected solar system. **(7)**

18.

a. In a water pumping system, the water is being pumped from a sump to an overhead tank situated 25m above ground. The sump bottom is 2m below ground. The motor-pump system is located at ground level. The water is being pumped at the rate of 24.6 litres/sec. The pipe inner diameter is 10 cm. The pipe is placed completely vertical with no horizontal part. The friction factor is 0.037. The efficiencies of the pump, motor and dc-dc converter are 70%, 80% and 90% respectively. If the system is being powered by a PV source, what is the output power requirement for the PV panels? **(7)**
b. Explain the voltage and frequency matching method in grid connected PV system.(7)

Module 5

19.

a. Detail the anti-islanding protection with suitable block diagram. (7)
b. The life cycle cost of a system is Rs. 10000/- for a life period of 20 years. The rate of interest is 8% and the inflation rate is 5%. What is the annual life cycle cost for the system? (7)

20.

a. Draw and explain the line of protection equipment in PV array installation. (6)

b. Suppose the energy-efficiency retrofit of a large building reduces the annual electricity demand for heating and cooling from 2.3 × 106 kWh to 0.8 × 106 kWh and the peak demand for power from by 150 kW. Electricity costs Rs. 5/kWh and demand charges are Rs. 500/kW per month, both of which are projected to rise at an annual rate of 5%. If the project costs Rs. 3,50,00,000, what is the internal rate of return over a project lifetime of 15 years? (8)

**Syllabus**

**Module 1**

Introduction - Basic Concept of Energy -Source of Solar Energy -Formation of the Atmosphere - Solar Spectrum. Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer –Pyranometer -Sunshine Recorder -Solar Radiation on a Horizontal Surface - Extra-terrestrial Region.-Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors -Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces .

**Module 2**

Solar Thermal system-Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) –performance evaluation. Applications -Solar heating system, Air conditioning and Refrigeration system, Pumping system, solar cooker, Solar Furnace, Solar Greenhouse -Design of solar water heater

**Module 3**

Solar PV Systems-Introduction -Fundamentals of Semiconductor and Solar Cells -Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials-.Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III–V Single Junction and Multifunction PV Modules-Emerging and New PV Systems -Packing Factor of the PV Module - Efficiency of the PV Module -Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules.- Effect of shadowing-MPPT Techniques-P&O , incremental conductance method-Maximum Power Point Tracker (MPPT) using buck-boost converter.

**Module 4**

Solar PV Systems –stand-alone and grid connected -Design steps for a Stand-Alone system –Storage batteries and Ultra capacitors. Design PV powered DC fan and pump without battery-Design of Standalone System with Battery and AC or DC Load. A Grid Interactive PV System - Phase , Frequency Matching and Voltage Consideration – Operation of a Grid Interactive Inverter –Overview of IEEE -2018 Standard for Interconnecting Distributed Resources with Electric Power Systems

**Module 5**

Protection Against Islanding and Reverse Power Flow – AC Modules Design of EMI Filters. Overcurrent protection of solar PV power system, Selective fuse links for PV String protection, PV fuse selection flow chart, Fuse rating for PV Applications.

Life cycle costing, Growth models, Annual payment and present worth factor, payback period, LCC with examples. Introduction to simulation software for solar PV system design.*(An assignment can be given corresponding to CO2,CO3 and CO4 utilizing the simulation tools)*

**Text book:**

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4. A.A.M. Saigh(Ed): Solar Energy Engineering, Academic Press, 1977

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7. D.P.Kothari, K.C.Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009.
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10. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
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13. Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy –Sources for Fuel and Electricity, Earth scan Publications, London, 1993.
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15. "IEEE Application Guide for IEEE Std 1547(TM), IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems," in IEEE Std 1547.2-2008 , vol., no., pp.1-217, 15 April 2009, doi: 10.1109/IEEESTD.2008.4816078

**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Solar energy (7 hours)** | |
| 1.1 | Introduction - Basic Concept of Energy -Source of Solar Energy - Formation of the Atmosphere - Solar Spectrum. | 1 |
| 1.2 | Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer –Pyranometer -Sunshine Recorder | 2 |
| 1.3 | Solar Radiation on a Horizontal Surface –Extra-terrestrial Region.-Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors | 2 |
| 1.4 | Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces. | 2 |
| **2** | **Solar Thermal Systems (6 hours)** | |
| 2.1 | Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics | 1 |
| 2.2 | Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) –performance evaluation. | 2 |
| 2.3 | Applications -Solar heating system, Air conditioning and Refrigeration system | 1 |
| 2.4 | Pumping system, solar cooker, Solar Furnace, Solar Greenhouse | 1 |
| 2.5 | Design of solar water heater | 1 |
| **3** | **Solar PV systems (7 Hours)** | |
| 3.1 | Introduction -Fundamentals of Semiconductor and Solar Cells -Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials | 2 |
| 3.2 | Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III–V Single Junction and Multijunction PV Modules -Emerging and New PV Systems | 1 |
| 3.3 | Packing Factor of the PV Module - Efficiency of the PV Module -Energy Balance Equations for PV Modules | 1 |
| 3.4 | Series and Parallel Combination of PV Modules.- Effect of shadowing- | 1 |
| 3.5 | MPPT Techniques-P&O , incremental conductance methd-Maximum Power Point Tracker (MPPT) using buck-boost converter. | 2 |
| **4** | **Stand Alone and Grid integrated PV System (9 Hours)** | |

