# Course Scheme for Under Graduate Program
# in
# Electrical Engineering


## Department of Electrical & Instrumentation Engg.

## Sant Longowal Institute of Engineering. & Technology

## (Deemed to be university)

**Vision of Department**

Electrical and Instrumentation Engineering Department shall strive to act as a podium for the development and transfer of technical competence in academics, entrepreneurship and research in the field of Electrical and Instrumentation Engineering to meet the changing need of society.

**MISSION**

**1** To provide modular Programs from skill development to the research level.
**2** To impart education and training in innovative state-of-the-art technology in the field of Electrical and Instrumentation Engineering.
**3** To promote holistic development among the students.
**4** To provide extension services to rural society, industry professionals, institutions of research and higher learning in the field of Electrical and Instrumentation Engineering.
**5** To interact with the industry, educational and research organizations, and alumni in the fields of curriculum development, training and research for sustainable social development and changing needs of society.

**PROGRAM EDUCATIONAL OBJECTIVES (PEO):**

The following Program Educational Objectives are designed based on the department mission. The graduates of Instrumentation and Control Engineering should be able to demonstrate

**1** skill in professional / academic career using the knowledge of mathematical, scientific and engineering principles.
**2** expertise in solving real life problems, designing innovative products and systems that are techno-economically and socially sustainable.
**3** sustained learning and adaptation to modern engineering tools, techniques and practices through instruction, group activity and self-study.
**4** leadership and team work while working with diverse multidisciplinary / interdisciplinary groups.
**5** professional ethics and commitment to organizational goals.

**PROGRAM OUTCOMES**

**Engineering Graduates will be able to:**

**1** **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
**2** **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
**3** **Design/development of solutions**: Design solutions for complex engineering problems and design

system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4 **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5 **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6 **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7 **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8 **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10 **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11 **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12 **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## PROGRAM SPECIFIC OUTCOMES (PSO)

1. To understand and find the appropriate solution for Power Systems, Electrical energy utilization and conservation.
2. Use of latest technologies to develop innovative solutions for Electrical Engineering and its allied field problems.

## Study Scheme for Bachelor of Engineering in Electrical (GEE)

**Semester-I Group-A (GEE)**

| S. No. | Sub Code | Subject Name | L | T | P | Hrs. | Credits |
|---|---|---|---|---|---|---|---|
| 1 | BSMA-401 | Engineering Mathematics I | 3 | 1 | 0 | 4 | 4 |
| 2 | BSPH-401 | Applied Physics | 3 | 1 | 0 | 4 | 4 |
| 3 | ESEE-401 | Elements of Electrical Engineering | 2 | 1 | 0 | 3 | 3 |
| 4 | ESCS-401 | Elements of Computer Engineering | 2 | 0 | 0 | 2 | 2 |
| 5 | ESEC-401 | Elements of Electronics Engineering | 2 | 0 | 0 | 2 | 2 |
| 6 | BSPH-402 | Applied Physics Lab | 0 | 0 | 2 | 2 | 1 |
| 7 | ESEE-402 | Elements of Electrical Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| 8 | ESCS-402 | Elements of Computer Engineering Lab | 0 | 0 | 4 | 4 | 2 |
| 9 | ESEC-402 | Elements of Electronics Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| | | Total | 12 | 03 | 10 | 25 | 20 |

**Semester-II A Group-A (GEE)**

| S. No. | Sub Code | Subject Name | L | T | P | Hrs. | Credits |
|---|---|---|---|---|---|---|---|
| 1 | BSMA-402 | Engineering Mathematics II | 3 | 1 | 0 | 4 | 4 |
| 2 | BSCH-401 | Applied Chemistry | 3 | 1 | 0 | 4 | 4 |
| 3 | ESME-401 | Elements of Mechanical Engineering | 2 | 1 | 0 | 3 | 3 |
| 4 | ESME-402 | Workshop Technology and Practice | 1 | 0 | 0 | 1 | 1 |
| 5 | HSMC-401 | English Communication and Soft Skills | 1 | 0 | 0 | 1 | 1 |
| 6 | BSCH-402 | Applied Chemistry Lab | 0 | 0 | 2 | 2 | 1 |
| 7 | ESME-403 | Elements of Mechanical Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| 8 | ESME-404 | Engineering Drawing | 0 | 0 | 4 | 4 | 2 |
| 9 | ESME-405 | Workshop Technology and Practice Lab | 0 | 0 | 4 | 4 | 2 |
| 10 | HSMC-402 | English Communication and Soft Skills Lab | 0 | 0 | 2 | 2 | 1 |
| 11 | MCCH-401 | Mandatory Course-1 | 3 | 0 | 0 | 3 | 0 |
| | | Total | 13 | 03 | 14 | 30 | 20 |

