Dr. M.G.R.
EDUCATIONAL AND RESEARCH INSTITUTE
DEEMED TO BE UNIVERSITY
University with Graded Autonomy Status
(An ISO 21001 : 2018 Certified Institution)
Periyar E.V.R. High Road, Maduravoyal, Chennai-95. Tamilnadu, India.

# FACULTY OF ENGINEERING AND TECHNOLOGY

## DEPARTMENT
## OF
## ELECTRICAL AND ELECTRONICS ENGINEERING

## OUTCOME BASED EDUCATION

## Curriculum and Syllabus

## M.Tech(Part Time)-Power System

## 2022 REGULATION

## VISION STATEMENT

**We envision a department that renders services continuously to meet the requirements of changing world in Electrical Engineering Industry by educating the students for a global competition in line with Institution's Mission.**

## MISSION STATEMENT

| | |
|---|---|
| **M1** | **Enhance the quality of education by continuously updating curriculum and syllabi in correlation with the current trends** |
| **M2** | **Impart the students with latest technical and industry oriented software skills required for problem solving, design, testing and implementation of solutions in modern electrical power and energy related industries** |
| **M3** | **Enrich entrepreneurial skills that contributes to social-economic growth by utilizing the advanced technologies in electrical engineering** |
| **M4** | **Kindle their creative skills and encourage them to be innovators and provide a path for research and higher education** |
| **M5** | **Enlighten their communication skills and team spirit such that they reach out efficiently to the public on energy conservation and management, deal various situations practicing ethics.** |

## PROGRAMME EDUCATIONAL OBJECTIVES

| | |
|---|---|
| **PEO1** | **Proficient in engineering fundamentals such as mathematical, core science and engineering basics, hence capable of being competent and successful electrical engineers in various fields like industry/higher education/ research/entrepreneurship therefore building an energy efficient society.** |
| **PEO2** | **Inherit the characteristics of a renowned Electrical Engineer in the field of design, testing and manufacturing of electrical and electronic equipments, novel and creative design engineers for developing cost effective technology.** |
| **PEO3** | **Exploit real time problem solving skills, applying sustainable and renewable energy technology in developing smart grids to solve the energy crisis in the society.** |
| **PEO4** | **Communicate and compile engineering data and documents professionally to the benefit an entity or society, work in team building and exhibit leadership skills and entrepreneurial qualities.** |
| **PEO5** | **Exhibit lifelong learning through innovative research activities ensuring safety and ethics.** |

## PROGRAMME OUTCOMES

| | |
|---|---|
| **PO1** | **Ability to apply the enhanced knowledge in advanced technologies for modelling, analyzing and solving contemporary issues in power sector with a global perspective.** |
| **PO2** | **Ability to critically analyze and carry out detailed investigation on multifaceted complex Problems in area of Power Systems and envisage advanced research in thrust areas.** |
| **PO3** | **Ability to identify, analyze and solve real-life engineering problems in the area of Power Systems and provide strategic solutions satisfying the safety, cultural, societal and environmental aspects/ needs.** |

| | |
|---|---|
| **PO4** | **Ability for continued pursuance of research and to design, develop and propose theoretical and practical methodologies towards research and development support for the Power System infrastructure.** |
| **PO5** | **Ability to develop and utilize modern tools for modeling, analyzing and solving various Engineering problems related to Power Systems.** |
| **PO6** | **Willingness and ability to work in a team of engineers/ researchers with mutual understandings to take unsophisticated challenges, in the field of Power Systems, lead and motivate the group to inculcate multidisciplinary and collaborative approach.** |
| **PO7** | **Willingness and ability to take up administrative challenges including the management of various projects of interdisciplinary nature and carry out the same in an efficient manner giving due consideration to societal, environmental, economical and financial factors.** |
| **PO8** | **Ability to express ideas clearly and communicate orally as well as in writing with others in an effective manner, adhering to various national and international standards and practices for the documentation and presentation of the contents.** |

## PROGRAMME SPECIFIC OBJECTIVES

| | |
|---|---|
| **PSO1** | **Graduates acquire a rigid foundation in mathematical, core science and engineering fundamentals to pursue their higher education in various globally reputed institutions and are well versed in latest software to match the industrial needs.** |
| **PSO2** | **Graduates excel in designing, analyzing, testing and evaluating of various electrical systems such as Electrical Machines and Drives, Sub-station, Smart Grid, Micro Grid, Automation and Power systems in a cost effective manner to meet the energy crisis in the society.** |
| **PSO3** | **Graduates gain skills, confidence and expertise themselves in innovative technologies associated with current technology, capable of providing efficient energy management solutions and also compete vibrantly through the professional society platform and therefore crafted to be competent Entrepreneurs and industry ready electrical engineers.** |

**M.Tech –Power System (Part Time)**
**Curriculum and Syllabus**
**2022 Regulation**

| I SEMESTER | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| 1 | EMMA22012 | Random Process and Optimization Techniques | Ty | 3 | 1/0 | 0/0 | 4 |
| 2 | EMCC22001 | Research Methodology and IPR | Ty | 3 | 0/0 | 0/0 | 3 |
| 3 | EMPS22001 | Power System Dynamics and Control | Ty | 3 | 1/0 | 0/0 | 4 |
| 4 | EMPS22L01 | Power System Dynamics and Control Lab | Lb | 0 | 0/0 | 4/0 | 2 |
| 5 | EMCC22IXX | Audit Course 1 | IE | 2 | 0/0 | 0/0 | 0 |
| | | **Total** | | **11** | **2** | **4** | **13** |

| II SEMESTER | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22004 | Smart Grid | Ty | 3 | 0/0 | 0/0 | 3 |
| **2** | EMPS22EXX | Program Elective - I | Ty | 3 | 0/0 | 0/0 | 3 |
| **3** | EMPS22EXX | Program Elective - II | Ty | 3 | 0/0 | 0/0 | 3 |
| **4** | EMPS22L02 | Renewable Energy lab | Lb | 0 | 0/0 | 4/0 | 2 |
| **5** | EMCC22AUX | Audit Course 2 | IE | 2 | 0/0 | 0/0 | 0 |
| | | **Total** | | **11** | **0** | **4** | **11** |

| III SEMESTER | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22002 | Power System Analysis | Ty | 3 | 1/0 | 0/0 | 4 |
| **2** | EMPS22EXX | Program Elective - III | Ty | 3 | 0/0 | 0/0 | 3 |
| **3** | EMPS22EXX | Program Elective - IV | Ty | 3 | 0/0 | 0/0 | 3 |
| **4** | EMPS22L03 | Power System Analysis Lab | Lb | 0 | 0/0 | 4/0 | 2 |
| | | **Total** | | **9** | **1** | **4** | **12** |

| IV SEMESTER | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22003 | Digital Protection of Power System | Ty | 3 | 0/0 | 0/0 | 3 |
| **2** | EMPS22EXX | Program Elective - V | Ty | 3 | 0/0 | 0/0 | 3 |
| **3** | EMPS22L04 | Power System Protection Lab | Lb | 0 | 0/0 | 4/0 | 2 |
| **4** | EMPS22I01 | Term Paper | IE | 0 | 0/0 | 0/4 | 2 |
| | | **Total** | | **6** | **0** | **8** | **10** |

| V SEMESTER | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22005 | Power System Planning and Reliability | Ty | 3 | 1/0 | 0/0 | 4 |
| **2** | EMCC22OEX | Open Elective | Ty | 3 | 0/0 | 0/0 | 3 |
| **3** | EMPS22L05 | Dissertation Phase - I | Lb | 0 | 0/0 | 0/10 | 5 |
| | | **Total** | | **6** | **1** | **10** | **12** |

| VI SEMESTER | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22L06 | Dissertation Phase - II | Lb | 0 | 0/0 | 10/10 | 10 |
| | | **Total** | | **0** | **0** | **20** | **10** |

Ty/Lb/IE:Theory/Lab/Internal Evaluation.
L/T/SLr/P/R: Lecture/Tutorial/Supervised Learning/Practical/Research

# LIST OF PROGRAM ELECTIVES

| PROGRAM ELECTIVE - I | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22E01 | High Power Converters | Ty | 3 | 0/0 | 0/0 | 3 |
| **2** | EMPS22E02 | Energy Auditing ,Conservation and Management | Ty | 3 | 0/0 | 0/0 | 3 |
| **3** | EMPS22E03 | Optimization Techniques | Ty | 3 | 0/0 | 0/0 | 3 |
| **4** | EMPS22E04 | Dynamics of Electrical Machines | Ty | 3 | 0/0 | 0/0 | 3 |

| PROGRAM ELECTIVE - II | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22E05 | Wind and Solar Systems | Ty | 3 | 0/0 | 0/0 | 3 |
| **2** | EMPS22E06 | Electric and Hybrid Vehicles | Ty | 3 | 0/0 | 0/0 | 3 |
| **3** | EMPS22E07 | EHVAC Transmission | Ty | 3 | 0/0 | 0/0 | 3 |
| **4** | EMPS22E08 | Distributed generation and micro grid | Ty | 3 | 0/0 | 0/0 | 3 |

| PROGRAM ELECTIVE - III | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22E09 | Energy storage systems | Ty | 3 | 0/0 | 0/0 | 3 |
| **2** | EMPS22E10 | Electric Power Distribution System | Ty | 3 | 0/0 | 0/0 | 3 |
| **3** | EMPS22E11 | Digital Signal Processing | Ty | 3 | 0/0 | 0/0 | 3 |
| **4** | EMPS22E12 | Power Apparatus Design | Ty | 3 | 0/0 | 0/0 | 3 |

| PROGRAM ELECTIVE - IV | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22E13 | Advanced Micro-controller Based Systems | Ty | 3 | 0/0 | 0/0 | 3 |
| **2** | EMPS22E14 | Real Time Control of Power Systems | Ty | 3 | 0/0 | 0/0 | 3 |
| **3** | EMPS22E15 | Electric Power Quality | Ty | 3 | 0/0 | 0/0 | 3 |
| **4** | EMPS22E16 | Artificial Intelligence Techniques | Ty | 3 | 0/0 | 0/0 | 3 |

| PROGRAM ELECTIVE - V | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMPS22E17 | Restructured Power Systems | Ty | 3 | 0/0 | 0/0 | 3 |
| **2** | EMPS22E18 | Power System Transients | Ty | 3 | 0/0 | 0/0 | 3 |
| **3** | EMPS22E19 | FACTS and Custom Power Devices | Ty | 3 | 0/0 | 0/0 | 3 |
| **4** | EMPS22E20 | Industrial Load Modeling and Control | Ty | 3 | 0/0 | 0/0 | 3 |

| AUDIT COURSE 1 & 2 | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| **1** | EMCC22I01 | English for Research paper Writing | Ty | 2 | 0/0 | 0/0 | 0 |
| **2** | EMCC22I02 | Disaster Management | Ty | 2 | 0/0 | 0/0 | 0 |
| **3** | EMCC22I03 | Sanskrit for Technical Knowledge | Ty | 2 | 0/0 | 0/0 | 0 |
| **4** | EMCC22I04 | Value Education | Ty | 2 | 0/0 | 0/0 | 0 |
| **5** | EMCC22I05 | Constitution of India | Ty | 2 | 0/0 | 0/0 | 0 |
| **6** | EMCC22I06 | Pedagogy Studies | Ty | 2 | 0/0 | 0/0 | 0 |
| **7** | EMCC22I07 | Stress Management by Yoga | Ty | 2 | 0/0 | 0/0 | 0 |
| **8** | EMCC22I08 | Personality Development through Life Enlightenment Skills | Ty | 2 | 0/0 | 0/0 | 0 |
| **9** | EMCC22I09 | Research Publication Ethics | Ty | 2 | 0/0 | 0/0 | 0 |

| OPEN ELECTIVE | | | | | | | |
|---|---|---|---|---|---|---|---|
| S.No | Course Code | Course Title | Ty/Lb/ IE | Teaching Scheme | | | Credits |
| | | | | L | T/S.Lr | P/R | |
| 1 | EMCC22OE1 | Business Analytics | Ty | 3 | 0/0 | 0/0 | 3 |
| 2 | EMCC22OE2 | Industrial Safety | Ty | 3 | 0/0 | 0/0 | 3 |
| 3 | EMCC22OE3 | Cost Management of Engineering Projects | Ty | 3 | 0/0 | 0/0 | 3 |
| 4 | EMCC22OE4 | Composite Materials | Ty | 3 | 0/0 | 0/0 | 3 |
| 5 | EMCC22OE5 | Waste to Energy | Ty | 3 | 0/0 | 0/0 | 3 |

**Summary of Credits:**

| **Semester** | **Credits** |
|---|---|
| I | 13 |
| II | 11 |
| III | 12 |
| IV | 10 |
| V | 12 |
| VI | 10 |
| **Total** | **68** |

## Components of curriculum and Credit distribution

| S. No | CATEGORY | Description | No.of Courses | Credits | Total | Credit Weightage % | Contact hours |
|---|---|---|---|---|---|---|---|
| 1 | CORE COURSES | Core Theory | 05 | 3*4=12<br>2*3=06 | 26 | 38.2 | ((3*60)+ 2*45) = 270 |
| | | Core Lab | 04 | 04*2=08 | | | (4*45)= 180 |
| 2 | ELECTIVE COURSES | Department Core Electives/ Skill enhancement electives | 5 | 5*3=15 | 15 | 22 | (5*45)= 225 |
| 3 | MATHEMATICS | Theory | 01 | 1*4=4 | 04 | 06 | 1*60=60 |
| 4 | OPEN ELECTIVES | Open Elective theory | 01 | 1*03=3 | 03 | 4.41 | (1*45)= 45 |
| 5 | COMMON COURSE | Theory | 01 | 1*03=3 | 03 | 4.41 | (1*45)= 45 |
| 6 | SKILL BASED ELECTIVES (AUDIT COURSES) | Theory | 02 | 0 | 0 | 0 | (20*2)=40 |
| 7 | PROJECTS | Project | 02 | (1*5=5)+ (1*10=10) | 15 | 22 | (75+150)= 225 |
| 8 | TERM PAPER | Publication | 01 | 1*02=02 | 02 | 3 | 30 |
| **Total** | | | **22** | **68** | **68** | **100** | **1120** |

## Revision/modification done in syllabus content:

| S.No | Course (Subject ) Code | Course (Subject) Name | Concept/ topic if any, removed in current curriculum | Concept/topic added in the new curriculum | % of Revision/ Modification done |
|---|---|---|---|---|---|
| 1. | EMPS22L04 | POWER SYSTEM PROTECTION LAB | NIL | MODELING | 15 |
| 2. | EMPS22E01 | HIGH POWER CONVERTERS | CYCLOCONVERTERS,MATRIX CONVERTERS,UPS | FULL CONTENT CHANGED | 95 |
| 3. | EMPS22E04 | DYNAMICS OF ELECTRICAL MACHINES | TRANSFER FUNCTION | FULL CONTENT CHANGED | 90 |
| 4. | EMPS22E05 | WIND AND SOLAR SYSTEMS | FEW CONTENTS IN ALL UNITS TO BE CHANGED | FULL CONTENT CHANGED | 95 |
| 5. | EMPS22E06 | ELECTRIC AND HYBRID VEHICLES | FEW CONTENTS IN ALL UNITS TO BE CHANGED | FULL CONTENT CHANGED | 95 |
| 6. | EMPS22E17 | RESTRUCTURED POWER SYSTEMS | FEW CONTENTS IN ALL UNITS TO BE CHANGED | FULL CONTENT CHANGED | 80 |

**Details of New courses, Electives, inter disciplinary, life skill, courses focused on employability, entrepreneurship, skill etc.**

| S.No | New courses (Subjects) | Value added courses | Life skill | Electives | Inter Disciplinary | Focus on employability /entrepreneurship/ skill development |
|---|---|---|---|---|---|---|
| 1 | POWER SYSTEM DYNAMICS AND CONTROL | | | | RANDOM PROCESS AND OPTIMIZATION TECHNIQUES | TERM PAPER |
| 2 | RENEWABLE ENERGY LAB | NIL | NIL | ENERGY AUDITING , CONSERVATION AND MANAGEMENT | | |
| 3 | POWER SYSTEM DYNAMICS AND CONTROL LAB | NIL | NIL | OPTIMIZATION TECHNIQUES | NIL | NIL |
| 4 | POWER SYSTEM ANALYSIS LAB | NIL | NIL | EHVAC TRANSMISSION | NIL | |
| 5 | POWER SYSTEM PLANNING AND RELIABILITY | NIL | NIL | DISTRIBUTED GENERATION AND MICRO GRID | NIL | |
| 5 | NIL | NIL | NIL | ENERGY STORAGE SYSTEMS | NIL | RESEARCH PUBLICATION ETHICS |
| 6 | NIL | NIL | NIL | REAL TIME CONTROL OF POWER SYSTEMS | NIL | NIL |

| Course Code: | Course Title: RANDOM PROCESS AND OPTIMIZATION TECHNIQUES | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| EMMA22012 | Prerequisite: UG level Mathematics | Ty | 3 | 1/0 | 0/0 | 4 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Describe and analyze the statistical methods.
2. Student will be gaining knowledge of linear programming problem
3. Having critical thinking and innovative skills

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | To be able to understand Random variable |
| **CO2** | To Understand the relation between probability and statistics |
| **CO3** | To Use numerical methods to solve algebraic and transcendental equations. |
| **CO4** | To analyze the advanced matrix theory |
| **CO5** | To Understand the concepts linear programming problem |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 2 |
| CO2 | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 1 | 2 | 2 | 3 | 1 | 1 |
| CO4 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| CO5 | 3 | 3 | 1 | 2 | 1 | 1 | 2 | 1 |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| CO1 | 3 | 3 | 2 | | | | | |
| CO2 | 2 | 2 | 1 | | | | | |
| CO3 | | 3 | 2 | | | | | |
| CO4 | 3 | 3 | 3 | | | | | |
| CO5 | 3 | 3 | 3 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | √ | | | | | | | | |

**EMMA22012 RANDOM PROCESS AND OPTIMIZATION TECHNIQUES 3 1/0 0/ 0 4**

**UNIT I RANDOM VARIABLES 12 hours**

Random variables – Distribution functions – Moments – Moment generating functions – Two dimensional Random variables – Marginal and conditional distributions.