| | | |
|---|---|---|
| 4.1 | Solar PV Systems –stand-alone and grid connected -Design steps for a Stand-Alone system –Storage batteries and Ultra capacitors. | 2 |
| 4.2 | Design PV powered DC fan and pump without battery | 2 |
| 4.3 | Design of Standalone System with Battery and AC or DC Load. | 2 |
| 4.4 | A Grid Interactive PV System - Phase , Frequency Matching and Voltage Consideration – Operation of a Grid Interactive Inverter | 2 |
| 4.5 | IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems | 1 |
| **5** | **GIPV System Protection and LCC (7)** | |
| 5.1 | Protection Against Islanding and Reverse Power Flow | 1 |
| 5.2 | AC Modules Design of EMI Filters. . | 1 |
| 5.3 | Overcurrent protection of solar PV power system, Selective fuse links for PV String protection, PV fuse selection flow chart, Fuse rating for PV Applications | 2 |
| 5.4 | Life cycle costing, Growth models, Annual payment and present worth factor, payback period of solar PV system, LCC with examples. | 2 |
| 5.5 | Introduction to simulation software for solar PV system design like PV syst, PV SOL etc. | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEE804.5** | **SOLAR PV SYSTEMS** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble** : This course introduces solar PV system and its grid integration aspects. It also give insight to basic knowhow for the implementation of Solar PV system utilizing modern simulation software.

**Prerequisite** : **Nil**

**Course Outcomes** : After the completion of the course the student will be able to:

| | |
|---|---|
| **CO 1** | Explain the basics of solar energy conversion systems.(K1) |
| **CO 2** | Design a standalone PV system. (K3) |
| **CO 3** | Demonstrate the operation of a grid interactive PV system and its protection against islanding.(K2) |
| **CO4** | Utilize life cycle cost analysis in the planning of Solar PV System (K3) |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | | | | | | | | | | 1 |
| **CO 2** | 3 | 3 | 3 | | | | | | | | | 2 |
| **CO 3** | 3 | 3 | 2 | | | | | | | | | 2 |
| **CO 4** | 3 | 3 | 2 | 1 | 2 | | | | | | 1 | 2 |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |
| Understand (K2) | 25 | 25 | 50 |
| Apply (K3) | 15 | 15 | 30 |
| Analyse (K4) | - | - | - |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**End Semester Examination Pattern** : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

4. Explain what do you mean by solar constant (K1, PO1)

5. Discuss about the different instruments used for measuring solar radiation and sun shine (K2,PO2)

**Course Outcome 2 (CO2):**

2. Design a stand alone PV system. (K3, PO1, PO2, PO3)
6. Design an off grid PV system to backup 10kW system for 3 hours and draw the block level representation of the final system. (K3, PO1, PO2, PO3)

**Course Outcome 3 (CO3):**

3. Demonstrate the operation of a grid connected PV system. (K2, PO1, PO2,PO3).
4. Summarize the protection of PV system against islanding and reverse power flow. (K2, PO1, PO2,PO3).

**Course Outcome 4 (CO4):**

3. The life cycle cost of a system is Rs. 10000/- for a life period of 20 years. The rate of interest is 8% and the inflation rate is 5%. What is the annual life cycle cost for the system? (K3, PO1, PO2,PO3)
4. Design a grid connected PV system utilizing a suitable simulation software. (K3, PO1, PO2,PO3,PO4,PO5)

**Model Question paper**

**QP CODE:**

PAGES:2

Reg. No:______________
Name:______________

**TKM COLLEGE OF ENGINEERING**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION,**
**MONTH & YEAR**

**Course Code: 22EEE804.5**

**Course Name: SOLAR PV SYSTEMS**

Max. Marks: 100 Duration: 3 Hours

**PART A (3 x 10 = 30 Marks)**

**Answer all Questions. Each question carries 3 Marks**

1. Explain briefly what do you mean by solar azimuth angle and zenith angle.
2. Differentiate between extraterrestrial and terrestrial solar radiation.
3. Write notes on the working of a solar cooker.
4. Discuss what do you mean by a solar green house.
5. Write notes on the different materials used for making solar cells.
6. Discuss the characteristics of a solar cell.
7. Give a description on of Power Quality related IEEE standards for distributed resource grid integration
8. Differentiate SoC and DoD of storage battery .
9. Write notes on the planned and unplanned islanding .
10. Explain life-cycle cost of renewable energy system.