**Semester-II B Group-A (GEE)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | TPIN-421 | Practical Training During Summer Vacations (In-house) 02 weeks | | | | 40 | 1 (S/US) |
| 2 | TPIN-422 | Technical Competency | | | | 40 | 1 (S/US) |

| Semester-III Group-A (GEE) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **S. No.** | **Sub Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | BSMA-501 | Numerical and Statistical Methods | 3 | 0 | 0 | 3 | 3 |
| 2 | PCEE-511 | Electrical Circuit Analysis and Synthesis | 3 | 1 | 0 | 4 | 4 |
| 3 | PCEE-512 | Electronic Devices and Circuits | 3 | 1 | 0 | 4 | 4 |
| 4 | PCEE-513 | Electrical Machines-I (Transformers and DC Machines) | 3 | 1 | 0 | 4 | 4 |
| 5 | BSBL-501 | Biology for Engineers | 2 | 0 | 0 | 2 | 2 |
| 6 | BSMA-502 | Numerical and Statistical Methods Lab | 0 | 0 | 2 | 2 | 1 |
| 7 | PCEE-514 | Electrical Machines-I Lab | 0 | 0 | 2 | 2 | 1 |
| 8 | PCEE-515 | Electrical Circuit Lab | 0 | 0 | 2 | 2 | 1 |
| | | Total | 14 | 03 | 06 | 23 | 20 |

| | Semester-IV –A Group-A (GEE) | | | | | | |
|---|---|---|---|---|---|---|---|
| **S. No.** | **Sub Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | ESME-501 | Engineering Mechanics | 3 | 1 | 0 | 4 | 4 |
| 2 | PCEE-521 | Digital Electronics | 3 | 0 | 0 | 3 | 3 |
| 3 | PCEE-522 | Electrical Machines-II (Asynchronous and Synchronous machines) | 3 | 1 | 0 | 4 | 4 |
| 4 | PCEE-523 | Signals and Systems | 3 | 1 | 0 | 4 | 4 |
| 5 | HSMC-501 | Principles of Management | 3 | 0 | 0 | 3 | 3 |
| 6 | PCEE-524 | Analog and Digital Electronics Lab | 0 | 0 | 2 | 2 | 1 |
| 7 | PCEE-525 | Electrical Machines-II Lab | 0 | 0 | 2 | 2 | 1 |
| 8 | MCMH-501 | Mandatory Course - 2 | 3 | 0 | 0 | 3 | 0 |
| | | Total | 18 | 3 | 4 | 25 | 20 |

| Semester-IV-B Group-A (GEE) | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | TPID-521 | Industrial Training 02 weeks | | | | 40 | 1 (S/US) |
| 2 | EAA-521+ | Fractional credit course/Extra Academic Activity +GROUP A/B/C | | | | 40 | 1 (S/US) |

| Semester-V-A Group-A (GEE) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **S No.** | **Sub Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | PCEE-611 | Electrical Power System-I (Generation, transmission and distribution) | 3 | 0 | 0 | 3 | 3 |
| 2 | PCEE-612 | Control Systems | 3 | 1 | 0 | 4 | 4 |
| 3 | OEXX-611 | Open Elective-1 | 3 | 0 | 0 | 3 | 3 |
| 4 | OEXX-612 | Open Elective-2 | 3 | 0 | 0 | 3 | 3 |
| 5 | PEEE-611 | Professional Elective-1 | 3 | 0 | 0 | 3 | 3 |
| 6 | HSMC-601 | Technical Communication | 2 | 0 | 0 | 2 | 2 |
| 7 | PCEE-613 | Control System Lab | 0 | 0 | 2 | 2 | 1 |
| 8 | HSMC-602 | Technical Communication Lab | 0 | 0 | 2 | 2 | 1 |
| | | Total | 17 | 1 | 4 | 22 | 20 |
| | | | | | | | |
| **Semester-V-B Group-A (GEE)** | | | | | | | |
| 1 | EAA-611+ | Fractional credit course/Extra Academic Activity +GROUP A/B/C | | | | 40 | 1(S/US) |
| | | | | | | | |
| **Semester-VI-A Group-A (GEE)** | | | | | | | |
| **S No.** | **Sub Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | PCEE-621 | Electrical and Electronic Measurements | 3 | 0 | 0 | 3 | 3 |
| 2 | PCEE-622 | Electrical Power System-II (Analysis and Protection) | 3 | 1 | 0 | 4 | 4 |
| 3 | OEXX-621 | Open Elective-3 | 3 | 0 | 0 | 3 | 3 |
| 4 | OEXX-622 | Open Elective-4 | 3 | 0 | 0 | 3 | 3 |
| 5 | PEEE-621 | Professional Elective-2 | 3 | 0 | 0 | 3 | 3 |
| 6 | HSMC-603 | Engineering Economics and Entrepreneurship | 3 | 0 | 0 | 3 | 3 |
| 7 | PCEE-623 | Power System Lab | 0 | 0 | 2 | 2 | 1 |
| | | Total | 18 | 1 | 2 | 21 | 20 |
| | | | | | | | |
| | | | | | | | |
| **Semester-VI-B Group-A (GEE)** | | | | | | | |
| 1 | TPID-621 | Industrial Training 04 weeks | | | | 40 | 2 (S/US) |
| 2 | EAA-622+ | Fractional credit course/Extra Academic Activity +GROUP A/B/C | | | | 40 | 1 (S/US) |
| | | | | | | | |