**UNIT II RANDOM PROCESS 12 hours**

Classification of Random Process – Stationary Process – Ergodic Process – Markov Process – Markov Chains – Auto Correlation – Auto Covariance – Cross Correlation – Cross Covariance – Spectral Density.

**UNIT III SOLUTION OF EQUATIONS 12 hours**

Solution of Algebraic and Transcendental equations – Method of false position – Iteration method – Newton-Raphson method – Solution of Linear system of equations – Gauss Elimination method – Gauss-Jordan method – Iterative methods – Gauss-Jacobi method – Gauss-Seidel method – Matrix Inversion by Gauss-Jordan method.

**UNIT IV ADVANCED MATRIX THEORY 12 hours**

Generalized Eigen vectors – Jordan canonical form – Matrix norms – QR algorithm – Pseudo inverse – Singular value decomposition – Least square solutions.

**UNIT V LINEAR PROGRAMMING 12 hours**

Formulation of LPP – Standard form of LPP – Graphical method – Simplex method – Big M method – Two phase method.

**Total no. of hours: 60**

**Suggested Reading:**

1. Richard Johnson A., Miller & Freund's ,"Probability and statistics for Engineers "(8th ed.), Prentice Hall of India, 2009.
2. Veerarajan T., "Probability, Statistics and, Random Processes", Tata McGraw Hill Publishing Co., 2008.
3. Gupta S.C., Kapoor V.K., "Fundamentals of Mathematical Statistics", S.Chand& Co., 2007.
4. Veerarajan T., "Numerical Methods", Tata McGraw Hill Publishing Co., 2005.
5. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice Hall of India, 2003.
6. Bronson R., "Theory and problems of Matrix operations" (Schaum's outline series), McGraw Hill, 1989.
7. Lewis D.W., "Matrix theory", Allied publishers, 1995.
8. Hamdy A. Taha, "Operations Research: An Introduction" (9th ed.), Pearson, 2010.
9. Panneerselvam R., "Operations Research" (2nd ed.), Prentice Hall of India, 2011.

| | | | | | | |
|---|---|---|---|---|---|---|
| **ourse Code: EMCC22001** | **Course Title: RESEARCH METHODOLOGY AND IPR** | **Ty/Lb/ IE** | **L** | **T/S.Lr** | **P/R** | **C** |
| | **Prerequisite: Core Subjects** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** The goal is to emphasize the importance of innovation and creativity by understanding the research concept and ethics which will aid to build the nation IPR status.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Understand research problem formulation by Analyzing research related information and its execution by following research ethics |
| **CO2** | Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity. |
| **CO3** | Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular. |
| **CO4** | Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| **COs/POs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **2** | **3** | **3** | **3** | **3** | | | |
| **CO2** | **2** | **3** | **3** | **3** | **3** | | | |
| **CO3** | **2** | **3** | **3** | **3** | **3** | | | |
| **CO4** | **3** | **3** | **2** | **3** | **2** | | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **3** | **3** | | | | | |
| **CO3** | **3** | **3** | **3** | | | | | |
| **CO4** | **3** | **3** | **3** | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | √ | | |

**EMCC22001 RESEARCH METHODOLOGY AND IPR 3 0/0 0/0 3**

**UNIT I SELECTION, ANALYSIS AND STATEMENT OF THE RESEARCH PROBLEM 9 hours**

Literature Review and Formulation of Objectives – using the following Critical thinking Skills – Drawing a Concept map, Oral Communication, Debating, Questioning, Collaborating, Evaluation and Reasoning

**UNIT II RESEARCH DESIGN 9 hours**

Types of Study, Types of Data, Measures of Variability, Setting up the Hypotheses, data collection techniques and tools, sampling, Describing data – Charts and graphs ; Data processing – Categorization, coding, summarization.

**UNIT III DATA ANALYSIS AND REPORT WRITING 9 hours**

Statistical measures, Regression and correlation, significance test; Report writing – Purpose, format, content, editing and evaluation. Using Citation tools; Report for specific purposes – Theses, Journals, Grant application. Oral presentation to an audience; use of project management digital tools and plagiarism checking.

**UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY 9 hours**

Types of intellectual property rights – Patent, Copyright, Trade Mark, Industrial Design, Geographical Indication, Trade Secrets - Traditional Knowledge. Elements of Patentability - Novelty, Non Obviousness (Inventive Steps), Industrial Application – Non patentable inventions – Process of patenting – National and International – Form and Fees for IP India

**UNIT V PRIOR ART SEARCH, PATENT DRAFTING 9 hours**

Drafting patent Claims – Types of claims - Registration Procedure, Rights and Duties of Patentee; Patent infringement; Licensing – Franchising - Joint ventures; Non-Disclosure Agreements (NDAs) - Material Transfer Agreements (MTAs).

**Total no. of hours: 45**

**Suggested Reading:**

1. C. Vijayalakshmi and C. Sivapragasam ,"Research Methods – Tips and Techniques" , MJP Publishers , 2011 .
2. P Deboraj Rumsey ," Statistics Essentials for Dummies", Wiley Publishing Incorporated,2010.
3. Bouchoux ," Intellectual Property", DELMAR CENGAGE Learning, USA,2013.
4. V K Ahuja ," Law Relating to Intellectual Property Rights", LexisNexis Butterworths India,2017.

**Important WebLinks:**

1. https://www.wipo.int/portal/en/index.html
2. http://ipindia.nic.in/
3. https://www.epo.org
4. https://www.uspto.gov

| Course Code: EMPS22001 | Course Title: POWER SYSTEM DYNAMICS AND CONTROL | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Electrical Machines, Control System , Power system | Ty | 3 | 1/0 | 0/0 | 4 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the fundamental dynamic behavior of power systems to perform basic stability issues
2. Acquire fundamental knowledge about modeling and dynamics of synchronous machines.
3. Derive Single and Multi-machine power system dynamic models.
4. Analyze methods of small-signal stability analysis of power system.
5. Realize about Transmission and Machine models and the effect of transients in transmission models.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Choose the fundamental dynamic behavior and controls of power systems to perform basic stability analysis. |
| **CO2** | Comprehend the concepts in modeling and simulating the dynamic phenomena of power systems and Interpret results of system stability studies. |
| **CO3** | Ability to analyze the single and Multi-machine power system. |
| **CO4** | Analyze the theory and practice the concept of small signal stability of a single-machine infinite bus system. |
| **CO5** | Model the transmission and synchronous machines and analyze the transient stability. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | 2 | | | |
| CO2 | 3 | 3 | 3 | 2 | 2 | | | |
| CO3 | 3 | 2 | 3 | 2 | 2 | | | |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | | |
| CO5 | 3 | 3 | 3 | 2 | 2 | | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 2 | | | | | |
| CO2 | 3 | 3 | 1 | | | | | |
| CO3 | | 2 | | | | | | |
| CO4 | 3 | 2 | | | | | | |
| CO5 | | 3 | | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | √ | | | | | |

**EMPS22001 POWER SYSTEM DYNAMICSAND CONTROL 3 1/0 0/0 4**

**UNIT I BASIC CONCEPTS AND REVIEW OF CLASSICAL METHODS 12 hours**

Introduction on Power System Stability –Review on the States of Operation and System Security - System Dynamic Problems - Current Status and Recent Trends - System Model - Some Mathematical Preliminaries - Analysis of Steady State Stability - Analysis of Transient Stability - Simplified Representation of Excitation Control.

**UNIT II SYNCHRONOUS MACHINE DYNAMIC MODELING AND CONTROL 12 hours**

Dynamic Modeling:Introduction - Three-Damper-Winding Model - Transformations and Scaling - Linear Magnetic Circuit - Nonlinear Magnetic Circuit - Single-Machine Steady State - Operational Impedances and Test Data.
Control Models:Voltage and Speed Control Overview - Exciter Models - Voltage Regulator Models - Turbine Models - Speed Governor Models – Problems.

**UNIT III SINGLE AND MULTIMACHINE DYNAMIC MODELS 12 hours**

Single Model:Multi-Time-Scale Model - Elimination of Stator/Network Transients - Two-Axis Model - One-Axis (Flux-Decay) Model - Classical Model - Damping Torques - Synchronous Machine Saturation – Problems.
Multimachine Model:Synchronously Rotating Reference Frame - Network and R-L Load Constraints - Elimination of Stator/Network Transients - Two-Axis Model - Flux{Decay Model - Classical Model - Damping Torques - Saturation - Frequency during Transients - Angle References and an Infinite Bus.

**UNIT IV SMALL SIGNAL STABILITY 12 hours**

Basic Linearization Technique: Linearization of Model A , Linearization of Model B - Participation Factors - Studies on Parametric effects:Effect of loading - Effect of $K_A$ - Effect of type of load - Hopf bifurcation - Electromechanical Oscillatory Modes - Power System Stabilizers: Basic approach - Derivation of K1- K6 constants - Synchronizing and damping torques - Power system stabilizer design-Problems.

**UNIT V TRANSMISSION LINES AND DYNAMICS OF A SYNCHRONOUS GENERATOR 12 hours**

Transmission Lines -D-Q Transformation using α - β Variables – Loads. Electromagnetic Transients: Fastest Transients - Transmission Line Models - Solution Methods. Dynamics of a Synchronous Generator Connected to

Infinite Bus: System Model - Synchronous Machine Model - Application of Model - Calculation of Initial Conditions - System Simulation - Consideration of other Machine Models.

**Total no. of Hours: 60**

**Suggested Reading:**

1. K.R.Padiyar, “Power System Dynamics, Stability & Control”, BS Publications, Second Edition, 2015.
2. P. Kundur, “Power system stability and control”, McGraw Hill Inc, New York, 2006.
3. P.M. Anderson ,A.A.Fouad, “Power System Control and Stability”, Galgotia Publications, New Delhi, 2003.
4. Peter W. Sauer, M. A. Pai,“Power System Dynamics and Stability”, Pearson Education Asia, India, 2002.
5. I.J. Nagrath, D.P. Kothari, “Modern Power System Analysis”, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
6. Harry G. Kwatny, Karen Miu-Miller,"Power System Dynamics and Control: A Nonlinear Hybrid Systems PerspectiveControl Engineering”, Springer New York, 2016.

| Course Code: | Course Title: POWER SYSTEM DYNAMICS AND CONTROL LAB | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| EMPS22L01 | Prerequisite: Electrical Machines, Control System , Power system | Lb | 0 | 0/0 | 4/0 | 2 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Acquire fundamental knowledge about modeling and dynamics of synchronous machines.
2. Analyze the methods of small-signal stability analysis of power system.
3. Realize about Transmission and Machine models and the effect of transients in power system.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Analyze the single and multi-machine models to be implemented in power system. |
| **CO2** | Comprehend the concepts in modeling and simulating the transmission and synchronous machines and analyze the dynamic and transient stability. |
| **CO3** | Design a stabilized power system with the knowledge of controlling aspects affecting the system. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | 2 | | | |
| CO2 | 3 | 3 | 3 | 2 | 2 | | | |
| CO3 | 3 | 2 | 3 | 2 | 2 | | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 1 | | | | | |
| CO3 | 3 | 2 | | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | ✓ |

| | | | | | |
|---|---|---|---|---|---|
| EMPS22L01 | **POWER SYSTEM DYNAMICSAND CONTROL LAB** | **0** | **0/0** | **4/0** | **2** |

**LIST OF EXPERIMENTS**

1. Design and analyze the dynamic modeling of the synchronous generator.
2. Design an excitation system for synchronous machine and regulate its terminal voltage in generating mode.
3. Perform a small-signal stability analysis of single machine-infinite bus system using classical machine model.
4. Perform a small-signal stability analysis of multi-machine-infinite bus system using classical machine model.
5. Design a power system stabilizer.
6. Electromagnetic Transients in Power systems: Transmission Line Energization.

**Total no.of hours:45**

| Course Code: EMPS22004 | Course Title: SMART GRID | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Electrical Machines, Control System ,Power system** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand concept of smart grid and its advantages over conventional grid.
2. Know smart metering techniques.
3. Learn wide area measurement techniques.
4. Understanding the problems associated with integration of distributed generation & its solution through smart grid.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Comprehend the difference between smart grid & conventional grid. |
| **CO2** | Apply smart metering concepts to industrial and commercial installations. |
| **CO3** | Ability to formulate the solutions in the areas of smart substations , distributed generation and wide area measurements. |
| **CO4** | Model the smart grid solutions using modern communication technologies. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **3** | **2** | **2** | | | |
| **CO2** | **3** | **3** | **3** | **2** | **2** | | | |
| **CO3** | **3** | **2** | **3** | **2** | **2** | | | |
| **CO4** | **3** | **3** | **3** | **3** | **3** | | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **3** | **3** | | | | | |
| **CO3** | **3** | **3** | **3** | | | | | |
| **CO4** | **3** | **2** | **3** | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | √ | | | | | |

**EMPS22004** **SMART GRID** **3 0/0 0/0 3**

**UNIT I INTRODUCTION TO SMART GRID** **9 hours**

Introduction to Smart Grid, Evolution of Electric Grid - Concept of Smart Grid, Definitions - Need of Smart Grid, Concept of Robust & Self Healing Grid Present development & International policies in Smart Grid Introduction to Smart Meters, Real Time Prizing, Smart Appliances - Automatic Meter Reading(AMR) - Outage Management System(OMS) - Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart - Sensors, Home & Building Automation - Smart Substations, Substation Automation, Feeder Automation .

**UNIT II WIDE AREA MEASUREMENT** **9 hours**

Geographic Information System(GIS) - Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro - Compressed Air Energy Storage, Wide Area Measurement System(WAMS) -Phase Measurement Unit(PMU).

**UNIT III MICROGRID** **9 hours**

Concept of micro-grid, need & applications of micro-grid, formation of micro-grid, Issues of interconnection, protection & control of micro-grid - Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuel-cells, micro-turbines - Captive power plants, Integration of renewable energy sources.

**UNIT IV POWER QUALITY IN SMART GRID** **9 hours**

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources - Power Quality Conditioners for Smart Grid- Web based Power Quality monitoring - Power Quality Audit.

**UNIT V COMPONENTS IN SMART GRID** **9 hours**

Advanced Metering Infrastructure (AMI), Home Area Network (HAN) - Neighborhood Area Network (NAN), Wide Area Network (WAN) -Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication -Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid Broadband over Power line (BPL) -IP based protocols.

**Total no. of Hours: 45**

**Suggested Reading:**

1. Ali Keyhani, “Design of smart power grid renewable energy systems”, Wiley IEEE, 2011.
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press , 2009.
3. JanakaEkanayake, Nick Jenkins, Kithsiri Liyanage, “Smart Grid: Technology and Applications”, Wiley 2012.
4. Stuart Borlase, “Smart Grid: Infrastructure, Technology and solutions “.CRC Press,2012.
5. A.G.Phadke, “Synchronized Phasor Measurement and their Applications”, Springer,2008.

| Course Code: EMPS22L02 | Course Title: RENEWABLE ENERGY LAB | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Non-Conventional Sources, HVDC | Lb | 0 | 0/0 | 4/0 | 2 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Obtain knowledge about specific wind power, calculate the wind frequency, turbines characteristics, time period and frequency of the rotating turbine at different speeds.
2. Analyze the Characteristics of Solar Modules when connected in series and parallel
3. Understand the modeling, simulation, implementation and performance characteristics of solar photovoltaic and wind turbine.
4. Design and simulate the performance characteristics of a Micro-grid.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Choose and design a wind turbine depending upon the generated wind power, turbines characteristics, performance of turbine at different speeds. |
| **CO2** | Design a PV system depending upon the illumination effect on PV Modules, effect of Temperature, effect of Shading on PV Modules and effect of angle of inclination of Solar Modules. |
| **CO3** | Comprehend the Characteristics of Solar Modules when connected in series and parallel in real time applications. |
| **CO4** | Design and determine the performance characteristics of solar photovoltaic and wind turbine in hybrid mode. |
| **CO5** | Design, simulate and test the performance characteristics of a Micro-grid. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | | | |
| CO2 | 3 | 3 | 3 | 3 | 2 | | | |
| CO3 | 3 | 2 | 3 | 2 | 2 | | | |
| CO4 | 3 | 3 | 3 | 3 | 3 | | | |
| CO5 | 3 | 3 | 3 | 3 | 3 | | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 3 | | | | | |
| CO3 | 3 | 3 | 1 | | | | | |
| CO4 | 3 | 3 | 3 | | | | | |
| CO5 | 3 | 3 | 3 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | √ |

**EMPS22L02** **RENEWABLE ENERGY LAB** **0 0/0 4/0 2**

## List of Experiments

1. Modeling of PV cell.
2. Modeling of Wind Turbine.
3. Analysis of the characteristics of charging and discharging of battery.
4. Design of solar PV boost converter using P&O MPPT technique.
5. Analyze the current waveform for linear & non-linear loads & calculations for grid tied PV system..
6. Impact of transmission line inductance on voltage quality at PCC.
7. Power factor correction using capacitor bank and its impact on power quality at PCC.
8. Design hybrid micro grid integration with grid and analyze the power flow.