**PART B (14 x 5 = 70 Marks)**

**Answer any one full question from each module. Each question carries 14 Marks**

**Module 1**

11. a.With the help of a neat diagram, explain the working of a pyrheliometer. **(7)**
b. Explain how monthly average solar radiation on inclined surfaces can be calculated. **(7)**

12. a. State the reasons for variation in the amount of solar energy reaching earth surface. **(4)**
b.With the help of a neat diagram, explain the working of a sunshine recorder. **(6)**
c. Explain the difference in the working of pyrheliometer and pyranometer. **(4)**

**Module 2**

13. a. Explain the different types of solar collectors based on the way they collect solar radiation. **(7)**

b. Explain in detail, the working of a solar air conditioning system **(7)**

14. a.With the help of a diagram, explain the function of different components of a flat plate solar collector. **(7)**

b. Design a solar water heater for domestic application. **(7)**

**Module 3**

15. a. Write notes on the efficiency of a solar cell. **(3)**

b. Discuss the effect of shadowing on the performance of solar cells. **(3)**

c. Explain how maximum power point tracking can be done using buck-boost converter. **(8)**

16. a. Compare the performance of single junction and multijunction PV modules. **(4)**

b. Write notes on packing factor of a PV module. **(3)**

c. Explain the Perturb and Observe MPPT method. Compare with incremental conductance method. **(7)**

**Module 4**

17.

a. Design an off grid PV system to backup 10kW system for 3 hours and draw the block level representation of the final system. (7)
b. Explain with a neat sketch, the working principle of a grid connected solar system. **(7)**

18.

a. In a water pumping system, the water is being pumped from a sump to an overhead tank situated 25m above ground. The sump bottom is 2m below ground. The motor-pump system is located at ground level. The water is being pumped at the rate of 24.6 litres/sec. The pipe inner diameter is 10 cm. The pipe is placed completely vertical with no horizontal part. The friction factor is 0.037. The efficiencies of the pump, motor and dc-dc converter are 70%, 80% and 90% respectively. If the system is being powered by a PV source, what is the output power requirement for the PV panels? **(7)**

b. Explain the voltage and frequency matching method in grid connected PV system.(7)

Module 5

19.

a. Detail the anti-islanding protection with suitable block diagram. (7)
b. The life cycle cost of a system is Rs. 10000/- for a life period of 20 years. The rate of interest is 8% and the inflation rate is 5%. What is the annual life cycle cost for the system? (7)
c.

20.

a. Draw and explain the line of protection equipment in PV array installation. (6)

b. Suppose the energy-efficiency retrofit of a large building reduces the annual electricity demand for heating and cooling from 2.3 × 106 kWh to 0.8 × 106 kWh and the peak demand for power from by 150 kW. Electricity costs Rs. 5/kWh and demand charges are Rs. 500/kW per month, both of which are projected to rise at an annual rate of 5%. If the project costs Rs. 3,50,00,000, what is the internal rate of return over a project lifetime of 15 years? (8)

**Syllabus**

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**Module 2**

Solar Thermal system-Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – performance evaluation. Applications -Solar heating system, Air conditioning and Refrigeration system, Pumping system, solar cooker, Solar Furnace, Solar Greenhouse -Design of solar water heater

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| **3** | **Solar PV systems (7 Hours)** | |
| 3.1 | Introduction -Fundamentals of Semiconductor and Solar Cells -Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell -Generation of Solar Cell (Photovoltaic) Materials | 2 |
| 3.2 | Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III–V Single Junction and Multijunction PV Modules -Emerging and New PV Systems | 1 |
| 3.3 | Packing Factor of the PV Module - Efficiency of the PV Module -Energy Balance Equations for PV Modules | 1 |
| 3.4 | Series and Parallel Combination of PV Modules.- Effect of shadowing- | 1 |
| 3.5 | MPPT Techniques-P&O , incremental conductance methd-Maximum Power Point Tracker (MPPT) using buck-boost converter. | 2 |
| **4** | **Stand Alone and Grid integrated PV System (9 Hours)** | |