| | Semester-VII Group-A (GEE) | | | | | | |
|---|---|---|---|---|---|---|---|
| **S No.** | **Sub Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | PCEE-711 | Microprocessors and Microcontrollers | 3 | 1 | 0 | 4 | 4 |
| 2 | PCEE-712 | Power Electronics and Drives | 3 | 0 | 0 | 3 | 3 |
| 3 | PEEE-711 | Professional Elective-3 | 3 | 0 | 0 | 3 | 3 |
| 4 | PEEE-712 | Professional Elective-4 | 3 | 0 | 0 | 3 | 3 |
| 5 | OEXX-711 | Open Elective-5 | 3 | 0 | 0 | 3 | 3 |
| 6 | PCEE-713 | Microprocessors and Microcontrollers Lab | 0 | 0 | 2 | 2 | 1 |
| 7 | PCEE-714 | Power Electronics and Drives Lab | 0 | 0 | 2 | 2 | 1 |
| 8 | PREE-711 | Project Stage I and Seminar | 0 | 0 | 4 | 4 | 2 |
| | | Total | 15 | 1 | 8 | 24 | 20 |

| | Semester-VIII Group-A (GEE) | | | | | | |
|---|---|---|---|---|---|---|---|
| **S No.** | **Sub Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | PEEE-721 | Professional Elective-5 | 3 | 0 | 0 | 3 | 3 |
| 2 | PREE-722 | Professional Elective-6 | 3 | 0 | 0 | 3 | 3 |
| 3 | PREE-721 | Project Stage II | 0 | 0 | 12 | 12 | 6 |
| | | Total | 6 | 0 | 12 | 18 | 12 |
| **OR** | | | | | | | |
| **S No.** | **Sub Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | INID-721 | Internship in Industry | | | | 40 | 6 |
| 2 | PREE-721 | Project Stage II | 0 | 0 | 12 | 12 | 6 |
| | | Total | | | | | 12 |

## Minor Degree (Electrical Engineering)

| Semester-III | | | | | | | |
|---|---|---|---|---|---|---|---|
| **S No** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | MDEE-511 | Instrumentation and Control | 3 | 1 | 0 | 4 | 4 |
| | | Total | 3 | 1 | 0 | 4 | 4 |
| **Semester-IV** | | | | | | | |
| **S No** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| | MDEE-521 | Electromechanical Energy Conversion | 3 | 1 | 0 | 4 | 4 |
| | | Total | 3 | 1 | 0 | 4 | 4 |
| **Semester-V** | | | | | | | |
| **S No** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | MDEE-611 | Elements of Power System | 3 | 1 | 0 | 4 | 4 |
| | | Total | 3 | 1 | 0 | 4 | 4 |
| **Semester-VI** | | | | | | | |
| **S No** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | MDEE-621 | Industrial Electronics | 3 | 1 | 0 | 4 | 4 |
| | | Total | 3 | 1 | 0 | 4 | 4 |
| **Semester-VII** | | | | | | | |
| **S No** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | MDEE-711 | Solar and Wind Energy Systems | 3 | 1 | 0 | 4 | 4 |
| | | Total | 3 | 1 | 0 | 4 | 4 |

## Honors Degree (Electrical Engineering)

| Semester-V | | | | | | | |
|---|---|---|---|---|---|---|---|
| **S No** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | HDEE-611 | Modelling and control of Electrical Machines | 3 | 1 | 0 | 4 | 4 |
| | HDEE-612 | Micro-grid Systems | 3 | 1 | 0 | 4 | 4 |
| | | Total | 6 | 2 | 0 | 8 | 8 |
| **Semester-VI** | | | | | | | |
| **S No** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| | HDEE-621 | Advanced Electrical Machines | 3 | 1 | 0 | 4 | 4 |
| | | Total | 3 | 1 | 0 | 4 | 4 |
| **Semester-VII** | | | | | | | |
| **S No** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | HDEE-711 | Power System Operation and Control | 3 | 1 | 0 | 4 | 4 |
| | | Total | 3 | 1 | 0 | 4 | 4 |
| **Semester-VIII** | | | | | | | |
| **S No** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | HDEE-721 | Project Honours | 3 | 1 | 0 | 4 | 4 |
| | | Total | 3 | 1 | 0 | 4 | 4 |

**List of Mandatory Courses**

1. **MCCH-401 Mandatory Course – 1:** Environmental Studies
2. **MCMH-501 Mandatory Course – 2:** Indian Constitution