**Total no.of hours:45**

| Course Code: | Course Title: POWER SYSTEM ANALYSIS | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| EMPS22002 | Prerequisite: Circuit Theory, Electrical Machines, Power System | Ty | 3 | 1/0 | 0/0 | 4 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Study various methods of load flow and their advantages and disadvantages.
2. Acquire fundamental knowledge on various types of faults in power system.
3. Understand power system security concepts and study the methods to rank the contingencies.
4. Gain knowledge of simple algorithms for state estimation.
5. Analyze voltage instability phenomenon.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Calculate voltage phasors at all buses , given the data using various methods of load flow. |
| **CO2** | Estimate the fault currents in each phase. |
| **CO3** | Rank various contingencies according to their severity. |
| **CO4** | Analyze the efficient algorithm to determine various parameters. |
| **CO5** | Determine the stability and instability of a power system. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 3 | 3 | 3 | | | |
| CO2 | 2 | 3 | 3 | 3 | 3 | | | |
| CO3 | 3 | 3 | 3 | 3 | 3 | | | |
| CO4 | 3 | 3 | 3 | 3 | 3 | | | |
| CO5 | 3 | 3 | 3 | 2 | 3 | 1 | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 3 | | | | | |
| CO3 | 3 | 2 | 3 | | | | | |
| CO4 | 3 | 2 | 3 | | | | | |
| CO5 | 3 | 3 | 3 | | | | | |

| 3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22002** **POWER SYSTEM ANALYSIS** **3 1/0 0/0 4**

**UNIT I LOAD FLOW** **12 hours**

Over view of Newton-Raphson, Gauss Seidal – Fast Decoupled methods-Convergence Properties- Sparsity Techniques – Handling Q-max- violations in constant matrix, inclusion in frequency effects- AVR in load flow, handling of discrete variable in load flow.

**UNIT II FAULT ANALYSIS** **12 hours**

Simultaneous faults - open conductors faults- generalized method of fault analysis.

**UNIT III SECURITY ANALYSIS** **12 hours**

Security state diagram, contingency analysis, generator shift distribution factors- line outage distribution factor, multiple line outages -overload index ranking – Power System Equivalents –WARD –REI Equivalents.

**UNIT IV STATE ESTIMATION** **12 hours**

Sources of errors in Measurement – Virtual and Pseudo – measurement – Observability – Tracking State Estimation – WSL Method –Bad Data Correction.

**UNIT V VOLTAGE STABILITY** **12 hours**

Voltage Collapse- P-V Curve, Multiple Power Flow Solution – Continuation Power Flow – Optimal Multiples Load Flow – Voltage Collapse Proximity Indices.

**Total no. of hours: 60**

**Suggested Reading:**

1. J.J. Grainger &W.D.Stevenson, “Power system analysis ”, McGraw Hill ,2017
2. A.R. Bergen & Vijay Vittal , “Power System Analysis” ,Pearson , 2000
3. L.P. Singh , “Advanced Power System Analysis and Dynamics”, New Age International, 2006
4. G.L. Kusic, “Computer aided power system analysis” ,Prentice Hall India, 2007
5. A.J. Wood, “ Power Generation, Operation and Control” , John Wiley, 2013
6. P.M. Anderson, “Faulted power system analysis” , IEEE Press , 1995

| Course Code: EMPS22L03 | Course Title: POWER SYSTEM ANALYSIS LAB | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Circuit Theory, Electrical Machines, Power System** | **Lb** | **0** | **0/0** | **4/0** | **2** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Model the transmission lines.
2. Perform various power and load flow analysis.
3. Ability to acquire knowledge on transient and short circuit analysis.
4. Gain knowledge on fault analysis on transmission line models.
5. Forecast load and estimate the economic load dispatch in power systems.
6. Familiar about Voltage Security in power system.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Comprehend the concepts in modeling transmission lines under normal and fault conditions. |
| **CO2** | Analyze the load and power flow performance in power system. |
| **CO3** | Determine the effect of the transient and short circuit fault in a power system and analysis the impact. |
| **CO4** | Estimate the economic load dispatch in power system. |
| **CO5** | Assess the methods to secure power system. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO2** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO3** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO4** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO5** | **3** | **3** | **3** | **2** | **3** | | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **3** | **3** | | | | | |
| **CO3** | **3** | **2** | | | | | | |
| **CO4** | **3** | **2** | | | | | | |
| **CO5** | **3** | **3** | | | | | | |

| **3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22L03** **POWER SYSTEM ANALYSIS LAB** **0** **0/0** **4/0** **2**

**LIST OF EXPERIMENTS**

1. Transmission line and modeling..
2. Power flow analysis by Newton-Raphson/ Fast decoupled method.
3. Transformers in power flow.
4. Estimation of the effect of sudden short-circuit on a synchronous generator output.
5. Transient stability studies.
6. Study the effect of short-circuits faults and overloading of transmission lines.
7. Economic load dispatch using lambda-iteration method.
8. Load Forecasting in Power System.
9. Unit commitment solution by Priority-list scheme and dynamic programming approach.
10. Study of Voltage Security in power system Real Time Voltage Assessment.

**Total no. of Hours: 45**

| Course Code: EMPS22003 | Course Title: DIGITAL PROTECTION OF POWER SYSTEM | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Power System Switchgear and Protection, Mathematical Knowledge | Ty | 3 | 0/0 | 0/0 | 3 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Study of numerical relays.
2. Develop mathematical approach towards protection.
3. Study of algorithms for numerical protection.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Determine the position placement of Digital Relays. |
| **CO2** | Apply Mathematical approach towards protection. |
| **CO3** | Learn to develop various efficient Protection algorithms to be implemented in power system. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | | | |
| CO2 | 3 | 3 | 3 | 3 | 3 | | | |
| CO3 | 3 | 3 | 3 | 3 | 3 | | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 2 | 2 | | | | | |
| CO2 | 3 | 2 | 3 | | | | | |
| CO3 | 3 | 3 | 3 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | √ | | | | | |

**EMPS22003 DIGITAL PROTECTION OF POWER SYSTEM 3 0/0 0/0 3**

**UNIT I RELAYS 9hours**

Evolution of digital relays from electromechanical relays - Performance and operational characteristics of digital protection- Mathematical background to protection algorithms - Finite difference techniques.

**UNIT II NUMERICAL METHODS 9hours**

Interpolation formulae - Forward, backward and central difference interpolation -Numerical differentiation -Curve fitting and smoothing -Least squares method -Fourier analysis -Fourier series and Fourier transform -Walsh function analysis.

**UNIT III DIGITAL PROTECTION 9hours**

Basic elements of digital protection -Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers -Conversion subsystem: the sampling theorem, signal aliasing -Error, sample and hold circuits, multiplexers, analog to digital conversion - Digital filtering concepts -The digital relay as a unit consisting of hardware and software.

**UNIT IV ALGORITHMS 9hours**

Sinusoidal wave based algorithms -Sample and first derivative (Mann and Morrison) algorithm. -Fourier and Walsh based algorithms.

**UNIT V ADVANCEMENT IN PROTECTION 9hours**

Fourier Algorithm: Full cycle window algorithm, fractional cycle -window algorithm. -Walsh function based algorithm -Least Squares based algorithms. Differential equation based algorithms. -Traveling Wave based Techniques -Digital Differential Protection of Transformers -Digital Line Differential Protection -Recent Advances in Digital Protection of Power Systems.

**Total no. of Hours: 45**

**Suggested Reading:**

1. A.G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems”, Wiley/Research studies Press, 2009
2. A.T. Johns and S. K. Salman, “Digital Protection of Power Systems”, IEEE Press,1999
3. Gerhard Zeigler, “Numerical Distance Protection”, Siemens Publicis Corporate Publishing, 2006
4. S.R.Bhide “Digital Power System Protection” PHI Learning Pvt.Ltd,2014.

| Course Code: EMPS22L04 | Course Title: POWER SYSTEM PROTECTION LAB | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Power System Switchgear and Protection, Computer and Analytical Knowledge** | **Lb** | **0** | **0/0** | **4/0** | **2** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the operating characteristics and testing of Current Transformers, Potential Transformers and Circuit Breaker.
2. Analyze the performance of various relays.
3. Model various relays.
4. Testing the operation of various relays.
5. Design and test the Reverse power protection and losses in generators.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Comprehend the ability to understand the operating characteristics and testing of Current Transformers, Potential Transformers and Circuit Breaker. |
| **CO2** | Ability to determine the selection of relays based on the application in power system. |
| **CO3** | Gain the knowledge of to model the relays. |
| **CO4** | Understand the testing concepts of relays in power system. |
| **CO5** | Design and simulate to protect the generators and analyze the losses occurring. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO2** | **3** | **3** | **3** | **3** | **3** | | | **2** |
| **CO3** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO4** | **3** | **3** | **3** | **3** | **3** | | | **1** |
| **CO5** | **3** | **3** | **3** | **2** | **3** | | | **2** |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **3** | **3** | | | | | |
| **CO3** | **3** | **2** | **3** | | | | | |
| **CO4** | **3** | **2** | **3** | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CO5** | **3** | **3** | **3** | | | | | |
| **3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low** | | | | | | | | |

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
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**EMPS22L04** **POWER SYSTEM PROTECTION LAB** **0 0/0 4/0 2**

**LIST OF EXPERIMENTS**

1. Testing of ratio, polarity, magnetizing characteristic of Current Transformers & Potential Transformers.
2. Development of and validation of Over current and Earth fault relays for three phase system.
3. Testing of Transformer using Differential relays and protection.
4. Testing of Line Distance relays
5. Testing of Line Differential relays
6. Design and testing the Reverse power protection and loss of field protection of generator.
7. Modeling and testing of Over fluxing relays
8. Modeling and testing of load shedding relays
9. Modeling and testing of Under/Over frequency relays
10. Modeling and testing of over voltage and under voltage relays
11. Modeling and testing of Negative sequence relays
12. Modeling and testing of auxiliary relays.
13. Testing of Air Circuit Breaker.

**Total no. of Hours: 45**

| Course Code: EMPS22005 | Course Title: POWER SYSTEM PLANNING AND RELIABILITY | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Power system ,Electrical Machines. | Ty | 3 | 1/0 | 0/0 | 4 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the plan and forecast the load.
2. Gain the knowledge of basic reliability concepts.
3. Inculcate on load forecasting uncertainties.
4. Analyze the various reliability evaluation methods.
5. Acquire the knowledge of inter-connected Systems Generating Capacity.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Apply the knowledge of the subject to calculate the load forecasting. |
| **CO2** | Learn various models suitable for system reliability to be implemented in power system. |
| **CO3** | Analyze the uncertainties in load forecasting and plan a reliable system. |
| **CO4** | Comprehend the various reliability evaluation methods. |
| **CO5** | Design and analyze the interconnection of two systems. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 2 | | |
| CO2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | |
| CO3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | | |
| CO5 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 3 | | | | | |
| CO3 | 2 | 3 | 3 | | | | | |
| CO4 | 3 | 3 | 3 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CO5** | **2** | **3** | **3** | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
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**EMPS22005** **POWER SYSTEM PLANNING AND RELIABILITY** **3 1/0 0/0 4**

**UNIT I PLANNING AND LOAD FORECASTING** **12 hours**

Objectives of planning – Long and short term planning ,Load forecasting – characteristics of loads – methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting – annual and monthly peak demand forecasting. Objectives of forecasting - Load growth patterns and their importance in planning - Load forecasting based on discounted multiple regression technique-Weather sensitive load forecasting-Determination of annual forecasting-Use of AI in load forecasting.

**UNIT II BASIC RELIABILITY CONCEPTS** **12 hours**

Basic Reliability Evaluation General reliability functions, probability distributions in reliability evaluation, network modeling and evaluation of series, parallel ,series-parallel, network modeling and evaluation of complex systems, cut-set method, tie-set method, discrete Markov chains, continuous Markov process, frequency and duration technique concepts, application to multistate problems, approximate system reliability evaluation.

**UNIT III STATIC GENERATING CAPACITY RELIABILITY EVALUATION** **12 hours**

Outage definitions, loss of load probability methods, loss of energy probability method. Frequency and duration methods, load forecasting uncertainty.Generation System Reliability Generation system models, capacity outage table, recursive algorithm, loss of load indices, inclusion of scheduled outage, load forecast uncertainty, loss of energy indices, expected energy generation, energy limited systems, Gram-Charlier series and its application to generation system reliability evaluation, generating capacity-frequency and duration method.

**UNIT IV RELIABILITY EVALUATION** **12 hours**

Spinning capacity evaluation, load forecast uncertainty. Transmission System Reliability Evaluation: Average interruption rate method ,The frequency and duration method, Stormy and normal weather effects.

**UNIT V INTER-CONNECTED SYSTEMS GENERATING CAPACITY RELIABILITY EVALUATION**

**12 hours**

Introduction, loss of load approach, Reliability evaluation in two and more than two interconnected systems. Interconnection benefits. Interconnected System Probability array method in two inter-connected system, effect of tie capacity, tie reliability and number of tie lines, equivalent assistance unit method for reliability evaluation of inter-connected system, elementary concepts for reliability evaluation of multi-connected systems.

**Total no. of hours: 60**

**Suggested Reading:**

1. R.L. Sullivan, “Power System Planning”, Tata McGraw Hill Publishing Company Ltd, 2012.
2. X. Wang & J.R. McDonald, “Modern Power System Planning”, McGraw Hill Book Company,1994.
3. Roy Billinton, “Power System Reliability Evaluation”, Gordan & Breach Scain Publishers, 1990.
4. J. Endrenyi, “Reliability modelling in Electric Power System”, John Wiley, 1980.
5. David Elmakias, “New Computational Methods in Power System Reliability”, Springer--Verlag, 2008.
6. Ali Chowdhury, Don Koval, “Power Distribution System Reliability: Practical Methods and Applications”, Wiley--IEEE Press, 2009.
7. Richard E. Brown, “Electric Power Distribution Reliability”, CRC Press, 2002.

# PROGRAM ELECTIVES

| Course Code: EMPS22E01 | Course Title: HIGH POWER CONVERTERS | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Control System ,Power system | Ty | 3 | 0/0 | 0/0 | 3 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the power devices used in high power converters.
2. Acquire knowledge of different converter topologies.
3. Learn the different control strategies suitable for converters.
4. Analyze and model the converters to be used in power system.
5. Gain knowledge to select the type of converters applicable for specific applications.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Learn the characteristics of power semiconductor devices and use them in designing the circuits. |
| **CO2** | Analyze the different topologies of the converters and use it according to the application. |
| **CO3** | Ability to analyze and decide the efficient control strategy suitable for specific converters. |
| **CO4** | Comprehend and model the converters to be implemented in power system. |
| **CO5** | Design various converters to be implemented based on the application. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 2 | | |
| CO2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | |
| CO3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | |
| CO5 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 3 | | | | | |
| CO3 | 2 | 3 | 3 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CO4** | **3** | **3** | **3** | | | | | |
| **CO5** | **3** | **3** | **3** | | | | | |
| **3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low** | | | | | | | | |

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22E01** **HIGH POWER CONVERTERS** **3 0/0 0/0 3**

**UNIT I INTRODUCTION TO CONVERTERS** **9 hours**

Basic introduction to power devices:SCR, MOSFET,IGBT,TRIAC-Introduction to power Converters: Half ,Full Bridge operation-single and three phase-Modulation techniques ,harmonics in sinusoidal PWM,Space vector modulation.

**UNIT II MULTILEVEL INVERTERS** **9 hours**

Introduction to Multilevel inverters:Two level voltage source inverter- Diode clamped multilevel inverters-flying capacitor multilevel inverter- Neutral point clamped converter-Cascaded H- bridge multilevel inverter:output waveform synthesis,Phase shift PWM,Level shift PWM-Fault tolerant operation.

**UNIT III MODULAR MULTILEVEL CONVERTER** **9 hours**

Introduction to Modular Multilevel Converter(MMC): Topology and operation-Arm and Cell voltage ratings , arm currents ,arm energy balance-Different MMC circuit topologies-PWM Techniques- Capacitor voltage balancing- Fault tolerant operation.

**UNIT IV CONTROLLERS** **9 hours**

Switched mode power converters: objective ,control implications- Feedback control: single and multi loop- cascaded SMPC-Variable frequency control-constant on time control methods- constant off time control methods-hysteresis control method-sliding mode control.

**UNIT V MODELLING OF CONVERTERS** **9 hours**

Overview of modeling techniques-Design aspects of converters- -Small signal analysis of converters: Derivation of transfer functions-Closed current loop-Impedance analysis and Stability.

**Total no. of hours: 45**

**Suggested Reading:**

1. N. Mohan, T. M. Undeland and W. P. Robbins, “Power Electronics: Converter, Applications and Design”, John Wiley and Sons, 1989.
2. M.H. Rashid, “Power Electronics”, Prentice Hall of India, 1994.
3. B. K .Bose, “Power Electronics and A.C. Drives”, Prentice Hall, 1986.
4. Bin Wu, “High power converters and drives”, IEEE press, Wiley Enter science.
5. https://archive.nptel.ac.in/courses/108/105/108105180.

| Course Code: EMPS22E02 | Course Title: ENERGY AUDITING , CONSERVATION AND MANAGEMENT | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Power system, Electrical Machines. | Ty | 3 | 0/0 | 0/0 | 3 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the current energy scenario, energy conservation, audit and management.
2. Gain the knowledge to calculate the efficiency of various thermal utilities.
3. Analyze the various energy monitoring system and optimization techniques.
4. Inculcate systematic knowledge and skill about assessing the energy efficiency, energy auditing and energy management.
5. Acquire the need and methods of energy conservation.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | apply the knowledge of the subject to calculate the efficiency of various thermal utilities. |
| **CO2** | design suitable energy monitoring system to analyze and optimize the energy consumption in an organization. |
| **CO3** | use the energy audit methods learnt to identify the areas deserving tighter control to save energy expenditure. |
| **CO4** | Comprehend and carry out the cost- benefit analysis of various investment alternatives for meeting the energy needs of the organization. |
| **CO5** | guide the employees of the organization about the need and the methods of energy conservation. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 2 | | |
| CO2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | |
| CO3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | | |
| CO5 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 3 | | | | | |
| CO3 | 2 | 3 | 3 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CO4** | **3** | **3** | **3** | | | | | |
| **CO5** | **2** | **3** | **3** | | | | | |
| **3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low** | | | | | | | | |

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22E02** **ENERGY AUDITING , CONSERVATION AND MANAGEMENT** **3 0/0 0/0 3**

**UNIT I ENERGY SCENARIO AND BASICS OF ENERGY ITS VARIOUS FORMS AND CONSERVATION**

**9 hours**

Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, Indian energy scenario, sectoral energy consumption (domestic, industrial and other sectors), energy needs of growing economy, energy intensity, long term energy scenario, energy pricing, Energy security, energy conservation and its importance, energy strategy for the future, Energy Conservation Act 2001 and its features.Thermal Basics-fuels, thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity and heat transfer.