| | | |
|---|---|---|
| 4.1 | Solar PV Systems –stand-alone and grid connected -Design steps for a Stand-Alone system –Storage batteries and Ultra capacitors. | 2 |
| 4.2 | Design PV powered DC fan and pump without battery | 2 |
| 4.3 | Design of Standalone System with Battery and AC or DC Load. | 2 |
| 4.4 | A Grid Interactive PV System - Phase , Frequency Matching and Voltage Consideration – Operation of a Grid Interactive Inverter | 2 |
| 4.5 | IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems | 1 |
| **5** | **GIPV System Protection and LCC (7)** | |
| 5.1 | Protection Against Islanding and Reverse Power Flow | 1 |
| 5.2 | AC Modules Design of EMI Filters.  . | 1 |
| 5.3 | Overcurrent protection of solar PV power system, Selective fuse links for PV String protection, PV fuse selection flow chart, Fuse rating for PV Applications | 2 |
| 5.4 | Life cycle costing, Growth models, Annual payment and present worth factor, payback period of solar PV system, LCC with examples. | 2 |
| 5.5 | Introduction to simulation software for solar PV system design like PV syst, PV SOL etc. | 1 |

| CODE | COURSE NAME | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| **22EEE804 .6** | **INDUSTRIAL INSTRUMENTATION AND AUTOMATION** | **PEC** | **2** | **1** | **0** | **3** |

**Preamble** : This course introduces basic terms and techniques applicable to instrumentation and various automation activities related to the industry and power sector. It also provides a basic idea of the recent developments in communication techniques and process control in industrial automation.

**Prerequisite** : **Basics of Analog and digital electronics, control systems**

**Course Outcomes** : After the completion of the course, the student will be able to:

| | |
|---|---|
| **CO 1** | Identify the sensors/transducers suitable for industrial applications. |
| **CO 2** | Design the signal conditioning circuits for industrial instrumentation and automation. |
| **CO 3** | Analyze the concepts of data transmission and virtual instrumentation related to automation |
| **CO 4** | Develop the logic for the process control applications using PLC programming |
| **CO 5** | Describe the fundamental concepts of DCS and SCADA systems |

**Mapping of course outcomes with program outcomes**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | 1 | | | | | | | | | | 2 |
| **CO 2** | 3 | 1 | | | | | | | | | | 2 |
| **CO 3** | 3 | 1 | | | | | | | | | | 2 |
| **CO 4** | 3 | 1 | | | | | | | | | | 2 |
| **CO 5** | 3 | 1 | | | | | | | | | | 2 |

**Assessment Pattern**

| Total Marks | CIE marks | ESE marks | ESE Duration |
|---|---|---|---|
| 150 | 50 | 100 | 03 Hrs |

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination |
|---|---|---|---|
| | 1 | 2 | |
| Remember (K1) | 10 | 10 | 20 |

| | | | |
|---|---|---|---|
| Understand (K2) | 30 | 30 | 60 |
| Apply (K3) | 10 | 10 | 20 |
| Analyse (K4) | | | |
| Evaluate (K5) | - | - | - |
| Create (K6) | - | - | - |

**Continuous Internal Evaluation Pattern:**

**Attendance : 10 marks**

**Continuous Assessment Test (2 numbers) : 25 marks**

**Assignment/Quiz/Course project : 15 marks**

**End Semester Examination Pattern :** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer anyone. Each question can have a maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain different characteristics of transducers (K2)
2. Selection of transducers for various applications (K2, K3)

**Course Outcome 2 (CO2):**

1. Explain amplifier circuits used for signal conditioning in instrumentation systems (K2)
2. Explain different types of actuators used in instrumentation system (K2)

**Course Outcome 3 (CO3):**

1. Explain the protocols used in data transmission for instrumentation system (K2)
2. Describe the differences between traditional instruments and virtual instruments (K2)

**Course Outcome 4 (CO4):**

1. Describe the hardware details of programmable logic controllers (K2)
2. Implement logic gates and simple operations using PLC (K2, K3)

**Course Outcome 5 (CO5):**

1. Explain the architecture and protocols involved in SCADA systems (K2)
2. Describe the architecture of Distributed Control Systems (K2)

**Model Question paper**

**QP CODE:**

PAGES:2

Reg. No:_______________

Name:_______________

**TKM COLLEGE OF ENGINEERING**

**EIGHTH SEMESTER B. TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEE804.6**

**Course Name: INDUSTRIAL INSTRUMENTATION AND AUTOMATION**

Max. Marks: 100 Duration: 3 Hours

**PART A**

**Answer all questions. Each Question Carries 3 mark**

1. State the factors to be considered while selecting a transducer for a specific application.
2. Explain different modes of operation of hotwire anemometer.
3. How can a log amplifier be used for signal conditioning?
4. Describe the working of electrical actuators
5. Compare Profibus and Fieldbus used in data transmission
6. List the advantages of virtual instrumentation systems
7. Implement basic gate operations using PLC ladder logic
8. Write a PLC program to obtain a delay of 10ms for process control
9. List the main components associated with SCADA Systems.
10. Explain different protocols used in SCADA communication

**PART B**

**Answer any one full question from each module. Each question carries 14 marks.**

## Module 1

11. a) With the help of a diagram explain the process control loop.