## List of Open Electives

| LIST OF OPEN ELECTIVES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **S. No.** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| 1 | **OEEE-611** | **Open Elective-I** | 3 | 0 | 0 | 3 | 3 |
| a) | OEEE-611A | ~~Electrical Circuits~~ | 3 | 0 | 0 | 3 | 3 |
| b) | OEEE-611B | Electrical-Engineering Materials | 3 | 0 | 0 | 3 | 3 |
| c) | OEEE-611C | Renewable Energy Sources | 3 | 0 | 0 | 3 | 3 |
| d) | OEEE-611D/ PCIE611B | Electrical machines | 3 | 0 | 0 | 3 | 3 |
| **2** | **OEEE-612** | **Open Elective-II** | 3 | 0 | 0 | 3 | 3 |
| a) | OEEE-612A | Energy Conservation Practices | 3 | 0 | 0 | 3 | 3 |
| b) | OEEE-612B | Energy Auditing and Management | 3 | 0 | 0 | 3 | 3 |
| c) | OEEE-612C | Utilization of Electrical Energy | 3 | 0 | 0 | 3 | 3 |
| d) | OEEE-612D | Electric Vehicles Technology | 3 | 0 | 0 | 3 | 3 |
| **3** | **OEEE-621** | **Open Elective-III** | 3 | 0 | 0 | 3 | 3 |
| a) | OEEE-621A | ~~Microprocessors and Applications~~ | 3 | 0 | 0 | 3 | 3 |
| b) | OEEE-621B | Elements of Power System | 3 | 0 | 0 | 3 | 3 |
| c) | OEEE-621C | ~~Biomedical Instrumentation~~ | 3 | 0 | 0 | 3 | 3 |
| d) | OEEE-621D | Electrical Estimation and Costing | 3 | 0 | 0 | 3 | 3 |
| **4** | **OEEE-622** | **Open Elective-IV** | 3 | 0 | 0 | 3 | 3 |
| a) | OEEE-622A | ~~Control System~~ | 3 | 0 | 0 | 3 | 3 |
| b) | OEEE-622B | ~~Microcontrollers and Applications~~ | 3 | 0 | 0 | 3 | 3 |
| c) | OEEE-622C | Electrical Safety and Applications | 3 | 0 | 0 | 3 | 3 |
| d) | OEEE-622D | Electric Drives and Traction System | 3 | 0 | 0 | 3 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **5** | **OEEE-711** | **Open Elective-V** | 3 | 0 | 0 | 3 | 3 |
| a) | OEEE-711A | ~~Signals and Systems~~ | 3 | 0 | 0 | 3 | 3 |
| b) | OEEE-711B | ~~Sensors and Transducers~~ | 3 | 0 | 0 | 3 | 3 |
| c) | OEEE-711C | ~~Soft Computing Techniques~~ | 3 | 0 | 0 | 3 | 3 |
| d) | OEEE-711D | Special Electrical Machines | 3 | 0 | 0 | 3 | 3 |
| e) | OEEE-711E | Electrical Measurements and Instruments | 3 | 0 | 0 | 3 | 3 |

**List of Professional Electives**

| List of Professional Electives | | | | | | | |
|---|---|---|---|---|---|---|---|
| **S. No.** | **Sub. Code** | **Subject Name** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| **1** | **PEEE-611** | **Professional Elective-1** | 3 | 0 | 0 | 3 | 3 |
| a) | PEEE-611A | Biomedical Instrumentation | 3 | 0 | 0 | 3 | 3 |
| b) | PEEE-611B | Electromagnetic Field Theory | 3 | 0 | 0 | 3 | 3 |
| c) | PEEE-611C | Electrical Safety and Standards | 3 | 0 | 0 | 3 | 3 |
| d) | PEEE-611D | Group Chain Technology of Distributed System | 3 | 0 | 0 | 3 | 3 |
| **2** | **PEEE-621** | **Professional Elective-2** | 3 | 0 | 0 | 3 | 3 |
| a) | PEEE-621A | Electrical Energy Conservation and Auditing | 3 | 0 | 0 | 3 | 3 |
| b) | PEEE-621B | Non-Linear and Optimal Control | 3 | 0 | 0 | 3 | 3 |
| c) | PEEE-621C | Telemetry and Data Acquisition | 3 | 0 | 0 | 3 | 3 |
| d) | PEEE-621D | Smart Metering and Security System | 3 | 0 | 0 | 3 | 3 |
| **3** | **PEEE-711** | **Professional Elective-3** | 3 | 0 | 0 | 3 | 3 |
| a) | PEEE-711A | Wind and Solar Energy Systems | 3 | 0 | 0 | 3 | 3 |
| b) | PEEE-711B | Computational Electromagnetics | 3 | 0 | 0 | 3 | 3 |
| c) | PEEE-711C | Reliability Engineering | 3 | 0 | 0 | 3 | 3 |
| d) | PEEE-711D | Computer Relaying and Phasor Measurement Units | 3 | 0 | 0 | 3 | 3 |
| **4** | **PEEE-712** | **Professional Elective-4** | 3 | 0 | 0 | 3 | 3 |
| a) | PEEE-712A | Soft Computing Techniques | 3 | 0 | 0 | 3 | 3 |
| b) | PEEE-712B | Electric and Hybrid Vehicles | 3 | 0 | 0 | 3 | 3 |
| c) | PEEE-712C | Virtual Instrumentation | 3 | 0 | 0 | 3 | 3 |
| d) | PEEE-712D | Power System Compensation | 3 | 0 | 0 | 3 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **5** | **PEEE-721** | **Professional Elective-5** | 3 | 0 | 0 | 3 | 3 |
| a) | PEEE-721A | Power Quality and FACTs | 3 | 0 | 0 | 3 | 3 |
| b) | PEEE-721B | Utilization of Electrical Energy | 3 | 0 | 0 | 3 | 3 |
| c) | PEEE-721C | Robotics | 3 | 0 | 0 | 3 | 3 |
| d) | PEEE-721D | Power System Restructuring | 3 | 0 | 0 | 3 | 3 |
| **6** | **PEEE-722** | **Professional Elective-6** | 3 | 0 | 0 | 3 | 3 |
| a) | PEEE-722A | Advanced Microprocessors and Microcontrollers | 3 | 0 | 0 | 3 | 3 |
| b) | PEEE-722B | High Voltage Engineering | 3 | 0 | 0 | 3 | 3 |
| c) | PEEE-722C | Modelling and Simulation | 3 | 0 | 0 | 3 | 3 |
| d) | PEEE-722D | Power System Optimization | 3 | 0 | 0 | 3 | 3 |

| S. No. | Course Components | Curriculum contents (% of total number of the credits of the program) | Total number of contact hours | Total number of credits |
|---|---|---|---|---|
| 1 | Basic Sciences | 15 | 27 | 24 |
| 2 | Engineering Sciences | 15 | 33 | 24 |
| 3 | Humanities and Social Sciences | 6.875 | 13 | 11 |
| 4 | Program Core | 32.5 | 60 | 52 |
| 5 | Program Electives | 7.5 | 12 | 12 |
| 6 | Open Electives | 9.375 | 15 | 15 |
| 7 | Project | 3.75 | 12 | 6 |
| 8 | Internship/Seminar/Industrial Training | 8.125 | 204 | 13 |
| 9 | Any other (Mandatory course and fractional credit course) | 1.875 | 127 | 3 |
| | Total number of Credits | | | 160 |