**UNIT II THERMAL PERFORMANCE** **9 hours**

Calculation of heat loss - heat gain, estimation of annual heating & cooling loads, factors that influence thermal performance, analysis of existing buildings setting up an energy management programme and use management - electricity saving techniques. Energy efficiency in thermal utilities like boilers, furnaces, pumps and fans , compressors, cogeneration (steam and gas turbines), heat exchangers ,lighting system, Motors belts and drives, refrigeration system. Heat Recovery and Co-generation:Heat recovery from ventilation, air co-generation of heat and electricity, heat recovery and bottoming cycles.

**UNIT III ENERGY MANAGEMENT AND AUDIT** **9 hours**

Definition, energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, 3.1 Bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel and energy substitution, energy audit instruments and metering.

**UNIT IV ENERGY MONITORING AND TARGETING** **9 hours**

Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques - energy consumption, production, cumulative sum of differences (CUSUM). Energy Management Information Systems (EMIS).

**UNIT V FINANCIAL MANAGEMENT** **9 hours**

Investment-need, appraisal and criteria, financial analysis techniques simple payback period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis; financing options, energy performance contracts and role of Energy Service Companies (ESCOs).

**Total no. of hours: 45**

**Suggested Reading:**

1. W. F. Kenny, “Energy Conservation in Process Industries”, Elsevier Inc,1984.
2. Amlan Chakrabarti, “Energy Engineering and Management”, Prentice Hall India, 2019.
3. Craig B. Smith, Kelly Parmenter, “ Energy Management Principles-Applications, Benefits, Savings”, Pergamon Press, New York,2015.
4. https://beeindia.gov.in/.
5. W. C. Turner,”Energy Management Hand Book”, John Wiley and sons,2010.

| Course Code: EMPS22E03 | Course Title: OPTIMIZATION TECHNIQUES | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Mathematical and Computer Knowledge.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the necessity of optimization techniques in power system.
2. Create an Engineering design methodology using a mathematical formulation of a design problem to support selection of the optimal design among alternatives.
3. Ability to learn various algorithms.
4. Determine the effective optimization techniques for specific applications in power system.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Gain valuable insights into the fundamentals of various optimization techniques. |
| **CO2** | Comprehend and apply the theory of optimization methods and algorithms to develop and for solving various types of optimization problems. |
| **CO3** | Ability to go in research by applying optimization techniques in problems of Engineering and Technology. |
| **CO4** | Solve the mathematical results and numerical techniques of optimization theory to concrete Engineering problems by using computer software. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO2** | **3** | **3** | **3** | **3** | **3** | | | **2** |
| **CO3** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO4** | **3** | **3** | **3** | **3** | **3** | | | **1** |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **3** | **3** | | | | | |
| **CO3** | **3** | **3** | **3** | | | | | |
| **CO4** | **3** | **3** | **3** | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22E03** **OPTIMIZATION TECHNIQUES** **3 0/0 0/0 3**

**UNIT I FUNDAMENTALS OF OPTIMIZATION TECHNIQUES** **9 hours**

Fundamentals of optimization techniques: Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Lamda Iteration method, Linear programming, Quadratic programming).

**UNIT II LAMDA ITERATION METHOD** **9 hours**

Brief introduction to lamda iteration method, formulate the Lagrange function, Lamda iteration method to solve Optimal dispatch problem.

**UNIT III QUADRATIC PROGRAMMING AND LINEAR PROGRAMMING** **9 hours**

Introduction to quadratic programming-Working principle, sequential programming-Linear constrained optimization problem, Karush-Kuhn-Tucker conditions and its application to solve various problems-Interior point method,-lagrangian duality.Linear programming:Examples of linear programming problem-Simplex Method I-Fundamental theorem of linear programming-Weak and strong duality theorems-Integer programming-Network flow-develop a linear programming model from problem description.

**UNIT IV GENETIC ALGORITHM** **9 hours**

Introduction to genetic Algorithm - Working principle - Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming - Genetic Operators-Selection - Crossover and Mutation fitness function - GA operators-Similarities and differences between GA and traditional methods- Unconstrained and constrained optimization using Genetic Algorithm- Algorithms and flow chart for solving economic load dispatch and hydro-thermal scheduling problem.

**UNIT V PARTICLE SWARM OPTIMIZATION** **9 hours**

Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial. Algorithms and flow chart of various for solving economic load dispatch and hydro-thermal scheduling problem.

**Total no. of Hours: 45**

**Suggested Reading:**

1. S.S.Rao, “Engineering Optimization: Theory and Practice”, 3rd Edition, New Age International (P) Ltd,2013.
2. D.E.Goldberg ,”Genetic Algorithm” Pearson Education,2009

3. S.N.Sivanandam , S.N. Deepa, ”Principle of soft computing “,Wiley,2018.
4. Jizhong Zhu ,”Optimization on Power system Operation” Wiley-IEEE Press.
5. K.P. Chong, Stanislaw H. Zak.,”An Introduction to Optimization”, 3rd Edition.2011.
6. G. Hadley ,”Linear programming” , Narosa Publishing House, New Delhi,1997.

| Course Code: EMPS22E04 | Course Title: DYNAMICS OF ELECTRICAL MACHINES | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Power system ,Electrical Machines.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Learn the performance characteristics of machines
2. Gain knowledge how to model machines.
3. To understand the dynamics of the machines.
4. To analyze how to determine stability of machines.
5. Acquire knowledge about the transient conditions of synchronous machines.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Derive Kron's Primitive machine as an unified electrical machine model. |
| **CO2** | design the mathematical model and control a 3- phase Induction motor. |
| **CO3** | Analyze asymmetrical 2-phase induction motor. |
| **CO4** | Comprehend and derive the mathematical model of a separately excited DC motor and DC Series motor. |
| **CO5** | Determine a wide range of applications in electric power engineering careers. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **2** | **3** | **3** | **3** | **3** | **2** | | |
| **CO2** | **3** | **3** | **3** | **2** | **2** | **2** | | |
| **CO3** | **3** | **3** | **2** | **2** | **1** | **2** | | |
| **CO4** | **3** | **3** | **2** | **3** | **1** | **2** | | |
| **CO5** | **3** | **3** | **2** | **2** | **2** | **2** | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **2** | | | | | |
| **CO2** | **3** | **3** | **2** | | | | | |
| **CO3** | **2** | **3** | **3** | | | | | |
| **CO4** | **3** | **3** | **3** | | | | | |
| **CO5** | **2** | **3** | **3** | | | | | |

| 3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22E04 DYNAMIC OF ELECTRICAL MACHINES 3 0/0 0/0 3**

**UNIT-I: MODELING CONCEPTS 9 hours**

Basic Two-pole machine representation of commutator machines, 3-ph synchronous machine with and without damper bars and 3-ph induction machine, Kron's primitive machine-voltage, current and torque equations. Real time model of a two phase induction machine-transformation to obtain constant matrices-thee phase to two phase transformation- power equivalence.

**UNIT-II MODELING OF THREE PHASE INDUCTION MACHINE 9 hours**

Generalized model in arbitrary reference frame- Electromagnetic torque – Derivation of commonly used induction machine models- Stator reference frame modelRotor reference frame model- Synchronously rotating frame model- Equations in flux linkages - per unit model-Dynamic Simulation- Small signal equations of induction machine – derivation DQ flux linkage model derivation – control principle of Induction machine.Signal Transient - Small Oscillation Equations in State Variable form - Dynamical Analysis of Interconnected Machines.

**UNIT-III SYMMETRICAL AND UNSYMMETRICAL 2 PHASE INDUCTION MACHINE 9 hours**

Analysis of symmetrical 2 phase induction machine-voltage and torque equations for unsymmetrical 2 phase induction machine voltage and torque equations in stationary reference frame variables for unsymmetrical 2 phase induction machine-analysis of steady state operation of unsymmetrical 2 phase induction machine- single phase induction motor - Cross field theory of single-phase induction machine.

**UNIT-IV SYNCHRONOUS MACHINE MODELING 9 hours**

Mathematical model of a sep. excited DC motor- steady state and transient analysis - Transfer function of a sep. excited DC motor – Mathematical model of a DC series motor, shunt motor ,linearization techniques for small perturbations. Synchronous machine inductances – voltage equations in the rotor's DQ0 reference frame-electromagnetic torque-current in terms of linkages.

**UNIT-V DYNAMIC ANALYSIS OF SYNCHRONOUS MACHINE 9 hours**

Dynamic performance of synchronous machine, three-phase fault, comparison of actual and approximate transient torque characteristics, Equal area criteria- simulation of three phase synchronous machine – modeling of PMSM.

**Total no. of Hours: 45**

**Suggested Reading:**

1. D.P. Sengupta& J.B. Lynn," Electrical Machine Dynamics", The Macmillan Press Ltd. 1980.
2. R Krishnan "Electric Motor Drives, Modeling, Analysis, and Control", Pearson Education., 2001.
3. P.C. Kraus, "Analysis of Electrical Machines", McGraw Hill Book Company,1987.
4. Boldia& S.A. Nasar,,"Electrical Machine Dynamics", The Macmillan Press Ltd. 1992.
5. C.V. Jones, "The Unified Theory of Electrical Machines", Butterworth, London. 1967.
6. Chee Mun Ong "Dynamic simulation of Electric machinery using Matlab / Simulink" – Prentice Hall.
7. Woodson & Melcher, "Electromechanical Dynamics", John Wiley & Sons.

| Course Code: EMPS22E05 | Course Title: WIND AND SOLAR SYSTEMS | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Power system ,Electrical Machines. | Ty | 3 | 0/0 | 0/0 | 3 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Explain the concept of wind and solar energy systems.
2. Provide the students a deep insight in to the integration of power electronics converters with PV and wind energy sources.
3. Acquire knowledge about how to integrate power electronic converters with renewable energy sources.
4. Expose to study various maximum power point tracking (MPPT) techniques of wind and PV energy systems.
5. Inculcate on the need for hybrid energy systems and issues associated with it.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Explain the wind and solar energy conversion. |
| **CO2** | Design power electronic converters for stand-alone and grid tied wind and solar systems. |
| **CO3** | Ability of integrating power electronic converters with renewable energy sources. |
| **CO4** | Comprehend and Skill in developing MPPT techniques for wind and PV systems. |
| **CO5** | Develop proficiency in design and development of hybrid energy systems. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 3 | 3 | 1 | | |
| CO2 | 3 | 3 | 3 | 2 | 2 | 2 | | |
| CO3 | 3 | 3 | 2 | 2 | 1 | 2 | 1 | 1 |
| CO4 | 3 | 3 | 2 | 3 | 1 | 2 | | |
| CO5 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 3 | | | | | |
| CO3 | 2 | 3 | 3 | | | | | |
| CO4 | 3 | 3 | 3 | | | | | |
| CO5 | 2 | 3 | 3 | | | | | |

| 3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22E05** **WIND AND SOLAR SYSTEMS** **3 0/0 0/0 3**

**UNIT I SOURCES OF ENERGY** **9 hours**

Renewable energy sources and features. Introduction to wind and solar energy. Wind Energy: General theories of wind machines: Basic laws and concept of aerodynamics, efficiency limit for wind energy conversion. Description and performances of horizontal axis wind turbine: Design of the blades and determination of forces acting on the wind power plant, power - speed and torque - speed characteristics of wind turbines, wind turbine control systems. Description and performances of vertical axis wind turbine.

**UNIT II DESIGN AND OPERATION OF WIND POWER SYSTEM** **9 hours**

Induction and synchronous generators, grid connected and self-excited induction generator operation, generation schemes with variable speed turbines, constant voltage and constant frequency generation with power electronic control, Optimized control of induction generators and synchronous generators. Reactive power compensation, Types of converters, Type of wind energy conversion system, MPPT techniques for wind electrical systems.

**UNIT III DESIGN AND OPERATION OF PV SYSTEM AND BATTERIES** **9 hours**

Solar processes and spectral composition of solar radiation , Radiation flux at the Earth's surface, solar collectors, types and performance characteristics, applications. Solar Photovoltaic systems: Operating principle, photovoltaic cell concepts, cell, module, array, series and parallel connections. Solar PV system design and PV MPPT techniques. Applications Basics of Batteries: Types and parameters of batteries for PV systems, series and parallel connections and performance characteristics.

**UNIT IV GRID INTEGRATION AND HYBRID ENERGY SYSTEM** **9 hours**

Grid integration of wind and PV systems, charge controllers ,General overview of distributed generation ; Hybrid energy systems: Wind-Diesel hybrid system, Wind-solar hybrid system, System with energy storage, Special purpose applications.

**UNIT V WIND AND SOLAR ENERGY SYSTEM ECONOMICS** **9 hours**

Overview of economic assessment, capital, operation and maintenance costs of wind and solar energy systems, comparison of alternative energy systems using life cycle cost analysis.

**Total no. of Hours: 45**

**Suggested Reading:**

1. M.G. Simoes, F.A. Farret, "Alternative Energy Systems: Design and Analysis with Induction Generators", CRC Press , 2004
2. Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo, Massimo Vitelli, "Power Electronics And Control Techniques For Maximum Energy Harvesting in Photovoltaic Systems", CRC Press , 2012
3. Thomas Ackermann, Editor, "Wind power in Power Systems", John Willy and sons Ltd.2005
4. Siegfried Heier, "Grid integration of wind energy conversion systems", John Willy and sons Ltd., 2006
5. K. Sukhatme and S.P. Sukhatme, "Solar Energy". Tata McGraw Hill, Second Edition, 1996.

| Course Code: EMPS22E06 | Course Title: ELECTRIC AND HYBRID VEHICLES | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Basic electrical and electronics engineering ,Electrical Machines, IC Engines.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Explain the concept of Electric and Hybrid Electric Vehicles.
2. Gain deep insight knowledge in vehicle traction
3. Acquire knowledge about DC drives and energy storage systems.
4. To understand different aspects of drives application.
5. Determine an efficient management strategy and communication protocol.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Build a basic model of Electric and Hybrid Electric Vehicles. |
| **CO2** | Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources. |
| **CO3** | Design and develop basic schemes of electric vehicles and hybrid electric vehicles. |
| **CO4** | Choose proper energy storage systems for vehicle applications. |
| **CO5** | Identify various communication protocols and technologies used in vehicle networks. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **2** | **3** | **3** | **3** | **3** | **3** | | |
| **CO2** | **3** | **3** | **3** | **2** | **2** | **3** | | |
| **CO3** | **3** | **3** | **2** | **2** | **1** | **3** | | |
| **CO4** | **3** | **3** | **2** | **3** | **1** | **2** | | |
| **CO5** | **3** | **3** | **3** | **3** | **3** | **3** | **2** | **2** |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **2** | **3** | | | | | |
| **CO3** | **2** | **3** | **2** | | | | | |
| **CO4** | **3** | **2** | **3** | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CO5** | **3** | **3** | **3** | | | | | |
| **3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low** | | | | | | | | |

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22E06 ELECTRIC AND HYBRID VEHICLES 3 0/0 0/0 3**

**UNIT I HYBRID AND ELECTRIC VEHICLES** **9 hours**

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. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

**UNIT II HYBRID TRACTION** **9 hours**

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. 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.

**UNIT III DC DRIVES AND ENERGY STORAGE** **9 hours**

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives. Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices.

**UNIT IV SIZING THE DRIVE SYSTEM** **9 hours**

Matching the electric machine and the internal combustion engine (ICE)- Sizing the propulsion motor, sizing the power electronics Selecting the energy storage technology.

**UNIT V ENERGY MANAGEMENT** **9 hours**

Communications, supporting subsystems: CAN control system, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies

**Total no. of Hours: 45**

**Suggested Reading:**

1. Tom Denton ," Electric and Hybrid Vehicles", Routledge Publishers,2020.
2. Iqbal Hussein," Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.
3. James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley, 2003.
4. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2010.
5. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2000 .http://nptel.ac.in/courses/108103009/

| Course Code: EMPS22E07 | Course Title: EHVAC TRANSMISSION | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Basic electrical and electronics engineering ,Transmission and Distribution, FACT Devices.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Calculate the transmission line parameters.
2. Derive the field effect on EHV and UHV AC lines.
3. Acquire knowledge on corona, RI and audible noise in EHV and UHV lines.
4. Gain knowledge of voltage control and compensation problems in EHV and UHV transmission systems.
5. Learn various compensation methods.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Calculate the transmission line parameters. |
| **CO2** | Calculate the field effects on EHV and UHV AC lines. |
| **CO3** | Determine the corona, RI and audible noise in EHV and UHV lines |
| **CO4** | Analyze voltage control and compensation problems in EHV and UHV transmission systems. |
| **CO5** | Understand reactive power compensation using SVC and TCR. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 3 | 3 | 3 | | |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | | |
| CO3 | 3 | 3 | 3 | 1 | 1 | 1 | | |
| CO4 | 3 | 3 | 3 | 3 | 2 | 2 | | |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 2 | 3 | | | | | |
| CO3 | 2 | 1 | 1 | | | | | |
| CO4 | 3 | 2 | 3 | | | | | |
| CO5 | 3 | 3 | 3 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | √ | | | | |

**EMPS22E07 EHVAC TRANSMISSION 3 0/0 0/0 3**

**UNIT I INTRODUCTION OF EHVAC TRANSMISSION** **9 hours**

E.H.V. A.C. Transmission, line trends and preliminary aspects, standard transmission voltages :power handling capacities and line losses, mechanical aspects. Calculation of line resistance and inductance: resistance of conductors, temperature rise of conductor and current carrying capacity. Properties of bundled conductors and geometric mean radius of bundle, inductance of two conductor lines and multi conductor lines, Maxwell's coefficient matrix. Line capacitance calculation. Capacitance of two conductor line, and capacitance of multi conductor lines, potential coefficients for bundled conductor lines, sequence inductances and capacitances and diagonalization.