**(10)**

b) Explain second order time response of sensor.

**(4)**

12. a) Explain the principal and operation of variable reluctance tachometer

**(7)**

b) Discuss the working principle of Capacitive differential pressure measurement

**(7)**

## Module 2

13. a) Explain different types of actuators.

**(10)**

b) Explain the working principle of charge amplifier.

**(4)**

14. a) Explain the operation of Instrumentation amplifier

**(7)**

b) How phase sensitive detectors can be employed for phase measurement.

**(7)**

## Module 3

15. a) Explain the architecture of Virtual instrumentation system

**(10)**

b) Describe the concept of graphical programming

**(4)**

16. a) Explain the different types of communication networks used for data collection and control in industrial applications **(10)**

b) Explain Field bus. **(4)**

**Module 4**

17. Devise a ladder program to switch on a pump for 100 s. It is then to be switched off , and a heater switched on for 50 s. Then the heater is switched off, and another pump is used to empty the water. **(14)**

18. Draw a block diagram of a PLC showing the main functional items and how buses link them, explaining the functions of each block **(14)**

**Module 5**

19. a) With neat diagram explain the architecture of Distributed control system **(7)**

b) Describe in detail protocols for SCADA communication **(7)**

20. a) Explain role of MTU in SCADA communication **(4)**

b) With neat diagram explain the architecture of SCADA system (**10)**

**Syllabus and Course Plan**

| Module | Contents | Hours |
|---|---|---|
| I | **Sensors and Transducers**<br><br>Introduction to Process Control - block diagram of the process control loop, definition of elements. Sensor time response - first and second-order responses.<br><br>Transducers- Characteristics and Choice of the transducer. Applications of Transducers- Displacement measurement using Resistance Potentiometer- Capacitive differential pressure measurement, Flow measurement using Hotwire anemometer, speed measurement- Variable reluctance tachometers, Phase measurement- Analog and digital | 7 |
| II | **Signal conditioning circuits and Final control**<br><br>Electronic amplifiers-Differential Amplifier, Instrumentation Amplifiers, Precision rectifiers, Log amplifiers, Carrier Amplifiers, Lock-In Amplifiers, Isolation Amplifiers, Charge amplifiers, Phase-sensitive detectors. Final control operation- signal conversion- actuators- control elements, Actuators- Electrical – Pneumatic- Hydraulic, Control elements-mechanical- electrical- fluid valves | 8 |
| III | **Data transmission and Virtual instrumentation system**<br><br>Cable transmission of analog and digital data, Fiber optic data transmission, Pneumatic transmission. Process control Network- Functions- General characteristics- Fieldbus and Profibus, radio-wireless communication, WLAN architecture.<br><br>Virtual instrumentation system: The architecture of virtual instruments – Virtual instruments and traditional instruments – concepts of graphical programming | 7 |
| IV | **Programmable logic controllers (PLC)**<br><br>Programmable logic controllers- Organization- Hardware details- I/O- Power supply- CPU- Standards Programming aspects- Ladder programming- realization of AND, OR logic, the concept of latching, Introduction to Timer/Counters, Exercises based on Timers and Counters. | 7 |
| V | **SCADA and DCS systems**<br><br>**SCADA**: Introduction, SCADA Architecture, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Protocols-IEC 60870-5-101 and DNP3.<br><br>**DCS:** Introduction, DCS Architecture, Control modes. | 6 |

**Text Books**


1. Curtis D Johnson , "Process Control Instrumentation Technology", PHI Learning Pvt Ltd New Delhi, 1997
2. Doeblin E.O, "Measurement Systems: Application and Design", Fourth Edition, McGraw Hill, Newyork, 1992
3. DVS. Murty, "Transducers and Instrumentation", Second Edition, PHI Learning Pvt Ltd New Delhi, 2013
4. Jovitha Jerome, "Virtual instrumentation using LabVIEW", Prentice Hall of India, 2010.
5. William Bolton, "Programmable Logic Controllers", Fifth edition, ELSEVIER INDIA Pvt Ltd New Delhi, 2011
6. Stuart A. Boyer, "SCADA: Supervisory Control and Data Acquisition", Fourth edition, International Society of Automation, 2010


**References:**


1. G.K.McMillan, 'Process/Industrial Instrument and control and hand book' McGraw Hill, New York,1999
2. Michael P .Lucas, 'Distributed Control system', Van Nastrant Reinhold Company, New York
3. Patranabis, D., 'Principles of Industrial Instrumentation', Second Edition Tata McGraw Hill Publishing Co. Ltd. New Delhi
4. Robert B. Northrop, 'Introduction to instrumentation and measurements', CRC, Taylor and Francis 2005