Total Credits

| S. No. | Program | Total No. of Credits |
|---|---|---|
| 1 | Undergraduate Program | 160 |
| 2 | Minor Degree(Electrical Engineering) | 20 |
| 3 | Honors (Electrical Engineering) | 20 |

# SYLLABUS

# of

# Bachelor of Electrical Engineering

**Subject Code : ESEE-401**

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**Dr. Rishabh Verma** **Dr. Gurmeet Singh** **Dr. Charanjiv Gupta** **Dr. M. S. Manna** **Prof. Manpreet Kaur** **Prof. A.S. Arora**

**Prof. Sanjay Marwaha** **Prof. J.S. Dhillon** **Dr. Chetan Vasudeva** **Er. Baljeet Singh** **Prof. Mukesh Pathak** **Prof. Surita Maini**

**Title of the course : Elements of Electrical Engineering**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 2 | 1 | 0 | 3 | 3 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1: Identify DC** and AC circuits.

**CO 2: Formulate and analyze** electrical circuits.

**CO 3: Interpret** basic principles of electromagnetism to implement in electrical machines and transformers.

**CO 4: Recognize** and select various electrical machines according to the applications.

**CO 5: Apply** the ethical principles for troubleshooting & installation of safety devices as per norms of engineering practice.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL4 | BL2 | BL5 | BL3 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 1 | 1 | 1 | - | - | 1 | 2 | 1 | - | 3 | 3 | 1 |
| CO2 | 3 | 3 | - | 2 | - | 1 | - | - | 2 | - | - | - | 3 | 1 |
| CO3 | 3 | 1 | 2 | 3 | 1 | - | 1 | - | 2 | 1 | 1 | 3 | 3 | 1 |
| CO4 | 3 | - | 2 | - | - | 1 | - | 1 | 2 | 1 | - | 2 | 3 | 1 |
| CO5 | 2 | 2 | 3 | 1 | 1 | 1 | - | - | 2 | 1 | - | 2 | 2 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Basic Elements:** Concepts of electric charge, current and electromotive force, potential and potential difference; conductor, semiconductor insulator and dielectric, electrical power and energy; basics of instruments used for measuring current, voltage, power and energy, methods and precautions, introduction to digital measuring instruments. | 6 |
| | **Concepts of DC:** Ohm's law, resistance, and color coding; capacitance and inductance, their ratings; effects of temperature on resistance, series and parallel connection of resistance , | 6 |

| | | |
|---|---|---|
| | capacitances, Kirchhoff's laws and applications, network theorems | |
| | **AC Fundamentals**: Concept of alternating voltage and alternating current, difference between AC and DC, various terms related with AC waves; RMS and average values, concept of phase difference and phasor, single phase and three phase supply; alternating voltage applied to pure resistance, pure inductance, pure capacitance and their combinations, concept of impedance and power in AC circuit. | 6 |
| | **Three phase AC:** Phasor representation of three phases, star and delta connections, inter-relation between phase and line values of voltage/current, power measurement in three phase system. | 6 |
| **Unit-2** | **Electromagnetic Induction:** Concept of magnetic field, magnetic flux, reluctance, magneto motive force (MMF), permeability; self and mutual induction, basic electromagnetic laws, effects on a conductor moving in a magnetic field, various losses in magnetic circuits. | 6 |
| | **Electrical Machines:** Elementary concepts and classification of electrical machines, common features of rotating electrical machines, basic principle of a motor and a generator, need of starters and their classifications. transformer- classification, principle of operation, construction, working and applications. | 9 |
| | **Basic Electrical Installation and Protection:** Basic testing and faults diagnosis in electrical systems, oscilloscopes, signal generators etc. basics of various protection and safety devices e.g. fuses, earthing, miniature circuit breaker (MCB) and earth leakage circuit breaker (ELCB) and their applications, replacement of different passive components e.g. lamps and lamp holders, switches, cables, cable connectors, electromagnetic relays. | 9 |

**Recommended Books:**

1. D.P. Kothari and I J Nagrath, Basic Electrical Engineering, 3rd edition, Tata McGraw Hill Education, 2009.
2. D.P. Kothari and I.J. Nagrath, Electric Machines, 4th edition, McGraw Hill Education, 2010.
3. E Hughes and J Hiley, Electrical and Electronic Technology, 10th edition, Pearson Education, 2010.
4. S.K. Bhattacharya, Electrical Machines, 3rd edition, Tata McGraw - Hill Education, 2008.
5. B.L. Thereja, A Textbook of Electrical Technology, S Chand; Twenty Third edition,2002.
6. Linsley, Trevor. Basic Electrical Installation Work. United Kingdom, Routledge, 2018.
7. Uday A. Bakshi, Dr. Mayuresh V. Baksh Electrical Machines - I. N.p., Technical Publications, 2020.
8. Prof. N.K. De, Prof. G.D. Roy, Prof. T.K. Bhattacharya, Basic Electrical Technology, IIT Kharagpur , NPTEL
   Course code 108105053