**UNIT II EFFECTS OF ELECTRO STATIC FIELD** **9 hours**

Calculation of electro static field of AC lines - Effect of high electrostatic field on biological organisms and human beings. Surface voltage Gradient on conductors, surface gradient on two conductor bundle and cosine law, maximum surface voltage gradient of bundle with more than 3 sub conductors, Mangoldt formula.

**UNIT III CORONA** **9 hours**

Corona in EHV lines ,corona loss formulae ,attenuation of traveling waves due to corona ,Audio noise due to corona, its generation, characteristics and limits, measurement of audio noise.

**UNIT IV POWER FREQUENCY VOLTAGE CONTROL** **9 hours**

Problems at power frequency, generalized constants, No load voltage conditions and charging currents, voltage control using synchronous condenser, cascade connection of components : Shunt and series compensation, sub synchronous resonance in series ,capacitor compensated lines.

**UNIT V REACTIVE POWER COMPENSATING SYSTEMS** **9 hours**

Introduction, SVC schemes, Harmonics injected into network by TCR, design of filters for suppressing harmonics

injected into the system.

**Total no. of Hours: 45**

**Suggested Reading:**

1. S.Rao ,"EHV-AC, HVDC Transmission & Distribution Engineering" Khanna Publishers,3rd Edition,2001.
2. Rakesh Das Begamudre ,"Extra High Voltage AC Transmission Engineering", Wiley Eastern ltd., New Delhi,2009.
3. Sanjay Kumar Sharma , "EHV-AC, HVDC Transmission and Distribution Engineering", S.K. Kataria & Sons,2016.
4. EHV Transmission line reference book – Edison Electric Institute (GEC) 1986.

| Course Code: EMPS22E08 | Course Title: DISTRIBUTED GENERATION AND MICRO GRID | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Basic electrical and electronics engineering ,Electrical Machines, IC Engines.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Explain the concept of conventional power generation systems.
2. Illustrate the concept of distributed generation.
3. To analyze the impact of grid integration.
4. Gain deep insight knowledge in designing a microgrid.
5. Acquire knowledge about power quality issues and controlling aspects in microgrid.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Review the conventional power generation |
| **CO2** | Analyze the concept of distributed generation and installation |
| **CO3** | Design the grid integration system with conventional and non-conventional energy sources. |
| **CO4** | Design the DC and AC micro grid. |
| **CO5** | Analyze power quality issues and control operation of micro grid. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 3 | 3 | 3 | | |
| CO2 | 3 | 3 | 3 | 2 | 2 | 3 | | |
| CO3 | 3 | 3 | 2 | 3 | 2 | 2 | | |
| CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 2 | 3 | | | | | |
| CO3 | 2 | 2 | 1 | | | | | |
| CO4 | 3 | 3 | 3 | | | | | |
| CO5 | 3 | 3 | 3 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | √ | | | | |

**EMPS22E08 DISTRIBUTED GENERATION AND MICRO GRID 3 0/0 0/0 3**

**UNIT I INTRODUCTION** **9 hours**

Conventional power generation: advantages and disadvantages, Energy crises, Non - conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

**UNIT II DISTRIBUTED GENERATIONS** **9 hours**

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

**UNIT III IMPACT OF GRID INTEGRATION** **9hours**

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

**UNIT IV BASICS OF MICROGRID** **9hours**

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.

**UNIT V CONTROL AND OPERATION OF MICROGRID** **9 hours**

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

**Total no. of Hours: 45**

**Suggested Reading:**

1. S Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009.
2. DorinNeacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006.
3. Chetan Singh Solanki, "Solar Photo Voltaics", PHI learning Pvt. Ltd., New Delhi, 2009
4. J.F. Manwell, J.G "Wind Energy Explained, Theory Design and Applications", McGowan Wiley publication, 2nd Edition, 2009.
5. D. D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York, 1987.
6. John Twidell ,Tony Weir, "Renewable Energy Resources", Taylor and Francis Publications, Second Edition, 2006.

| Course Code: EMPS22E09 | Course Title: ENERGY STORAGE SYSTEMS | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Basic electrical and electronics engineering.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Study details of various energy storage systems along with applications.
2. Analyze the operation of different energy storage systems.
3. Learn about batteries.
4. Acquire knowledge about Fuel cells.
5. Enabling to identify the optimal solutions to a particular energy storage application/utility.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Understand need of energy storage systems |
| **CO2** | Acquire knowledge pertaining to various ways to store energy, its analysis and use. |
| **CO3** | Design different energy storage systems. |
| **CO4** | Determine the operation of fuel cells. |
| **CO5** | Focus and select efficient energy storage systems for specific applications. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 3 | 3 | 3 | | |
| CO2 | 3 | 3 | 3 | 2 | 2 | 2 | | |
| CO3 | 3 | 3 | 2 | 3 | 2 | 2 | | |
| CO4 | 3 | 3 | 2 | 3 | 3 | 2 | | |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 2 | 3 | | | | | |
| CO3 | 2 | 2 | 2 | | | | | |
| CO4 | 3 | 3 | 3 | | | | | |
| CO5 | 3 | 3 | 3 | | | | | |

| 3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22E09** **ENERGY STORAGE SYSTEMS** **3 0/0 0/0 3**

**UNIT I INTRODUCTION** **9 hours**

Energy availability, Necessity of energy storage, different types of energy storage, mechanical, chemical, electrical, electrochemical, biological, magnetic, electromagnetic, thermal, comparison of energy storage technologies.

**UNIT II ENERGY STORAGE SYSTEMS** **9 hours**

Thermal Energy storage, sensible and latent heat, phase change materials, Energy and exergy analysis of thermal energy storage, Electrical Energy storage-super-capacitors, Magnetic Energy storage-Superconducting systems, Mechanical-Pumped hydro, flywheels and pressurized air energy storage.

**UNIT III ELECTROCHEMICAL ENERGY STORAGE** **9hours**

Battery: fundamentals and technologies, characteristics and performance comparison: Lead-acid, Nickel-Metal hydride, Lithium Ion; Battery system model, emerging trends in batteries. Hydrogen as energy carrier and storage, Hydrogen resources and production.

**UNIT IV FUEL CELLS** **9 hours**

Basic principle of direct energy conversion using fuel cells; Thermodynamics of fuel cells Fuel cell types: AFC, PEMFC, MCFC, SOFC, Microbial Fuel cell; Fuel cell performance, characterization and modeling; Fuel cell system design and technology, applications for power and transportation.

**UNIT V APPLICATIONS OF ENERGY STORAGE** **9 hours**

Renewable energy storage ,Battery sizing and stand-alone applications, stationary (Power Grid application), Small scale application :Portable storage systems and medical devices, Mobile storage Applications- Electric vehicles (EVs), types of EVs, batteries and fuel cells, future technologies, hybrid systems for energy storage.

**Total no. of Hours: 45**

**Suggested Reading:**

1. Dincer I., and Rosen M. A. m" Thermal Energy Storage: Systems and Applications", Wiley ,2011.
2. Huggins R. A. ," Energy Storage: Fundamentals, Materials and Applications", Springer ,2015.
3. O'Hayre R., Cha S., Colella W., Prinz F. B. m" Fuel Cell Fundamentals", Second Edition, Wiley,2009.
4. Narayan R. ,Viswanathan Bm" Chemical and Electrochemical Energy System", Universities Press,1998.
5. Rahn C. D.,Wang C.," Battery Systems Engineering, First Edition", Wiley,2013.
6. Moseley P. T., and Garche J ," Electrochemical Energy Storage for Renewable Sources and Grid Balancing", Elsevier Science,2014.

| Course Code: EMPS22E10 | Course Title: ELECTRIC POWER DISTRIBUTION SYSTEM | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Basic electrical and electronics engineering ,Transmission and Distribution.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Learn about power distribution system
2. Analyze the interconnection of distribution.
3. Acquire knowledge about SCADA System.
4. Decide on the selection and placement of devices.
5. Understand how to maintain automated distribution system.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Determine the load forecasting and manage the distributed network. |
| **CO2** | Acquire knowledge pertaining to various methods of metering and controlling the parameters in interconnection of networks. |
| **CO3** | Design a SCADA automated system. |
| **CO4** | Analyze the distributed network and optimize the selection and placement of devices in a distributed system. |
| **CO5** | Implement an automated distribution system. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **3** | **3** | **3** | **3** | | |
| **CO2** | **3** | **3** | **3** | **2** | **2** | **3** | | |
| **CO3** | **3** | **3** | **2** | **3** | **2** | **3** | | |
| **CO4** | **3** | **3** | **2** | **3** | **3** | **2** | | |
| **CO5** | **3** | **3** | **3** | **3** | **3** | **3** | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **2** | **3** | | | | | |
| **CO3** | **2** | **2** | **2** | | | | | |
| **CO4** | **3** | **3** | **3** | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CO5** | **3** | **3** | **3** | | | | | |
| **3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low** | | | | | | | | |

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22E10 ELECTRIC POWER DISTRIBUTION SYSTEM 3 0/0 0/0 3**

**UNIT I DISTRIBUTION SYSTEM** **9 hours**

Distribution of Power, Management, Power Loads - Load Forecasting Short-term & Long-term - Power System Loading, Technological Forecasting. Advantages of Distribution Management System (D.M.S.) Distribution Automation- Definition - Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints -Power Factor Correction.

**UNIT II INTERCONNECTION OF DISTRIBUTION** **9 hours**

Control and Communication Systems - Remote Metering -Automatic Meter Reading and its implementation.

**UNIT III SCADA** **9 hours**

Introduction- Block Diagram-SCADA Applied To Distribution Automation- Common Functions of SCADA - Advantages of Distribution Automation through SCADA.

**UNIT IV OPTIMIZATION IN DISTRIBUTION** **9 hours**

Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial - Distribution Systems, Sectionalizing Switches – Types, Benefits -Bellman's Optimality Principle - Remote Terminal Units -Energy efficiency in electrical distribution & Monitoring.

**UNIT V MAINTENANCE OF AUTOMATED DISTRIBUTION SYSTEMS** **9 hours**

Difficulties in Implementing Distribution Automation in Actual Practice- Urban/Rural Distribution- Energy Management- AI techniques applied to Distribution Automation.

**Total no. of Hours: 45**

**Suggested Reading:**

1. A.S. Pabla, “Electric Power Distribution”, Tata McGraw Hill Publishing Co. Ltd., Fourth Edition.2000.
2. M.K. Khedkar, G.M. Dhole, “A Text Book of Electrical power Distribution Automation”, University Science Press, New Delhi
3. Anthony J Pansini, “Electrical Distribution Engineering”, CRC Press,2020.
4. James Momoh, “Electric Power Distribution, automation, protection & control”, CRC Press,2007.

| Course Code: EMPS22E11 | Course Title: DIGITAL SIGNAL PROCESSING | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Signals and Systems** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Learn about difference between discrete-time and continuous-time signals
2. Study about the techniques for IIR and FIR filters.
3. Acquire knowledge about finite word length.
4. Gain knowledge about various signal models .
5. Understand how to design a FIR and IIR filter.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Differentiate between the time domain and frequency domain representations as well analyze the discrete time signals and systems. |
| **CO2** | Design and analyze the techniques for IIR and FIR filters and their realization structures. |
| **CO3** | Acquire knowledge about the finite word length effects in implementation of digital filters. |
| **CO4** | Knowledge about the various linear signal models and estimation of power spectrum of stationary random signals |
| **CO5** | Design optimum FIR and IIR filters |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **2** | **3** | **3** | **3** | **1** | | |
| **CO2** | **3** | **3** | **3** | **2** | **2** | **2** | | |
| **CO3** | **3** | **2** | **2** | **3** | **2** | **1** | | |
| **CO4** | **3** | **2** | **2** | **3** | **3** | | | |
| **CO5** | **3** | **3** | **3** | **3** | **3** | | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **1** | **3** | | | | | |
| **CO3** | **1** | | **1** | | | | | |
| **CO4** | **1** | **1** | **1** | | | | | |
| **CO5** | **1** | | **3** | | | | | |

| 3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
| | | | | | √ | | | | |

**EMPS22E11 DIGITAL SIGNAL PROCESSING 3 0/0 0/0 3**

**UNIT I DISCRETE TIME SIGNALS** **9 hours**

Discrete time signals - Linear shift invariant systems- Stability and causality -Sampling of continuous time signals Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform - Z transform-Properties of different transforms.

**UNIT II DISCRETE FOURIER TRANSFORM (DFT)** **9 hours**

Linear convolution using DFT - Computation of DFT Design of IIR digital filters from analog filters -Impulse invariance method - Bilinear transformation method.

**UNIT III FINITE IMPULSE RESPONSE(FIR)** **9 hours**

FIR filter design using window functions - Comparison of IIR and FIR digital filters -Basic IIR and FIR filter realization structures - Signal flow graph representations Quantization process and errors - Coefficient quantization effects in IIR and FIR filters.

**UNIT IV ANALOG TO DIGITAL CONVERSION** **9 hours**

A/D conversion noise- Arithmetic round-off errors - Dynamic range scaling - Overflow oscillations and zero Input limit cycles in IIR filters - Linear Signal Models.

**UNIT V POWER SPECTRUM** **9 hours**

All pole, All zero and Pole-zero models - Power spectrum estimation- Spectral analysis of deterministic signals Estimation of power spectrum of stationary random signals - Optimum linear filters- Optimum signal estimation Mean square error estimation - Optimum FIR and IIR Filters.

**Total no. of Hours: 45**

**Suggested Reading:**

1. Sanjit K Mitra, "Digital Signal Processing: A computer-based approach ",Tata McGraw-Hill Edition,1998.
2. Dimitris G .Manolakis, Vinay K. Ingle, Stephen M. Kogon, "Statistical and Adaptive Signal Processing", Mc Graw Hill international editions,2000.

| Course Code: EMPS22E12 | Course Title: POWER APPARATUS DESIGN | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: DC Machines and Transformers, AC Machines.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Learn about DC machines and Transformers.
2. Study about the dimensions in designing various machines.
3. Acquire knowledge about losses in machines.
4. Gain knowledge about harmonics.
5. Understand how to design an efficient machine.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Model the DC machines and Transformers. |
| **CO2** | Analyze the heating and cooling of DC machines, Induction motors and Synchronous machines. |
| **CO3** | Comprehend the losses occurring in machines. |
| **CO4** | Determine the harmonics and concentrate on the aspects in designing the machines in order to reduce the harmonics. |
| **CO5** | Design efficient machines. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **2** | **3** | **3** | **3** | | | |
| **CO2** | **3** | **3** | **3** | **2** | **3** | | | |
| **CO3** | **3** | **2** | **2** | **3** | **3** | | | |
| **CO4** | **3** | **2** | **2** | **3** | **3** | | | |
| **CO5** | **3** | **3** | **3** | **3** | **3** | | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **3** | **3** | | | | | |
| **CO3** | **2** | **3** | **2** | | | | | |
| **CO4** | **3** | **3** | **1** | | | | | |
| **CO5** | **3** | **3** | **3** | | | | | |

| 3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
| | | | | | √ | | | | |

**EMPS22E12 POWER APPARATUS DESIGN 3 0/0 0/0 3**

**UNIT I DC MACHINES AND TRANSFORMERS** **9 hours**

Principles of Design of Machines -Specific loadings, choice of magnetic and electric loadings - Real and apparent flux densities, temperature rise calculation, Separation of main dimension for DC machines - Induction machines and synchronous machines - Design of Transformers-General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling.

**UNIT II INDUCTION AND SYNCHRONOUS MACHINES** **9 hours**

Specific loadings, choice of magnetic and electric loadings Real and apparent flux -densities, temperature rise calculation - Separation of main dimension for DC machines - Induction machines and synchronous machines - Heating and cooling of machines, types of ventilation, continuous and intermittent rating.

**UNIT III EMF EQUATIONS** **9 hours**

General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling tubes - Calculation of losses, efficiency and regulation - Forces winding during short circuit.

**UNIT IV HARMONICS** **9 hours**

General considerations, output equation - Choice of specific electric and magnetic loadings, efficiency, power factor- Number of slots in stator and rotor - Elimination of harmonic torques.

**UNIT V DESIGN OF ENERGY EFFICIENT OF MACHINES** **9 hours**

Design of stator and rotor winding, slot leakage flux - Leakage reactance, equivalent resistance of squirrel cage rotor - Magnetizing current, efficiency from design data - Types of alternators, comparison, specific loadings, output co-efficient - design of main dimensions - Introduction to Computer Aided Electrical Machine Design Energy efficient machines.

**Total no. of Hours: 45**

**Suggested Reading:**

1. Clayton A.E, "The Performance and Design of D.C. Machines", Sir I. Pitman & sons, Ltd.
2. M.G. Say, "The Performance and Design of A.C. Machines ", Pitman
3. Sawhney A.K, "A course in Electrical Machine Design", DhanpatRai & Sons, 5th Edition.

| Course Code: EMPS22E13 | Course Title: ADVANCED MICRO-CONTROLLER BASED SYSTEMS | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Microprocessor and Microcontroller | Ty | 3 | 0/0 | 0/0 | 3 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Learn about the computer organization.
2. Study about the architecture of advance microcontrollers.
3. Acquire knowledge about the programming.
4. Gain knowledge about the interfacing devices.
5. Understand about controllers and its applications.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Analyze the configuration of a computer and its protocols. |
| **CO2** | Understand the working of microcontrollers. |
| **CO3** | Learn how to program a processor in assembly language and develop an advanced processor based system. |
| **CO4** | Comprehend and configure the different peripherals which are interfaced with the microcontroller. |
| **CO5** | Frame the program and control the devices interfaced with the microcontroller. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 3 | 2 | | | |
| CO2 | 2 | 3 | 3 | 2 | 2 | | | |
| CO3 | 2 | 2 | 2 | 3 | 2 | | | |
| CO4 | 2 | 2 | 2 | 3 | 2 | | | |
| CO5 | | 1 | | 2 | 3 | | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 3 | | | | | |
| CO3 | 2 | 3 | 2 | | | | | |
| CO4 | | | 1 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CO5** | **2** | **1** | **1** | | | | | |
| **3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low** | | | | | | | | |

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | √ | | | | |

**EMPS22E13 ADVANCED MICRO-CONTROLLER BASED SYSTEMS 3 0/0 0/0 3**

**UNIT I COMPUTER ORGANIZATIONS** **9 hours**

Basic Computer Organization- Accumulator based Processes-Architecture – Memory Organization-I/O Organization.