**Course Contents and Lecture Schedule:**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Sensors and Transducers (07 hours)** | |
| 1.1 | Introduction to Process Control - block diagram of the process control loop, definition of elements. Sensor time response - first and second-order responses. | 2 |
| 1.2 | Transducers- Characteristics and Choice of transducer. | 1 |
| 1.3 | Applications of Transducers- Displacement measurement using Resistance Potentiometer- Capacitive differential pressure measurement | 2 |
| 1.4 | Flow measurement using Hotwire anemometer, speed measurement- Variable reluctance tachometers, Phase measurement- Analog and digital | 2 |
| **2** | **Signal conditioning circuits and Final control (08 hours)** | |

| | | |
|---|---|---|
| 2.1 | Electronic amplifiers-Differential Amplifier, Instrumentation Amplifiers, Precision rectifiers, Log amplifiers, Carrier Amplifiers | 3 |
| 2.2 | Lock-In Amplifiers, Isolation Amplifiers, Charge amplifiers, Phase sensitive detectors | 2 |
| 2.3 | Final control operation- signal conversion- actuators- control elements<br><br>Actuators- Electrical – Pneumatic- Hydraulic<br><br>Control elements-mechanical- electrical- fluid valves | 3 |
| **3** | **Data transmission and Virtual instrumentation system(07Hours)** | |
| 3.1 | Cable transmission of analog and digital data, Fiber optic data transmission, Pneumatic transmission | 2 |
| 3.2 | Process control Network- Functions- General characteristics- Fieldbus and Profibus, radio and wireless communication and WLAN | 2 |
| 3.3 | Virtual instrumentation system: architecture of virtual instruments – Virtual instruments and traditional instruments – concepts of graphical programming | 3 |
| **4** | **Automation using PLC (07 Hours)** | |
| 4.1 | Programmable logic controllers- Introduction | 1 |
| 4.2 | Organisation and Hardware details - I/O- Power supply- CPU etc. | 2 |
| 4.3 | Standards Programming aspects- Ladder programming- realization of AND, OR logic, concept of latching, | 2 |
| 4.4 | Introduction to Timer/Counters, Exercises based on Timers and Counters | 2 |
| **5** | **Automation using SCADA and DCS Systems (06 Hours)** | |
| 5.1 | Introduction to SCADA, its Architecture and Common System Components | 1 |
| 5.2 | Supervision and Control, HMI, RTU and Supervisory Stations, Protocols-IEC 60870-5-101 and DNP3. | 3 |
| 5.3 | DCS: Introduction, DCS Architecture, Control modes. | 2 |

| **CODE** | **COURSE NAME**<br>**BIG DATA ANALYTICS** | **CATEGORY** | **L** | **T** | **P** | **CREDIT** |
|---|---|---|---|---|---|---|

| 22EEE 804.7 | | PEC | 2 | 1 | 0 | 3 |
|---|---|---|---|---|---|---|

**Preamble**: This course is offered to introduce fundamental algorithmic ideas in processing data. The preliminary concepts of Hadoop and Map Reduce are included as part of this course.

**Prerequisite: Nil**

**Course Outcomes:** After the completion of the course the student will be able to

| | |
|---|---|
| CO 1 | Explain the key concepts of data science. |
| CO 2 | Describe big data and use cases from selected business domains |
| CO 3 | Perform big data analytics using Hadoop and related tools like Pig and Hive. |
| CO 4 | Perform preliminary analytics using R language on simple data sets. |
| CO 5 | Differentiate various learning approaches in machine learning to process data, and to interpret the concepts of supervised and unsupervised learning |

**Mapping of course outcomes with program outcomes**

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** | **PO 11** | **PO 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 3 | | | | | | | | | | | 2 |
| **CO 2** | 3 | | | | | | | | | | | 2 |
| **CO 3** | 3 | 2 | 2 | | 3 | | | | | | | 2 |
| **CO 4** | 3 | 2 | | | 3 | | | | | | | 2 |
| **CO 5** | 3 | 2 | | | 3 | | | | | | | 2 |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination** |
|---|---|---|---|
| | **1** | **2** | |
| Remember | 15 | 15 | 30 |
| Understand | 25 | 25 | 50 |
| Apply | 10 | 10 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

| **Total Marks** | **CIE** | **ESE** | **ESE Duration** |
|---|---|---|---|
| 150 | 50 | 100 | 3 hours |

**Continuous Internal Evaluation Pattern:**

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

**End Semester Examination Pattern:** There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain the main categories of data that we come across in data science. (K1)
2. Summarize distributed file system with examples. (K1)
3. List the significance of data science. (K2)

**Course Outcome 2 (CO2)**

1. What are the three characteristics of Big Data, and what are the main considerations in processing Big Data?(K1)
2. Explain Big Data Analytics Lifecycle. (K1)
3. Explain Apache Hadoop ecosystem. (K1)