**Subject Code : ESEE-401**
**Title of the course : Elements of Electrical Engineering Lab.**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 0 | 0 | 2 | 1 | 2 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1: Identify** DC and AC circuits.
**CO 2: formulate and analyze** electrical circuits.
**CO 3: Interpret** basic principles of electromagnetism to implement in electrical machines and transformers.
**CO 4: Recognize** and select various electrical machines according to the applications.
**CO 5: apply** the ethical principles for troubleshooting & installation of safety devices as per norms of engineering practice.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL4 | BL2 | BL5 | BL3 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Specific Outcomes(POs) | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | 1 | 2 | - | 1 | - | - | 3 | 2 | 1 | 3 | 1 | 1 |
| CO2 | 3 | 3 | - | 2 | 1 | - | - | 1 | 3 | - | - | 3 | 2 | 1 |
| CO3 | 3 | - | 1 | 2 | - | 1 | 2 | - | - | 2 | 1 | 3 | 2 | 2 |
| CO4 | 3 | 3 | - | - | 1 | - | - | 1 | 3 | 2 | 3 | - | 3 | 3 |
| CO5 | 3 | - | 1 | 2 | - | 1 | - | - | 2 | - | 3 | 3 | 2 | 1 |

To understand the practicability of **Elements of Electrical Engineering**, the list of experiments is given below to be performed (at least 10) in the laboratory.

1. Study of various passive components and measuring instruments and their connections in electrical circuits.
2. Verification of Kirchhoff's current and voltage laws.
3. Measurement of voltage, current, phase angle, power and power factor in RL, RC and RLC circuits.
4. Implementation of various types of earthing.
5. Study of various types of protection devices e.g. fuses, Miniature circuit Breaker (MCB) and Earth leakage circuit Breaker (ELCB)

6. Verification of Faraday's laws and Lenz's law.
7. Starting and reversing of DC and AC motors with various types of starters.
8. Verification of turns ratio of transformer
9. Determination of voltage regulation of transformer.
10. Fault diagnosis and removal in general electrical connection /apparatus.
11. To study the breakdown strength of transformer oil.
12. To measure the Insulation resistance of cable
13. Demonstration of cut-out sections of various machines.

**Subject Code : TPIN-421**
**Title of the course : Practical Training (In House)**

| L | T | P | Credits | Load |
|---|---|---|---|---|
| - | - | - | 1 | Two weeks(80hrs.) |

**Course Outcomes:**
After successful completion of industrial training, the students should be able to
**CO 1**: **Illustrate** the use of various tools, components and measuring instruments.
**CO 2:** implement work requiring individual and teamwork skill.
**CO 3:** correlate the theoretical concepts with the practical outputs.
**CO 4:** communicate their work effectively through writing.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL2 | BL3 | BL5 | BL3 |

| CO/PO Mapping:(Strong (3) / Medium (2) / Weak (1) indicates strength of correlation) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/ Program Specific Outcomes (PSOs) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 2 | 2 | - | 2 | - | 3 | 3 | 3 | - | 3 | 3 | 1 |
| CO2 | 3 | - | 3 | - | 3 | - | 3 | 2 | 2 | 3 | 1 | - | 3 | 1 |
| CO3 | 3 | 3 | - | 3 | 2 | 2 | 2 | 2 | 1 | - | - | 3 | 3 | 3 |
| CO4 | 1 | 1 | - | - | 1 | 1 | - | - | - | 3 | 1 | 3 | 1 | 3 |

Objective of the Program is to
1. enrich the students with a basic understanding of the Electrical Engineering.
2. familiarize and provide "hands on" training experience with the requisite tools, components and instruments likely to be used.
3. get students well versed with various practical aspects.
4. introduce the way of troubleshooting various engineering faults related to respective fields.
5. make the students able to present work in written, oral or formal presentation formats.

**Subject Code : PCEE-511**

**Title of the course : Electrical Circuit Analysis and Synthesis**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 1 | 0 | 4 | 4 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1:** be familiar with the fundamental concepts of network analysis.

**CO 2:** know about the network theorems and two port network descriptions.

**CO 3:** determine system stability using network stability criteria.

**CO 4:** be familiar with the fundamental concepts of synthesis of two-port passive networks.

**CO 5:** learn various characteristics of Attenuators and Filters.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL2 | BL3 | BL2 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Specific Outcomes(POs) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO2 |
| CO1 | 3 | 2 | 2 | - | - | 1 | - | - | 1 | 1 | 1 | 3 | 3 | 1 |
| CO2 | 3 | - | 2 | - | 2 | - | - | - | 3 | - | - | 2 | 3 | 1 |
| CO3 | 3 | 3 | - | 3 | 3 | 1 | - | - | 3 | 2 | 1 | - | 3 | 2 |
| CO4 | 3 | 2 | 3 | 2 | - | 1 | - | - | 2 | 2 | - | 3 | 3 | 1 |
| CO5 | 3 | 2 | 3 | - | 3 | 1 | - | - | 2 | - | 1 | 2 | 3 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit -1** | **Graph Theory:** Graph of a network, definitions, tree, co tree, link, basic loop and basic cut set, incidence matrix, cut set matrix, tie set matrix duality, loop and node methods of analysis. | 6 |
| | **Network Theorems (Applications to AC Networks):** Super-position theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, reciprocity theorem. Millman's theorem, compensation theorem, Tellegen's theorem. | 8 |