**UNIT II MICRO-CONTROLLER** **9 hours**

Micro-Controllers-Intel 8051 - Intel 8056- Registers, Memories - I/O Ports, Serial Communication – Timers – Interrupts – Programming.

**UNIT III INTEL 8051** **9 hours**

Intel 8051 – Assembly language programming - Addressing-Operations - Stack & Subroutines - Interrupts-DMA.

**UNIT IV INTERFACING** **9 hours**

PIC 16F877- Architecture Programming - Interfacing Memory/ I/O Devices - Serial I/O and data communication.

**UNIT V DSP** **9hours**

Digital Signal Processor (DSP) - Architecture – Programming - Introduction to FPGA – Microcontroller development for motor control applications - Stepper motor control using micro controller.

**Total no. of Hours: 45**

**Suggested Reading:**

1. John.F.Wakerly: "Microcomputer Architecture and Programming", John Wiley and Sons 1981
2. Ramesh S.Gaonker: "Microprocessor Architecture, Programming and Applications with the 8085", Penram International Publishing (India), 1994
3. Raj Kamal: "The Concepts and Features of Microcontrollers", Wheeler Publishing, 2005
4. Kenneth J. Ayala, "The 8051 microcontroller", Cengage Learning, 2004
5. John Morton," The PIC microcontroller: your personal introductory course", Elsevier, 2005
6. Dogan Ibrahim," Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F Series", Elsevier, 2008
7. Microchip datasheets for PIC16F877

| Course Code: EMPS22E14 | Course Title: REAL TIME CONTROL OF POWER SYSTEMS | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Power system operation and control** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the importance of state estimation in power systems.
2. Know the importance of security and contingency analysis.
3. Acquire knowledge on SCADA, its objectives and its importance in power systems.
4. Learn the significance of voltage stability analysis.
5. Apply AI to power systems problems.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Understand state estimation, security and contingency evaluation. |
| **CO2** | Design a secured and perform contingency analysis in power systems. |
| **CO3** | Analyze and apply Supervisory control and data acquisition in power systems. |
| **CO4** | Real time software application to state estimation. |
| **CO5** | Build an efficient power system incorporating AI. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 3 | 3 | 3 | | |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | |
| CO3 | 3 | 3 | 3 | 2 | 3 | 3 | | |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | | |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 3 | | | | | |
| CO3 | 3 | 3 | 2 | | | | | |
| CO4 | 3 | 3 | 3 | | | | | |
| CO5 | 3 | 3 | 3 | | | | | |

| 3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
| | | | | | √ | | | | |

**EMPS22E14 REAL TIME CONTROL OF POWER SYSTEMS 3 0/0 0/0 3**

**UNIT I STATE ESTIMATION 9 hours**

Different types of State Estimations, Theory of WLS state estimation, sequential and non-sequential methods to process measurements, Bad data Observability, Bad data detection, identification and elimination.

**UNIT II HYBRID TRACTION 9 hours**

Security and Contingency Evaluation : Security concept, Security Analysis and monitoring, Contingency Analysis for Generator and line outages by iterative linear power flow method, Fast Decoupled model, and network sensitivity methods.

**UNIT III DC DRIVES AND ENERGY STORAGE 9 hours**

Computer Control of Power Systems: Need for real time and computer control of power systems, operating states of a power system, SCADA - Supervisory control and Data Acquisition systems implementation considerations, energy control centres, software requirements for implementing the above functions.

**UNIT IV SIZING THE DRIVE SYSTEM 9 hours**

Voltage Stability, voltage collapse, and voltage security, relation of voltage stability to rotor angle stability. Voltage stability analysis Introduction to voltage stability analysis `P-V' curves and `Q-V' curves, voltage stability in mature power systems, long-term voltage stability, power flow analysis for voltage stability, voltage stability static indices.

**UNIT V ENERGY MANAGEMENT 9 hours**

Synchrophasor Measurement units: Introduction, Phasor representation of sinusoids, a generic PMU, GPS, Phasor measurement systems, Communication options for PMUs, Functional requirements of PMUs and PDCs, Phasors for nominal frequency signals, types of frequency excursions in power systems, DFT estimation at off nominal frequency with a nominal frequency clock.

**Total no. of Hours: 45**

**Suggested Reading:**

1. John J.Grainger ,William D.Stevenson, Jr.,"Power System Analysis", McGraw-Hill, 1994, International Edition.
2. Allen J.Wood ,Bruce F.Wollenberg ,"Power Generation operation and control", John Wiley & Sons, 1984.
3. A.G.Phadka ,J.S. Thorp, "Synchronized Phasor Measurements and Their Applications", Springer, 2008.
4. R.N.Dhar,"Computer Aided Power Systems Operation and Analysis", Tata McGraw Hill, 1982.
5. L.P.Singh ,"Advanced Power System Analysis and Dynamics", Wiley Eastern Ltd. 1986.
6. PrabhaKundur ,"Power System Stability and Control", McGraw Hill, 1994.

| Course Code: EMPS22E15 | Course Title: ELECTRIC POWER QUALITY | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Basic Electrical and Electronics Engineering,Power electronics.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Study about different power quality issues.
2. Gain knowledge about harmonics.
3. Learn about modeling of electrical devices.
4. Acquire knowledge about improving the power quality.
5. Understand about FACTs devices.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Identify the factors and devices that affect the power system. |
| **CO2** | Acquire knowledge about the harmonics, harmonic introducing devices and effect of harmonics on system equipment and loads |
| **CO3** | Develop analytical modeling skills needed for modeling and analysis of harmonics in networks and components. |
| **CO4** | Decide the devices to be implemented in power network to improve the power factor. |
| **CO5** | Comprehend and decide the devices to be used for compensation. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **2** | **3** | **3** | **3** | | | |
| **CO2** | **3** | **3** | **3** | **2** | **3** | | | |
| **CO3** | **3** | **2** | **2** | **3** | **3** | | | |
| **CO4** | **3** | **2** | **2** | **3** | **3** | **2** | | |
| **CO5** | **3** | **3** | **3** | **3** | **3** | **2** | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **3** | **3** | | | | | |
| **CO3** | **2** | **3** | **2** | | | | | |
| **CO4** | **3** | **3** | **3** | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CO5** | **3** | **3** | **3** | | | | | |
| **3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low** | | | | | | | | |

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | √ | | | | |

**EMPS22E15 ELECTRIC POWER QUALITY 3 0/0 0/0 3**

**UNIT I OVERVIEW OF POWER QUALITY** **9 hours**

Introduction-power quality-voltage quality-overview of power quality phenomena - classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C message weights-flicker factor transient phenomena-occurrence of power quality problems power acceptability curves-IEEE guides, standards and recommended practices.

**UNIT II HARMONICS** **9 hours**

Harmonics-individual and total harmonic distortion - RMS value of a harmonic waveform- Triplex harmonics-important harmonic introducing devices-SMPS-Three phase power converters-arcing devices saturable devices-harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.

**UNIT III MODELLING OF NETWORK** **9 hours**

Modeling of networks and components under non-sinusoidal - conditions transmission and distribution systems Shunt capacitors-transformers-electric machines-ground systems loads that cause power quality problems power quality problems created by drives and its impact on drive.

**UNIT IV IMPROVEMENT OF POWER QUALITY** **9 hours**

Power factor improvement- Passive Compensation Passive Filtering , Harmonic – Resonance Impedance Scan Analysis- Active Power Factor Corrected Single Phase Front end ,Control Methods for Single Phase APFC Three Phase APFC and Control Techniques, PFC Based on Bilateral Single Phase and Three Phase Converter.

**UNIT V FACTS** **9 hours**

Static VAR compensators-SVC and STATCOM Active Harmonic Filtering-Shunt Injection Filter for single phase, three-phase three-wire and three-phase fourwire systems d-q domain control of three phase shunt active filters uninterruptible power supplies constant voltage transformers series active power filtering techniques for harmonic cancellation and isolation - Dynamic Voltage Restorers for sag , swell and flicker problems - Grounding and wiring

introduction - NEC grounding requirements-reasons for grounding - typical grounding and wiring problems solutions to grounding and wiring problems.

**Total no. of Hours: 45**

**Suggested Reading:**

1. G.T. Heydt, “Electric power quality”, McGraw-Hill Professional, 2007.
2. Math H. Bollen, “Understanding Power Quality Problems”, IEEE Press, 2000.
3. J. Arrillaga, “Power System Quality Assessment”, John wiley, 2000.
4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,”Power system Harmonic Analysis”, Wiley, 1997.

| Course Code: EMPS22E16 | Course Title: ARTIFICIAL INTELLIGENCE TECHNIQUES | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Circuit Theory, Electrical Machines, Power System** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the concepts of AI.
2. Study about fuzzy logic.
3. Ability to acquire knowledge on neural networks.
4. Gain knowledge on the identification of a system.
5. Familiar about genetic algorithm.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Comprehend the concepts of AI. |
| **CO2** | Analyze the fuzzy logic and defuzzication. |
| **CO3** | Write algorithms to solve problems. |
| **CO4** | Identify the system and apply the fuzzy logic and neural network to solve the problem. |
| **CO5** | Utilize the concept of genetic algorithm to solve problems. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **3** | **3** | **1** | | | |
| **CO2** | **3** | **3** | **3** | **3** | **2** | | | |
| **CO3** | **3** | **3** | **3** | **3** | **2** | | | |
| **CO4** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO5** | **3** | **2** | **3** | **2** | **3** | | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **3** | **3** | | | | | |
| **CO3** | **3** | **2** | **2** | | | | | |
| **CO4** | **3** | **2** | **3** | | | | | |
| **CO5** | **3** | **3** | **3** | | | | | |

| 3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
| | | | | | √ | | | | |

**EMPS22E16 ARTIFICIAL INTELLIGENCE TECHNIQUES 3 0/0 0/0 3**

**UNIT I INTRODUCTION TO AI** **9 hours**

Biological foundations to intelligent Systems -Artificial Neural Networks, Single layer and Multilayer Feed Forward NN - LMS and Back Propagation Algorithm - Feedback networks and Radial Basis Function Networks.

**UNIT II FUZZY LOGIC** **9 hours**

Fuzzy Logic - Knowledge Representation and Inference Mechanism - Defuzzification Methods.

**UNIT III FUZZY NEURO** **9 hours**

Fuzzy Neural Networks - some algorithms to learn the parameters of the network like GA.

**UNIT IV SYSTEM IDENTIFICATION** **9 hours**

System Identification using Fuzzy and Neural Network.

**UNIT V GENETIC ALGORITHM** **9 hours**

Genetic algorithm - Reproduction cross over, mutation - Introduction to evolutionary program -Applications of above mentioned techniques to practical problems.

**Total no. of Hours: 45**

**Suggested Reading:**

1. J M Zurada , “An Introduction to ANN”,Jaico Publishing House.
2. Simon Haykins, “Neural Networks”, Prentice Hall.
3. Timothy Ross, “Fuzzy Logic with Engg.Applications”, McGraw. Hill.
4. Driankov, Dimitra, “An Introduction to Fuzzy Control”, Narosa Publication.

5. Golding, “Genetic Algorithms”, Addison-Wesley Publishing Company.

| Course Code: EMPS22E17 | Course Title: RESTRUCTURED POWER SYSTEMS | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: DC Machines and Transformers, AC Machines.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Learn about restructuring of power industry.
2. Study about the economics in power system.
3. Acquire knowledge about market models of power system.
4. Gain knowledge about importance of congestion management.
5. Understand how to design an efficient transmission network and generation entity based on pricing..

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Restructure an efficient power system. |
| **CO2** | Acquire the knowledge of the new dimensions associated with the power system and fundamentals of microeconomics. |
| **CO3** | Differentiate the various operating mechanism between conventional and restructured power system. |
| **CO4** | Discover various power markets and market architectural aspects. |
| **CO5** | Identify issues related to Efficient pricing and usage of the transmission network and generation entity in the power market operation. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO2** | **3** | **3** | **3** | **2** | **3** | | | |
| **CO3** | **3** | **3** | **3** | **3** | **3** | | | |
| **CO4** | **3** | **2** | **2** | **3** | **3** | **2** | | |
| **CO5** | **3** | **3** | **3** | **3** | **3** | **2** | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **3** | **3** | | | | | |
| **CO3** | **2** | **3** | **2** | | | | | |
| **CO4** | **3** | **3** | **2** | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **CO5** | **3** | **3** | **3** | | | | | |
| **3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low** | | | | | | | | |

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | √ | | | | |

**EMPS22E17 RESTRUCTURED POWER SYSTEMS 3 0/0 0/0 3**

**UNIT I RESTRUCTURED SYSTEM** **9 hours**

Introduction to restructuring of power industry ,Reasons for restructuring of power industry, Understanding the restructuring process, Entities involved, Levels of competition, The market place mechanisms, Sector-wise major changes required; Reasons and objectives of deregulation of various power systems across the world. Developments in India -IT applications in restructured markets -Working of restructured power systems –PJM- Recent trends in Restructuring.

**UNIT II FUNDAMENTALS OF ECONOMICS** **9 hours**

Consumer and suppliers behavior, Total utility and marginal utility, Law of diminishing marginal utility, Elasticity of demand and supply curve, Market equilibrium, Consumer and supplier surplus, Global welfare, Deadweight loss.

**UNIT III THE PHILOSOPHY OF MARKET MODELS** **9 hours**

Monopoly model, Single buyer model, Wholesale competition model, Retail competition model, distinguishing features of electricity as a commodity, Four pillars of market design,Cournot, Bertrand and Stackelberg competition model.

**UNIT IV TRANSMISSION CONGESTION MANAGEMENT** **9 hours**

Transfer capability, Importance of congestion management, Effects of congestion, Classification of congestion management methods, ATC, TTC,TRM, CBM,ATC calculation using DC and AC model, Nodal pricing, Locational Marginal Prices (LMPs), Implications of nodal pricing, Price area congestion management Capacity alleviation methods, Redispatching, Counter-trade, Curtailment .

**UNIT V PRICING OF TRANSMISSION NETWORK USAGE AND LOSS ALLOCATION** **9 hours**

Introduction to transmission pricing, Principles of transmission pricing, Classification of transmission pricing, Rolled-in transmission pricing paradigm, Marginal transmission pricing paradigm, Composite pricing paradigm, Merits and

de-merits of different paradigms, Classification of loss allocation methods, Pro-rata methods, Incremental methods, Power flow tracing based allocation .

**Total no. of Hours: 45**

**Suggested Reading:**

1. LorrinPhilipson, H. Lee Willis, "Understanding electric utilities and de-regulation", Marcel Dekker Pub.,1998.
2. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley and Sons, 2002.
3. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.
4. Mohammad Shahidehpour, MuwaffaqAlomoush, "Restructured electrical power systems: operation, trading and volatility", Marcel Dekker.
5. NPTEL Cource-Restructured Power Systems, A. R. Abhyankar, S. A. Khaparde, Available: http://nptel.iitm.ac.in/courses/108101005/
6. Daniel Kirschen and Goran Strbac, "Fundamentals of Power System economics ",John Wiley & Sons Ltd, 2004.
7. Sally Hunt ,"Making competition work in electricity", John Wiley & Sons, Inc., 2002.

| Course Code: EMPS22E18 | Course Title: POWER SYSTEM TRANSIENTS | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Basic electrical and electronics engineering ,High voltage Engineering. | Ty | 3 | 0/0 | 0/0 | 3 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Learn the reasons for occurrence of transients in a power system.
2. Understand the change in parameters like voltage and frequency during transients.
3. Acquire knowledge about the lightning phenomenon and its effect on power system.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Analyze the various transients that could occur in power system and their mathematical formulation. |
| **CO2** | Design various protective devices in power system for protecting equipment and personnel. |
| **CO3** | Derive mathematically the opening and closure timing of devices during overvoltage. |
| **CO4** | Model the power system for transient analysis. |
| **CO5** | Coordinate the insulation of various equipments in power system. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | | | |
| CO2 | 3 | 3 | 3 | 3 | 3 | | | |
| CO3 | 3 | 3 | 2 | 3 | 2 | | | |
| CO4 | 3 | 3 | 3 | 3 | 3 | | | |
| CO5 | 3 | 3 | 3 | 3 | 3 | 2 | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 2 | 2 | | | | | |
| CO3 | 2 | 2 | 2 | | | | | |
| CO4 | 3 | 3 | 3 | | | | | |
| CO5 | 3 | 3 | 3 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMPS22E18** **POWER SYSTEM TRANSIENTS** **3 0/0 0/0 3**

**UNIT I ELECTRIC TRANSIENT** **9 hours**

Fundamental circuit analysis of electrical transient - Laplace Transform method of solving simple Switching transients - Damping circuits -Abnormal switching transients, Three-phase circuits and transients - Computation of power system transients.

**UNIT II LIGHTNING** **9 hours**

Principle of digital computation – Matrix method of solution - Modal analysis- Z transform- Computation using EMTP - Lightning, switching and temporary over voltages, Lightning -Physical phenomena of lightning.

**UNIT III OVERVOLTAGE** **9 hours**

Interaction between lightning and power system - Influence of tower footing resistance and Earth Resistance - Switching: Short line or kilometric fault -Energizing transients - closing and - re-closing of lines -line dropping, load rejection – over voltages induced by faults.