**Course Outcome 3(CO3):**

1. Demonstrate the map reduce execution flow to perform word count on data set.(K3)
2. Explain the stages of Map Reduce. (K2)
3. Write short notes on Pig and Hive. (K1)

**Course Outcome 4 (CO4):**

1. **How do you list the preloaded datasets in R? (K2)**
2. **Use R to find the highest common factor of two numbers. (K3)**
3. Why is R useful for data science? (K2)

**Course Outcome 5 (CO5):**

1. Mention the difference between Data Mining and Machine learning? (K2)
2. What are the different Algorithm techniques in Machine Learning? (K2)
3. Give a popular application of machine learning that you see on day-to-day basis? (K2)

**Model Question paper**

QP CODE: Reg No:______________
PAGES:3 Name :______________

**TKM COLLEGE OF ENGINEERING**

**THIRD/FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: 22EEE804.7**

**Course Name: BIG DATA ANALYTICS**

**Max. Marks: 100 Duration: 3 Hours**

**(2019-Scheme)**

## PART A

**(Answer all questions, each question carries 3 marks)**

1. List any six Data Science applications.
2. Briefly explain the data transformation step in the process of Data Science.
3. Explain the important characteristics of Bigdata.
4. List the functions of Namenode in HDFS.
5. Identify the need of MapReduce Partitioner in Hadoop.
6. Differentiate between Hadoop MapReduce and Pig.
7. In R how missing values are represented.
8. How you can import Data in R.
9. Discuss any four examples of machine learning applications.
10. Describe the applications of clustering in various domains.

**(10x3 = 30 marks)**

## PART B

**(Answer one full question from each module, each question carries 14 marks)**

### MODULE I

11.a)Illustrate with an example different stages of data science project.
b. Categorise the different roles associated with a data analysis project. (10+4 =14 marks)

Or

12. a) Explain the data cleansing subprocess of data science process.
b) Discuss in detail about Exploratory Data analysis. (8+6 =14 marks)

### MODULE II

13.a) Explain the core components of Apache Hadoop.
b) Write short note on YARN. (8+6 = 14 marks)

Or

14. a) Explain read and write operations in HDFS.
b) What are Blocks in HDFS Architecture. (10+4 = 14 marks)

### MODULE III

15.a) With a neat diagram, explain MapReduce architecture?
b) Describe the stages of MapReduce with an example. (5+9 = 14 marks)

Or

16. a) Write short note on Pig and HIVE.
b) Compare NoSQL & RDBMS (10+4 = 14 marks)

### MODULE IV

17.a) Explain data frames in R. Illustrate attach (), detach () and search () functions in R.
b) Explain any three functions in R to visualize a single variable. (8+6 = 14 marks)

Or

18. a) What are the data structures in R that is used to perform statistical analyses and create graphs?

b) Mention how you can produce co-relations and covariances with example?

(9+5 = 14 marks)

**MODULE V**

19.a) Distinguish between classification and regression with an example.

b) Describe in detail with examples (i) Supervised Learning(ii) Unsupervised Learning (iii) Reinforcement Learning. (5+9 = 14 marks)

Or

20. a) Is regression a supervised learning technique? Justify your answer. Compare regression with classification with examples.?

b) Illustrate K means clustering algorithm with an example.? (8+6 = 14 marks)

## Syllabus

**Module I-Data science in a big data world:** Benefits and uses of data science and big data-Facets of data-the big data ecosystem and data science-Data science process-roles-stages in data science project- Defining research goals-Retrieving data-Cleansing, integrating, and transforming data- Data Exploration-Data modelling - Presentation and automation.
(6 hours)

**Module II-Big Data Overview**–the five V's of big data-State of the Practice in Analytics-Examples of Big Data Analytics-Apache Hadoop and the Hadoop Ecosystem-HDFS-Design of HDFS, HDFS Concepts-Daemons-Reading and Writing Data-Managing File system Metadata-Map Reduce-The Stages of Map Reduce -Introducing Hadoop Map Reduce-Daemons-YARN
(8 hours)

**Module III-Analysing the Data with Hadoop using Map and Reduce**-Developing a Map Reduce Application-Anatomy of a Map Reduce Job- Scheduling-Shuffle and Sort - Task execution.
Big data Management Tools: PIG- : Introduction to PIG, Execution Modes of Pig,Pig Latin, HIVE: Hive Architecture, HIVEQL, Introduction to NoSQL. (Introduction only)
(7 hours)

**Module IV -Review of Basic Analytic methods using R**- Introduction to R -Data Import and Export -Attribute and Data Types - ordered and unordered factors-arrays and matrices- lists and data frames -Descriptive Statistics-Exploratory Data Analysis-Dirty Data-Visualizing a Single Variable-Examining Multiple Variables-statistical models in R-Graphical Procedures-High-level plotting commands-Low-level plotting commands.
(7 hours)