| | | |
|---|---|---|
| | **Network Functions:** Concept of complex frequency, transform impedances network functions of one port and two port networks, concept of poles and zeros, properties of driving point and transfer functions, time response and stability from pole zero plot, frequency response and bode plots. | 10 |
| **Unit -2** | **Two Port Networks:** Characterization of LTI two port networks ZY, ABCD and h parameters, reciprocity and symmetry, inter-relationships between the parameters, inter-connections of two port networks, Ladder and Lattice networks. T & Π Representation. | 10 |
| | **Network Synthesis:** Positive real function; definition and properties; properties of LC, RC and RL driving point functions, synthesis of LC, RC and RL driving point immittance functions using Foster and Caurer first and second forms. | 8 |
| | **Filters:** Image parameters and characteristics impedance, passive and active filter fundamentals, low pass, high pass, band pass, band elimination filters. | 6 |

**Recommended Books: -**

1. A. Chakrabarti, "Circuit Theory", 6th Edition, Dhanpat Rai Co., 2010.
2. E. Donald Scott, "An Introduction to Circuit analysis: A System Approach", New York Mc-Graw Hill, 1987
3. D. Roy Choudhary, "Networks and Systems", 2nd Edition, New Age International Publication, 2010.
4. M.E. Van Valkenburg, "Network Analysis", 3rd Edition, Prentice Hall of India/Pearson Education,2002
5. VK Aatre, "Network Theory and Filter Design," Wiley and Sons
6. Sundararajan, D.. Introductory Circuit Theory. Germany, Springer International Publishing, 2019.
7. Bakshi, Uday A., and Bakshi, Late Ajay V.. Network Synthesis and Filter Design. India, UNICORN Publishing Group, 2020.
8. Prof. S.C. Dutta Roy, Circuit Theory, IIT Delhi, NPTEL course code 108102042

**Subject Code : PCEE-512**
**Title of the course : Electronic Devices and Circuits**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 1 | 0 | 4 | 4 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1:** be familiar with the structure of basic electronic devices.
**CO 2:** be exposed to the operation of electronic devices.
**CO 3**: implement applications of electronic devices.
**CO 4:** be familiar with the Operational amplifier characteristics and applications.
**CO 5**: be familiar with the multivibrators.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **Cos** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL1, BL2 | BL3 | BL2, BL4 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | - | - | 1 | 2 | - | - | - | 2 | 1 | - | 3 | 1 |
| CO2 | 3 | 3 | 2 | 3 | 3 | - | 1 | - | 2 | 2 | 2 | 2 | 3 | 1 |
| CO3 | 2 | 3 | 2 | - | 2 | 2 | 1 | 1 | 2 | 2 | - | 2 | 3 | 1 |
| CO4 | 3 | - | 2 | 2 | - | 2 | - | - | 2 | 2 | 3 | - | 3 | 1 |
| CO5 | 2 | 3 | 3 | 3 | 2 | - | - | 1 | 2 | 2 | 2 | 2 | 3 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| | **PN Junction Devices:** PN junction diode: structure, operation, V-I characteristics, rectifiers: half wave and full wave rectifier, Special purpose diodes: Zener diode, Tunnel diode and varactor diode, Photodiode, Zener diode characteristics, Zener as regulator. | 08 |

| | | |
|---|---|---|
| | **Bipolar Junction Transistor:** Transistors-construction, operation, characteristics, parameters, transistor as an amplifier at low frequency, hybrid model and re model of BJT, analysis of amplifier using hybrid model and re model, amplifier types-CE, CB, CC. DC operating point, Biasing circuits fixed bias, emitter bias, voltage divider bias, bias stabilization. | 10 |
| | **FET and MOSFET:** Introduction to FET, MOSFET, their construction, operation and characteristics | 06 |
| **Unit-2** | **Feedback Amplifier and Oscillators:** Feedback concept, advantages of negative feedback, voltage / current, series, shunt feedback, positive feedback, Criterion for oscillations, phase shift, Wien bridge, Hartley, Colpitts and crystal oscillators. | 08 |
| | **Introduction to Op-Amps:** Op-amp- analysis, Ideal op-amp building blocks, open loop op-amp configurations, practical op-amp, offset voltage, input bias and offset current, CMRR. Applications of op-amps. Specialized ICs: 555 Timer-monostable multivibrator, astable multivibrator, PLL. | 16 |

**Recommended Books-**

1. Bell, David "Electronic Devices and Circuits", Prentice Hall of India, 2004.
2. Sedra and Smith, "Microelectronic Circuits", Oxford University Press, 2004.
3. RA Gayakwad, "Op-amps and Linear Integrated Circuits", 4th Edition, Pearson Education.
4. Rashid, "Micro Electronic Circuits" Thomson Publications, 1999.
5. Floyd, "Electron Devices" Pearson Asia 5th Edition, 2001.
6. Yawale, Sangita, and Yawale, Shrikrishna. Operational Amplifier: Theory and Experiments. Singapore, Springer Singapore, 2021.
7. Yawale, Sangita, and Yawale, Shrikrishna. Operational Amplifier: Theory and Experiments. Singapore, Springer Singapore, 2021.
8. By Prof. Sanjiv Sambandan, Semiconductor Devices and Circuits, IISC Banglore, NPTEL course.