**UNIT IV TRAVELLING WAVES** **9 hours**

Switching HVDC lineTravelling waves on transmission line -Circuits with distributed Parameters Wave Equation - Reflection, Refraction, Behaviour of Travelling waves at the line terminations - Lattice Diagrams – Attenuation and Distortion - Multi-conductor system.

**UNIT V INSULATION COORDINATION** **9 hours**

Insulation co-ordination: Principle of insulation co-ordination in Air - Insulated substation (AIS) and Gas Insulated Substation (GIS) Coordination between insulation and protection level - Statistical approach - Protective devices - Protection of system against over voltages - lightning arresters, substation earthing.

**Total no. of Hours: 45**

**Suggested Reading:**

1. Allan Greenwood, 'Electrical Transients in Power Systems', Wiley Inter Science, New York, 2ndEdition, 1991.
2. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, 2009.
3. C.S. Indulkar, D.P.Kothari, K. Ramalingam, "Power System Transients – A statistical approach", PHI Learning Private Limited, Second Edition, 2010.

| Course Code: EMPS22E19 | Course Title: FACTS AND CUSTOM POWER DEVICES | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: Basic electrical and electronics engineering ,Transmission and Distribution.** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. To learn the active and reactive power flow control in power system.
2. To understand the need for static compensators.
3. To develop the different control strategies used for compensation.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Acquire knowledge about the fundamental principles of Passive and Active Reactive Power Compensation Schemes at Transmission and Distribution level in Power Systems. |
| **CO2** | Learn various Static VAR Compensation Schemes like Thyristor/GTO Controlled Reactive Power Systems, PWM Inverter based Reactive Power Systems and their controls. |
| **CO3** | Develop analytical modeling skills needed for modeling and analysis of such Static VAR Systems. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **3** | **3** | **3** | **3** | | |
| **CO2** | **3** | **3** | **3** | **2** | **2** | **3** | | |
| **CO3** | **3** | **3** | **2** | **3** | **2** | **3** | | |
| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** | | | | | |
| **CO1** | **3** | **3** | **3** | | | | | |
| **CO2** | **3** | **2** | **3** | | | | | |
| **CO3** | **2** | **2** | **2** | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|

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**EMPS22E19 FACTS AND CUSTOM POWER DEVICES 3 0/0 0/0 3**

**UNIT I REACTIVE POWER** **9 hours**

Reactive power flow control in Power Systems - Control of dynamic power unbalances in Power System - Power flow control - Constraints of maximum transmission line loading -Benefits of FACTS Transmission line compensation - Uncompensated line -Shunt compensation, Series compensation Phase angle control Reactive power compensation Shunt and Series compensation principles - Reactive compensation at transmission and distribution level.

**UNIT II COMPENSATORS** **9 hours**

Static versus passive VAR compensator- Static shunt compensators: SVC and STATCOM - Operation and control of TSC, TCR and STATCOM –Compensator control -Comparison between SVC and STATCOM.

**UNIT III SERIES COMPENSATION** **9 hours**

Static series compensation: TSSC, SSSC -Static voltage and phase angle regulators - TCVR and TCPAR Operation and Control - Applications, Static series compensation -GCSC,TSSC, TCSC and Static synchronous series compensators and their Control.

**UNIT IV UPFC** **9 hours**

SSR and its damping Unified Power Flow Controller Circuit Arrangement, Operation and control of UPFC Basic Principle of P and Q control Independent real and reactive power flow control- Applications.

**UNIT V FACTS** **9 hours**

Introduction to interline power flow controller - Modeling and analysis of FACTS Controllers Simulation of FACTS controllers Power quality problems in distribution systems - harmonics, loads that create harmonics modeling, harmonic propagation, series and parallel resonances mitigation of harmonics passive filters, active filtering – shunt series and hybrid and their control Voltage swells , sags, flicker, unbalance and mitigation of these problems by power line conditioners IEEE standards on power quality.

**Total no. of Hours: 45**

**Suggested Reading:**

1. K R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age InternationalPublishers, 2007
2. X P Zhang, C Rehtanz, B Pal, “Flexible AC Transmission Systems- Modelling and Control”, SpringerVerlag, Berlin, 2006
3. N.G. Hingorani, L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible ACTransmission Systems”, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.

4. K.S.Sureshkumar ,S.Ashok , "FACTS Controllers & Applications", E-book edition, Nalanda DigitalLibrary, NIT Calicut,2003
5. G T Heydt , "Power Quality", McGraw-Hill Professional, 2007
6. T J E Miller, "Static Reactive Power Compensation", John Wiley and Sons, New York, 1982.

| Course Code: EMPS22E20 | Course Title: INDUSTRIAL LOAD MODELING AND CONTROL | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: Power system operation and control | Ty | 3 | 0/0 | 0/0 | 3 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the energy demand scenario.
2. Gain knowledge in modeling of load and its ease to study load demand industrially.
3. Learn about Electricity pricing models.
4. Study Reactive power management in Industries.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Comprehend and apply the concepts of load control techniques in industries. |
| **CO2** | Apply different types of industrial processes and optimize the process using various tools. |
| **CO3** | Determine load management to reduce demand of electricity during peak time |
| **CO4** | Analyze and apply different energy saving opportunities in industries |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 3 | 3 | | | |
| CO2 | 3 | 3 | 3 | 3 | 3 | | | |
| CO3 | 3 | 3 | 3 | 2 | 2 | | | |
| CO4 | 3 | 3 | 3 | 3 | 3 | | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 3 | 3 | 3 | | | | | |
| CO2 | 3 | 3 | 3 | | | | | |
| CO3 | 3 | 3 | 2 | | | | | |
| CO4 | 3 | 3 | 3 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
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**EMPS22E20 INDUSTRIAL LOAD MODELING AND CONTROL 3 0/0 0/0 3**

**UNIT I ENERGY SCENARIO** **9 hours**

Electric Energy Scenario- Demand Side management – Industrial Load Management – Load Curves – Load Shaping Objectives – Methodologies – barriers – Classification of Industrial Loads Continuous and batch Processes – Load modeling.

**UNIT II ELECTRICITY PRICING** **9 hours**

Electricity Pricing – Dynamic and spot pricing – Models – Direct Load Control – Interruptible Load Control – Bottom Up approach – Scheduling – Formulation of Load models – Optimization and Control Algorithms – Case Studies.

**UNIT III REACTIVE POWER MANAGEMENT** **9 hours**

Reactive Power Management in Industries – Controls – Power Quality impacts – Application of Filters Energy saving in Industries.

**UNIT IV COOLING AND HEATING LOADS** **9 hours**

Cooling and heating loads – Load profiling – Modeling Cool Storage – Types Control Strategies – Optimal Operation-Problem Formulation – Case studies.

**UNIT V CONTROL STRATEGIES** **9 hours**

Captive power units - Operating and control strategies - Power Pooling- Operation models - Energy banking- Industrial Cogeneration - Selection of Schemes Optimal Operating Strategies - Peak load saving - Constraints Problem formulation- Case study - Integrated Load management for Industries.

**Total no. of Hours: 45**

**Suggested Reading:**

1. C.O. Bjork " Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands,1989.
2. C.W. Gellings and S.N. Talukdar,. Load management concepts. IEEE Press, New York, 1986, pp. 3-28.
3. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 198.1
4. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Interscience Publication, USA, 1989.
5. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers, NewDelhi, 1995.
6. IEEE Bronze Book- "Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities", IEEE Inc, USA.

# AUDIT COURSES

# 1 & 2

| Course Code: EMCC22I01 | Course Title: ENGLISH FOR RESEARCH PAPER WRITING | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 2 | 0/0 | 0/0 | 0 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Know the art of writing the research paper and thesis.
2. Ensure the good quality of paper at very first-time submission.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Understand that how to improve your writing skills and level of readability. |
| **CO2** | Learn about what to write in each section. |
| **CO3** | Understand the skills needed when writing a title. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 1 | 1 | 1 | | | |
| CO2 | 1 | | 1 | | 1 | | | 2 |
| CO3 | | | | | 1 | | | 3 |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | 1 | | 1 | | | | | |
| CO2 | | | | | | | | |
| CO3 | 3 | | 3 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | √ | |

**EMCC22I01 ENGLISH FOR RESEARCH PAPER WRITING 2 0/0 0/0 0**

**UNIT I** **4 hours**

Planning and Preparation, Word Order- Breaking up long sentences- Structuring Paragraphs and Sentences- Being Concise and Removing Redundancy,-Avoiding Ambiguity and Vagueness.

**UNIT II** **4 hours**

Clarifying Who Did What, Highlighting Your Findings- Hedging and Criticising- Paraphrasing and Plagiarism- Sections of a Paper- Abstracts- Introduction.

**UNIT III** **8 hours**

Review of the Literature- Methods- Results- Discussion- Conclusions- The Final Check- key skills are needed when writing a Title- key skills are needed when writing an Abstract- key skills are needed when writing an Introduction- skills needed when writing a Review of the Literature.

**UNIT IV** **4 hours**

Skills are needed when writing the Methods- skills needed when writing the Results- skills are needed when writing the Discussion- skills are needed when writing the Conclusions.

**UNIT V** 4 **hours**

Useful phrases- how to ensure paper is as good as it could possibly be the first- time submission.

**Total no. of Hours: 16**

**Suggested Reading:**

1. Goldbort R ," Writing for Science", Yale University Press , 2006.
2. Day R ," How to Write and Publish a Scientific Paper", Cambridge University Press, 2006.
3. Highman N ,"Handbook of Writing for the Mathematical Sciences, SIAM", Highman's book , 1998.
4. Adrian Wallwork , "English for Writing Research Papers", Springer New York Dordrecht Heidelberg London, 2011.

| Course Code: EMCC22I02 | Course Title: DISASTER MANAGEMENT | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 2 | 0/0 | 0/0 | 0 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. Understand the strengths and weaknesses of disaster management approaches.
5. Planning and programming in different countries, particularly their home country or the countries they work in.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives. |
| **CO2** | Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. |
| **CO3** | Understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | 1 | | | |
| CO2 | | | | | 1 | | | |
| CO3 | | | | | 1 | 2 | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | | | 1 | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | 1 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
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**EMCC22I02** **DISASTER MANAGEMENT** **2 0/0 0/0 0**

**UNIT I INTRODUCTION** **4 hours**

Disaster: Definition, Factors And Significance- Difference Between Hazard And Disaster- Natural And Manmade Disasters: Difference- Nature- Types And Magnitude.

**UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS** **4 hours**

Economic Damage- Loss Of Human And Animal Life- Destruction Of Ecosystem-Natural Disasters: Earthquakes- Volcanisms- Cyclones- Tsunamis- Floods- Droughts And Famines- Landslides And Avalanches- Man-made disaster: Nuclear Reactor Meltdown- Industrial Accidents- Oil Slicks And Spills-Outbreaks Of Disease And Epidemics War And Conflicts.

**UNIT III DISASTER PRONE AREAS IN INDIA** **4 hours**

Study of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics.

**UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT** **4 hours**

Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

**UNIT V RISK ASSESSMENT AND DISASTER MITIGATION** **8 hours**

Disaster Risk: Concept And Elements, Disaster Risk Reduction- Global And National Disaster Risk Situation- Techniques Of Risk Assessment- Global Co- Operation In Risk Assessment And Warning- People's Participation In

Risk Assessment- Strategies for Survival- Concept and Strategies of Disaster Mitigation- Emerging Trends In Mitigation- Structural Mitigation And Non-Structural Mitigation- Programs of Disaster Mitigation In India.

**Total no. of Hours: 16**

**Suggested Reading:**

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , "Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

| Course Code: EMCC22I03 | Course Title: SANSKRIT FOR TECHNICAL KNOWLEDGE | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 2 | 0/0 | 0/0 | 0 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world.
2. Learning of Sanskrit to improve brain functioning.
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Understanding basic Sanskrit language. |
| **CO2** | Ancient Sanskrit literature about science & technology can be understood. |
| **CO3** | Being a logical language will help to develop logic in students. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | |
| CO2 | | | | | | 1 | | |
| CO3 | | | | | | 2 | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | | | 1 | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | 1 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
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**EMCC22I03 SANSKRIT FOR TECHNICAL KNOWLEDGE 2 0/0 0/0 0**

**UNIT I** **8 hours**

Alphabets in Sanskrit- Past/Present/Future Tense-Simple Sentences.

**UNIT II** **8 hours**

Order- Introduction of roots- Technical information about Sanskrit Literature.

**UNIT III** **8 hours**

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics.

**Total no. of Hours: 24**

**Suggested Reading:**

1. Dr.Vishwas ,"Abhyaspustakam" –, Samskrita-Bharti Publication, New Delhi.
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication.
3. Suresh Soni ,"India's Glorious Scientific Tradition", Ocean books (P) Ltd., New Delhi.

| Course Code: EMCC22I04 | Course Title: VALUE EDUCATION | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 2 | 0/0 | 0/0 | 0 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand value of education and self- development.
2. Imbibe good values in students.
3. Let the should know about the importance of character.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Knowledge of self-development. |
| **CO2** | Learn the importance of Human values. |
| **CO3** | Developing the overall personality. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | 1 |
| CO2 | | | | | | 1 | | 1 |
| CO3 | | | | | | 1 | | 1 |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | | | 1 | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | 1 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | √ | |

| EMCC22I04 | VALUE EDUCATION | 2 | 0/0 | 0/0 | 0 |
|---|---|---|---|---|---|

**UNIT I** 4 **hours**

Values and self-development –Social values and individual attitudes-Work ethics- Indian vision of humanism- Moral and non- moral valuation- Standards and principles- Value judgments.

**UNIT II** **6 hours**

Importance of cultivation of values-Sense of duty- Devotion- Self-reliance- Confidence- Concentration- Truthfulness- Cleanliness- Honesty- Humanity- Power of faith- National Unity-Patriotism-Love for nature-Discipline.

**Unit III** **6 hours**

Personality and Behavior Development - Soul and Scientific attitude- Positive Thinking- integrity and discipline- Punctuality- Love and Kindness- Avoid fault Thinking- Free from anger- Dignity of labour- Universal brotherhood and religious tolerance- True friendship- Happiness Vs suffering- love for truth-Aware of self-destructive habits- Association and Cooperation-Doing best for saving nature.

**UNIT IV** **6 hours**

Character and Competence –Holy books vs Blind faith-Self-management and Good health-Science of reincarnation- Equality- Nonviolence-Humility- Role of Women- All religions and same message-Mind your Mind- Self-control- Honesty- Studying effectively.

**Total no. of Hours: 22**

**Suggested Reading:**

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi.

| Course Code: EMCC22I05 | Course Title: CONSTITUTION OF INDIA | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 2 | 0/0 | 0/0 | 0 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. Address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics. |
| **CO2** | Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India. |
| **CO3** | Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution. |
| **CO4** | Discuss the passage of the Hindu Code Bill of 1956. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | |
| CO2 | | | | | | 1 | | |
| CO3 | | | | | | 1 | | |
| CO4 | | | | | | | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | | | 1 | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | 1 | | | | | |
| CO4 | | | | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | √ | |

**EMCC22I05** **CONSTITUTION OF INDIA** **2 0/0 0/0 0**

**UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION** **4 hours**

History-Drafting Committee-( Composition & Working)-Preamble-Salient Features.

**UNIT II CONTOURS OF CONSTITUTIONAL RIGHTS & DUTIES** **4 hours**

Fundamental Rights-Right to Equality -Right to Freedom-Right against Exploitation- Right to Freedom of Religion-Cultural and Educational Rights- Right to Constitutional Remedies- Directive Principles of State Policy-Fundamental Duties.

**UNIT III ORGANS OF GOVERNANCE** **4 hours**

Parliament- Composition- Qualifications and Disqualifications- Powers and Functions- Executive- President-Governor- Council of Ministers- Judiciary, Appointment and Transfer of Judges, Qualifications- Powers and Functions.

**UNIT IV LOCAL ADMINISTRATION** **4 hours**

District's Administration head: Role and Importance,- Municipalities: Introduction, Mayor and role of Elected Representative,-CEO of Municipal Corporation.- Pachayati raj: Introduction, PRI: Zila Pachayat.- Elected officials and their roles, CEO Zila Pachayat: Position and role.- Block level: Organizational Hierarchy (Different departments),- Village level: Role of Elected and Appointed officials,- Importance of grass root democracy.

**UNIT V ELECTION COMMISSION** **4 hours**

Election Commission: Role and Functioning.- Chief Election Commissioner and Election Commissioners.- State Election Commission: Role and Functioning.- Institute and Bodies for the welfare of SC/ST/OBC and women.

**Total no. of Hours: 20**

**Suggested Reading:**

1. The Constitution of India, 1950 (Bare Act), Government Publication.

2. Dr. S. N. Busi, “Dr. B. R. Ambedkar framing of Indian Constitution”, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, “Introduction to the Constitution of India”, Lexis Nexis, 2015.

| Course Code: EMCC22I06 | Course Title: PEDAGOGY STUDIES | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 2 | 0/0 | 0/0 | 0 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.

**COURSE OUTCOMES (COs) : The students will be able to understand**

| | |
|---|---|
| **CO1** | What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries? |
| **CO2** | What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners? |
| **CO3** | How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | | | | | | |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | | | | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | 1 | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | √ | |

**EMCC22I06** **PEDAGOGY STUDIES** **2 0/0 0/0 0**

**UNIT I** **4 hours**

Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions**.**Overview of methodology and Searching.

**UNIT II** **2 hours**

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries ,Curriculum, Teacher education.

**UNIT III** **4 hours**

Evidence on the effectiveness of pedagogical practices -Methodology for the in depth stage: quality assessment of included studies-How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy- Theory of change.Strength and nature of the body of evidence for effective pedagogical practices- Pedagogic theory and pedagogical approaches- Teachers' attitudes and beliefs and Pedagogic strategies.

**UNIT IV** **4 hours**

Professional development: alignment with classroom practices and followup Support -Peer support Support from the head teacher and the community- Curriculum and assessment Barriers to learning: limited resources and large class sizes.

**UNIT V** **2 hours**

Research design -Contexts Pedagogy- Teacher education - Curriculum and assessment - Dissemination and research impact.