**Module V -Machine learning -**Introduction to Machine Learning, Examples of Machine Learning applications-Supervised Learning- Regression – Single variable, Multi variable-Classification – Logistic Regression- Unsupervised Learning - Clustering: K-means-Reinforcement Learning-Model Selection and validation-k-Fold Cross Validation-Measuring classifier performance- Precision, recall
(7 hours)

**Reference Books**


1. Davy Cielen, Arno D. B. Meysman, and Mohamed Ali ,"Introducing Data Science - Big data, machine learning, and more, using Python tools" , Dreamtech Press 2016
2. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses",Wiley,2013
3. EMC Education Services, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", Wiley ,January 2015
4. Tom White,"Hadoop: The Definitive Guide", Third Edition, O'Reilley,2012.
5. Eric Sammer,"Hadoop Operations",O'Reilly Media, Inc ,2012
6. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
7. "Programming Pig", Alan Gates, O'Reilley,2011.
8. Ethem Alpaydın, "Introduction to Machine Learning (Adaptive Computation and Machine Learning)", MIT Press, 2004.
9. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014
10. Christopher Bishop, "Pattern Recognition and Machine Learning", Springer, 2007.
11. Matloff, Norman," The art of R programming: A tour of statistical software design". No Starch Press, 2011.
12. Crawley, Michael J. The R book. John Wiley & Sons, 2012.

13. Sourabh Mukherjee, Amit Kumar Das and Sayan Goswami, “ Big Data Simplified”, Pearson, 1st edition, 2019.
14. Murtaza Haider, “Getting Started with Data Science”, Fist Edition, Kindle Edition, IBM Press, 2015.
15. Thomas Erl, Wajid Khattak and Paul Buhler “ Big Data Fundamentals:Concepts, Drivers and Techniques”, Prentice Hall, Pearson Service, 2016.

**Course Contents and Lecture Schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **Module I Data science in a big data world 6 hours** | |
| 1.1 | Data science in a big data world, Benefits and uses of data science and big data-Facets of data | 1 |
| 1.2 | the big data ecosystem and data science-Data science process-roles | 1 |
| 1.3 | Defining research goals-Retrieving data | 1 |
| 1.4 | Cleansing, integrating, and transforming data | 1 |
| 1.5 | Data Exploration | 1 |
| 1.6 | Data modelling - Presentation and automation. | 1 |
| **2** | **Module II -Big Data Overview 8 hours** | |
| 2.1 | the five V’s of big data-State of the Practice in Analytics-Examples of Big Data Analytics | 1 |
| 2.2 | Apache Hadoop and the Hadoop Ecosystem- HDFS | 2 |
| 2.3 | Design of HDFS- HDFS Concepts-Daemons-Reading and Writing Data - Managing Filesystem Metadata | 2 |
| 2.4 | Map Reduce-The Stages of MapReduce -Introducing Hadoop MapReduce-Daemons | 2 |
| 2.5 | YARN | 1 |
| **3** | **Module III - Analysing the Data with Hadoop 7 hours** | |
| 3.1 | **Analysing the Data with Hadoop using Map and Reduce-** Developing a Map Reduce Application | 1 |
| 3.2 | Anatomy of a Map Reduce Job- Scheduling-Shuffle and Sort - Task execution | 2 |
| 3.3 | Bigdata Management Tools: PIG- : Introduction to PIG, Execution Modes of Pig,Pig Latin | 2 |
| 3.4 | HIVE: Hive Architecture, HIVEQL, | 1 |
| 3.5 | Introduction to NoSQL | 1 |
| **4** | **Module IV -Review of Basic Analytic methods using R 7 hours** | |
| 4.1 | Introduction to R -Data Import and Export -Attribute and Data Types - ordered and unordered factors-arrays and matrices | 2 |
| 4.2 | lists and data frames -Descriptive Statistics | 1 |
| 4.3 | Exploratory Data Analysis -Dirty Data | 1 |
| 4.4 | Visualizing a Single Variable-Examining Multiple Variables | 1 |
| 4.5 | statistical models in R-. | 1 |
| 4.6 | Graphical Procedures-High-level plotting commands-Low-level plotting commands | 1 |
| **5** | **Module V - Machine learning 7 hours** | |

| | | |
|---|---|---|
| 5.1 | Introduction to Machine Learning, Examples of Machine Learning applications | 1 |
| 5.2 | Supervised Learning- Regression – Single variable, Multi variable | 2 |
| 5.3 | Classification – Logistic Regression | 1 |
| 5.4 | Unsupervised Learning - Clustering: K-means | 1 |
| 5.5 | Model Selection and validation-k-Fold Cross Validation | 1 |
| 5.6 | Measuring classifier performance- Precision, recall | 1 |