**Total no. of Hours: 16**

**Suggested Reading:**

1. Ackers J, Hardman F ," Classroom interaction in Kenyan primary schools, Compare"2001, 31 (2):245-261.
2. Agrawal M ,"Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies",2004, 36 (3): 361-379.
3. Akyeampong K ,"Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID"2003.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J ,"Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development",2013, 33 (3): 272–282.
5. Alexander RJ ,"Culture and pedagogy: International comparisons in primary education",2001.. Oxford and Boston: Blackwell.
6. Chavan M," Read India: A mass scale, rapid, 'learning to read' campaign",2003.

7. www.pratham.org/images/resource%20working%20paper%202.pdf.

| Course Code: EMCC22I07 | Course Title: STRESS MANAGEMENT BY YOGA | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 2 | 0/0 | 0/0 | 0 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Understand the Basic Concepts of Yoga.
2. Gain knowledge on Ashtanga yoga.
3. Acquire knowledge of Techniques and Practice of Yogasanas.
4. Understand stress and the causes.
5. Attain the knowledge about stress busting through yoga.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Understand the Basic Concepts of Yoga. |
| **CO2** | Gain knowledge on Ashtanga yoga. |
| **CO3** | To Understand stress and the causes. |
| **CO4** | Acquire knowledge of Techniques and Practice of Yogasanas. |
| **CO5** | Attain the knowledge about stress busting through yoga. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | | | | | | |
| CO4 | | | | | | | | |
| CO5 | | | | | | 1 | | 1 |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | | | | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | | | | | | |
| CO4 | | | | | | | | |
| CO5 | | | | | | | | |

| 3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
| | | | | | | | | √ | |

**EMCC22I07 STRESS MANAGEMENT BY YOGA 2 0/0 0/0 0**

**UNIT I** **8 hours**

Definitions of Eight parts of yoga( Ashtanga ).

**UNIT II** **8 hours**

Yam and Niyam-Do`s and Don't's in life-Ahinsa, satya, astheya, bramhacharya and aparigraha- Shaucha, santosh, tapa, swadhyay, ishwarpranidhan.

**UNIT III** **8 hours**

Asan and Pranayam-i) Various yog poses and their benefits for mind & body-ii)Regularization of breathing techniques and its effects-Types of pranayam.

**Total no. of Hours: 24**

**Suggested Reading:**

1. Janardan Swami Yogabhyasi Mandal ,"Yogic Asanas for Group Tarining-Part-I" , Nagpur.
2. Swami Vivekananda, "Rajayoga or conquering the Internal Nature" , Advaita Ashrama,(Publication Department), Kolkata.

| Course Code: EMCC22I08 | Course Title: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS | Ty/Lb/ IE | L | T/S.Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 2 | 0/0 | 0/0 | 0 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation

**OBJECTIVE:** Students will be able to

1. Learn to achieve the highest goal happily.
2. Become a person with stable mind, pleasing personality and determination.
3. Awaken wisdom in students.

**COURSE OUTCOMES (COs) : The students will be able to**

| | |
|---|---|
| **CO1** | Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life |
| **CO2** | The person who has studied Geeta will lead the nation and mankind to peace and prosperity. |
| **CO3** | Study of Neetishatakam will help in developing versatile personality of students. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| Cos/Pos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 |
|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | | | | | | 1 |
| COs / PSOs | PSO1 | PSO2 | PSO3 | | | | | |
| CO1 | | | | | | | | |
| CO2 | | | | | | | | |
| CO3 | | | | | | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | √ | |

| | | | | | |
|---|---|---|---|---|---|
| **EMCC22I08** | **PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS** | **2** | **0/0** | **0/0** | **0** |

**UNIT I** **8 hours**

Neetisatakam-Holistic development of personality -Verses- 19,20,21,22 (wisdom)-Verses- 29,31,32 (pride & heroism)-Verses- 26,28,63,65 (virtue)-Verses- 52,53,59 (dont's)- Verses- 71,73,75,78 (do's).

**UNIT II** **8 hours**

Approach to day to day work and duties-Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48,- Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17,23, 35,-Chapter 18-Verses 45, 46, 48.

**UNIT III** **8 hours**

Statements of basic knowledge-Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68- Chapter 12 -Verses 13, 14, 15, 16,17, 18- Personality of Role model. Shrimad Bhagwad Geeta:-Chapter2-Verses 17, Chapter 3-Verses 36,37,42,-Chapter 4-Verses 18, 38,39-Chapter18 – Verses 37,38,63.

**Total no. of Hours: 24**

**Suggested Reading:**

1. Swami Swarupananda, "Srimad Bhagavad Gita" , Advaita Ashram (Publication Department), Kolkata.
2. P.Gopinath ,Bhartrihari's Three Satakam (Niti-sringar-vairagya) ", Rashtriya Sanskrit Sansthanam, New Delhi.

| **Subject Code: EMCC22I09** | **Subject Name : RESEARCH AND PUBLICATION ETHICS** | **Ty/Lb/ IE** | **L** | **T/S.Lr** | **P/R** | **C** |
|---|---|---|---|---|---|---|
| | Prerequisite: Core subjects | **Ty** | **2** | **0/0** | **0/0** | **0** |

T/L/ : Theory/Lab L : Lecture T : Tutorial P : Practical/Project R : Research C: Credits T/L Theory/Lab

**OBJECTIVE:**

1. To understand the philosophy of science and ethics, research integrity and publication ethics.
2. To identify research misconduct and predatory publications.
3. To understand indexing and citation databases, open access publications, research metrics (citations, h-index, impact Factor, etc.).

**COURSE OUTCOMES (COs) : By doing this course students will**

| | |
|---|---|
| **CO1** | Understand the ethical issues related to Research and Publication |
| **CO2** | Get to know about different types of plagiarism and ways for avoiding plagiarism |
| **CO3** | Know about best practices and guidelines in publication ethics and also learns to avoid Publication misconduct |
| **CO4** | Get to know about Violation of publication ethics, authorship and contributor ship and get to identify about Predatory publishers and journals. |

| | |
|---|---|
| **CO5** | Get to know about various open sources database and research metrics like indexing, citation etc., |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| **COs/POs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO2** | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO3** | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO4** | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |

| **COs / PSOs** | **PSO1** | **PSO2** | **PSO3** |
|---|---|---|---|
| **CO1** | 2 | 3 | 3 |
| **CO2** | 2 | 3 | 3 |
| **CO3** | 2 | 3 | 3 |
| **CO4** | 2 | 3 | 3 |
| **CO5** | 2 | 3 | 3 |

**1/2/3 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | √ | |

**EMCC22I09** **RESEARCH AND PUBLICATION ETHICS** **2 0/0 0/0 0**

**UNIT I: INTRODUCTION**

Introduction to philosophy: Definition, nature and scope, concept, branches - Ethics: Definition, moralphilosophy, nature of moral judgments and reactions – Ethics with respect to Science and Research Intellectual honesty and research integrity.

**UNIT II: SCIENTIFIC CONDUCT**

Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP),Redundant Publications: Duplicate and over lapping publications, salami slicing – Selective reportingand misrepresentation of data.

**UNIT III: PUBLICATION ETHICS -I**

Publication ethics: Definition, introduction and importance – Best practices/standards setting initiatives and guidelines: COPE, WAME etc. Publication misconduct: definition, Concept, problems that lead to unethical behavior and vice-versa, types.

**UNIT IV: PUBLICATION ETHICS - II**

Violation of publication ethics, authorship and contributor ship – Identification of publication misconduct, complaints and appeals – Predatory publishers and journals – Subject specific ethical issues, Complaints and appeals: examples and fraud from India and Abroad.

**UNIT V: DATA BASES AND RESEARCH METRICS**

Open Access publication and Initiatives – Indexing databases – Citation databases, Web of Science, Scopus, etc. – Impact factor of journals as per Journal Citation report .SNIP, SJR, IPP, Cite Score - Metrics: h-index,gindex,i10index,altmetrics – Conflict of interest.

**Suggested Reading:**

1. Bird A, “Philosophy of Science”, Routledge, 2006.
2. MacIntyre ,Alasdair, “A Short History of Ethics”, London, 1967.
3. Chaddah, P, “Ethics in Competitive Research: Do not get scooped; do not get plagiarized”, 2018, ISBN: 9789387480865.
4. On Being a Scientist: A Guide to Responsible Conduct in Research, National Academy of Sciences, National Academy of Engineering and Institute of Medicine, 2009,3rd edition, National Academies Press.
5. Resnik, D. B,”What is ethics in research & why is it important”2011, National Institute of Environmental Health Sciences,pp.1—10. https://www.niehs.nih.gov/research/reso_uuces/bioethics/whatis/index.cfm
6. Bcall, J 2012, Predatory publishers are corrupting open access, Nature, Vol. 489, no.7415,pp. 179—179. https://d0i.org/lO.1 03 8/48917%.
7. Ethics in Science Education,Indian National Science Academy (INSA), Research and Governance, 2019,ISBN: 978-81-939482-1-7. http://www.insaindia.rcs.Wpdf/Ethics_Book.pdf.

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Periyar E.V.R. High Road, Maduravoyal, Chennai-95. Tamilnadu, India.

# OPEN ELECTIVES

| Course Code: EMCC22OE1 | Course Title: BUSINESS ANALYTICS | Ty/Lb/ IE | L | T/S. Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 3 | 0/0 | 0/0 | 3 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation.

**Objectives** : Students will be able to

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. Gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. Become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

**COURSE OUTCOMES (COs) : At the end of this course the students would be able to**

| | |
|---|---|
| **CO1** | Students will demonstrate knowledge of data analytics. . Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.. |
| **CO2** | Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making. |
| **CO3** | Students will demonstrate the ability to translate data into clear, actionable insights |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |

| COs / PSOs | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO1 | | | |
| CO2 | | | |
| CO3 | | | 1 |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | √ | | | |

**EMCC22OE1** **BUSINESS ANALYTICS** **3 0/0 0/0 3**

**UNIT I BUSINESS ANALYTICS** **9 hours**

Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

**UNIT II TRENDINESS AND REGRESSION ANALYSIS** **9 hours**

Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

**UNIT III ORGANIZATION STRUCTURES OF BUSINESS ANALYTICS** **9 hours**

Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

**UNIT IV FORECASTING TECHNIQUES** **9 hours**

Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

**UNIT V DECISION ANALYSIS** **9 hours**

Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making - Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

**Total no. of Hours: 45**

**Suggested Reading:**

1. Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey ,"Business analytics Principles, Concepts, and Applications" , Pearson FT Press.
2. James Evans ,"Business Analytics", Persons Education.

| Course Code: EMCC22OE2 | Course Title: INDUSTRIAL SAFETY | Ty/Lb/ IE | L | T/S. Lr | P/R | C |
|---|---|---|---|---|---|---|
| | Prerequisite: NIL | Ty | 3 | 0/0 | 0/0 | 3 |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation.

**Objectives**: Students will be able to

1. Understand policies and protections put in place to ensure plant and factory worker protection from hazards that could cause injury.

**COURSE OUTCOMES (COs) : At the end of this course the students would be able to**

| | |
|---|---|
| **CO1** | The different safety measures followed in the industry. |
| **CO2** | Understand the fundamentals of safety policy. |
| **CO3** | To understand the periodic and preventive maintenance. |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |

| COs / PSOs | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO1 | | | 1 |
| CO2 | | | 1 |
| CO3 | | | 2 |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | √ | | | |

| | | | | | |
|---|---|---|---|---|---|
| **EMCC22OE2** | **INDUSTRIAL SAFETY** | **3** | **0/0** | **0/0** | **3** |

**UNIT I INDUSTRIAL SAFETY** **9 hours**

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING** **9 hours**

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**UNIT III WEAR AND CORROSION AND THEIR PREVENTION** **9 hours**

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**UNIT IV FAULT TRACING** **9 hours**

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**UNIT V PERIODIC AND PREVENTIVE MAINTENANCE** **9 hours**

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

**Total no. of Hours: 45**

**Suggested Reading:**

1. Higgins & Morrow ,"Maintenance Engineering Handbook" , Da Information Services.
2. H. P. Garg ,"Maintenance Engineering",S. Chand and Company.
3. Audels,,"Pump-hydraulic Compressors", Mcgrew Hill Publication.
4. Winterkorn, Hans ,"Foundation Engineering Handbook" , Chapman & Hall London.

| Course Code: EMCC22OE3 | Course Title: COST MANAGEMENT OF ENGINEERING PROJECTS | Ty/Lb/ IE | L | T/S. Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: NIL** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation.

**Objectives:** Students will be able to

1. Understand the process of planning and controlling the budget of a project or business.

**COURSE OUTCOMES (COs) : At the end of this course the students would be able to**

| | |
|---|---|
| **CO1** | understand Strategic Cost Management Process |
| **CO2** | Know cost concepts in decision-making in their projects |
| **CO3** | To familiarize Quantitative techniques for cost management |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |

| COs / PSOs | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO1 | | | |
| CO2 | | | |
| CO3 | | | 1 |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | √ | | | |

**EMCC22OE3 COST MANAGEMENT OF ENGINEERING PROJECTS 3 0/0 0/0 3**

**UNIT I OVERVIEW OF COST MANAGEMENT PROCESS** **9 hours**

Introduction and Overview of the Strategic Cost Management Process.

**UNIT II CONCEPT OF COST** **9 hours**

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control - Provision of data for Decision-Making.

**UNIT III PROJECT** **9 hours**

Meaning, Different types, why to manage, cost overruns centres, various stages of project execution : conception to commissioning. Project execution as conglomeration of technical and non technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team : Role of each member. Importance Project site : Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

**UNIT IV COST BEHAVIOR AND PROFIT** **9 hours**

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity- Based Cost Management, -Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control- Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

**UNIT V QUANTITATIVE TECHNIQUES** **9 hours**

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**Total no. of Hours: 45**

**Suggested Reading:**

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi.
2. Charles T. Horngren, George Foster," Advanced Management Accounting".
3. Robert S Kaplan Anthony A. Alkinson, "Management & Cost Acco',unting".
4. Ashish K. Bhattacharya," Principles & Practices of Cost Accounting A. H. Wheeler publisher.
5. N.D. Vohra, "Quantitative Techniques in Management", Tata McGraw Hill Book Co. Ltd.

| Course Code: EMCC22OE4 | Course Title: COMPOSITE MATERIALS | Ty/Lb/ IE | L | T/S. Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: NIL** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation.

**Objectives**: Students will be able to

1. Understand nature of the composite material and apply them wherever required.

**COURSE OUTCOMES (COs) : At the end of this course the students would be able to**

| | |
|---|---|
| **CO1** | Understand the nature ,types and th applications of composite materials . |
| **CO2** | Understand the synthesis of different types of metal matrix materials. |
| **CO3** | Understand the polymeric composite materials and the characteristic feature of composite materials . |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |

| COs / PSOs | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO1 | | | |
| CO2 | | | |
| CO3 | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | √ | | | |

**EMCC22OE4 COMPOSITE MATERIALS 3 0/0 0/0 3**

**UNIT I INTRODUCTION 9 hours**

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT II REINFORCEMENTS** **9 hours**

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES** **9 hours**

Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES** **9 hours**

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT V STRENGTH** **9 hours**

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**Total no. of Hours: 45**

**Suggested Reading:**

1. R.W.Cahn ,"Material Science and Technology – Vol 13 – Composites" ,VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.
3. Hand Book of Composite Materials-ed-Lubin.
4. K.K.Chawla ,"Composite Materials ".
5. Deborah D.L. Chung ,"Composite Materials Science and Applications".
6. Danial Gay, Suong V. Hoa, Stephen W. Tasi ,"Composite Materials Design and Applications ".

| Course Code: EMCC22OE5 | Course Title: WASTE TO ENERGY | Ty/Lb/ IE | L | T/S. Lr | P/R | C |
|---|---|---|---|---|---|---|
| | **Prerequisite: NIL** | **Ty** | **3** | **0/0** | **0/0** | **3** |

L : Lecture T : Tutorial S.Lr : Supervised Learning P : Project R : Research C: Credits
Ty/Lb/IE : Theory/Lab/Internal Evaluation.

**Objectives**: Students will be able to

1. Understand the concept of producing energy from the waste material

**COURSE OUTCOMES (COs) : At the end of this course the students would be able to**

| | |
|---|---|
| **CO1** | Understand the different type of waste which can be converted to fuel |
| **CO2** | Understand the concepts and methods of biomass pyrolysis, gasification and combustion |
| **CO3** | Understand the production and characterization of biogas technology |

**Mapping of Course Outcomes with Program Outcomes (POs)**

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |

| COs / PSOs | PSO1 | PSO2 | PSO3 |
|---|---|---|---|
| CO1 | | | |
| CO2 | | | |
| CO3 | | | |

**3/2/1 indicates Strength of Correlation 3- High, 2- Medium, 1-Low**

| Category | Basic Sciences | Engineering Sciences | Humanities and Social Sciences | Program Core | Program Electives | Open Electives | Interdisciplinary | Skill Component | Practical / Project |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | √ | | | |

**EMCC22OE5** **WASTE TO ENERGY** **3 0/0 0/0 3**

**UNIT I INTRODUCTION** **9 hours**

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

**UNIT II BIOMASS PYROLYSIS** **9 hours**

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**UNIT III BIOMASS GASIFICATION** **9 hours**

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**UNIT IV BIOMASS COMBUSTION** **9 hours**

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**UNIT V BIOGAS** **9 hours**

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**Total no. of Hours: 45**

**Suggested Reading:**

1. Desai, Ashok V., “Non Conventional Energy”, Wiley Eastern Ltd., 1990.
2. Khandelwal, K. C. and Mahdi, S. S., “Biogas Technology - A Practical Hand Book”,Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Challal, D. S., “Food, Feed and Fuel from Biomass”, IBH Publishing Co. Pvt. Ltd., 1991.
4. C. Y. WereKo-Brobby and E. B. Hagan, “Biomass Conversion and Technology”, John Wiley & Sons, 1996.