**Subject Code : PCEE-513**
**Title of the course : Electrical Machines-1 (Transformers and DC Machines)**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 1 | 0 | 4 | 4 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1**: understand construction and working principle of single phase and auto transformers.
**CO 2:** acquire the knowledge of three phase transformers, different type of winding connection, parallel operation and testing of transformers.
**CO 3:** explain construction and working principle of DC generator and various method of improving commutation.
**CO 4:** describe the construction, working principle and characteristics of DC motor.
**CO 5:** learn various method of starting and braking of DC motor.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL1, BL2 | BL2, BL4 | BL2, BL4 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | 2 | 3 | 2 | 2 | - | 1 | 1 | 2 | - | 2 | 3 | 1 |
| CO2 | 2 | - | 2 | 3 | 2 | - | 1 | - | - | 2 | 2 | 2 | 3 | 1 |
| CO3 | 3 | - | 2 | 3 | 2 | - | - | 2 | 1 | 2 | 2 | 2 | 3 | 1 |
| CO4 | 3 | 2 | 2 | 3 | - | 2 | 1 | - | - | 2 | 2 | 2 | 3 | 1 |
| CO5 | 3 | 2 | 2 | 3 | - | 2 | - | - | 1 | 2 | 2 | - | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Transformers:** Working principle, construction of single phase transformer, EMF equation, phasor diagrams on no-load and on loaded conditions, open circuit and short circuit tests, equivalent circuit parameters estimation, voltage regulation and efficiency, back to back test. effect of saturation on exciting current and in-rush current phenomenon. Parallel operation of single phase transformers. | 10 |
| | **Auto Transformers:** Principle of operation, equivalent circuit and phasor diagrams, comparison with two winding transformer. | 04 |

| | | |
|---|---|---|
| | **Three-Phase Transformers:** Different types of winding connections, Voltage and current ratios, Parallel operation of three phase transformers. Three winding transformer's equivalent circuit, off-load and on-load tap changing transformer, Scott connections. Testing of transformers. | 10 |
| **Unit-2** | **D.C. Generator:** Working principle, construction of DC machines, armature windings, single and double layer winding diagrams, electro motive force (E.M.F.) and torque equations, armature reaction, effect of brush shift, compensating winding, commutation, causes of bad commutation, methods of improving commutation, methods of excitation of d.c. generators and their characteristics. | 12 |
| | **D.C. Motor:** Working principle characteristics, starting of shunt and series motor, starters, speed control methods: field and armature control. Braking: plugging, dynamic and regenerative braking, Testing: Swinburn's test, Hopkinson test, Field test. estimation of losses and efficiency. | 12 |

**Recommended Books-**

1. A.E. Fitzgerald, C. Kingsley.and S.D. Umans, Electric Machinery, 6th Edition, McGraw Hill, 2005.
2. E.H. Langsdorff, Principles of D.C. machines, McGraw Hill, 2013.
3. I.J. Nagrath and D.P. Kothari, Electrical Machines, 4th Edition, Tata McGraw Hill, 2010.
4. M.G. Say, Alternating Current Machines, 5th edition, Sir Isaac Pitman & Sons Ltd, 2005.
5. P.S. Bimbhra, Electrical Machinery, 7th edition, Khanna Publishers, 2015.
6. Melkebeek, Jan A.. Electrical Machines and Drives: Fundamentals and Advanced Modelling. Switzerland, Springer International Publishing, 2019.
7. Sen, P. C.. Principles of Electric Machines and Power Electronics. United Kingdom, John Wiley & Sons, Limited, 2021.
8. Prof. Tapas Kumar Bhattacharya, Electrical Machines - I, IIT Kharagpur, NPTEL course code 108105155.

**Subject Code : PCEE-514**
**Title of the course : Electrical Machines Lab-1**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 0 | 0 | 2 | 1 | 2 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1**: understand construction and working principle of single phase and auto transformers.
**CO 2:** acquire the knowledge of three phase transformers, different type of winding connection, parallel operation and testing of transformers.
**CO 3:** explain construction and working principle of DC generator and various method of improving commutation.
**CO 4:** describe the construction, working principle and characteristics of DC motor.
**CO 5:** learn various method of starting and braking of DC motor.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL1, BL2 | BL2, BL4 | BL2, BL4 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO2 |
| CO1 | 3 | 3 | 2 | 3 | - | 2 | - | 1 | - | 2 | - | 2 | 2 | 1 |
| CO2 | 2 | - | 2 | 3 | 2 | 2 | 1 | - | 1 | 2 | 2 | 2 | 2 | 1 |
| CO3 | 3 | - | 2 | 3 | 2 | 2 | - | - | 1 | 2 | 2 | 2 | 1 | 1 |
| CO4 | 3 | 2 | 2 | 3 | - | 2 | 1 | 1 | - | 2 | 2 | - | 1 | 1 |
| CO5 | 3 | 2 | 2 | 3 | 2 | 2 | - | - | 1 | 2 | 2 | - | 2 | 2 |

To understand the practicability of **Electrical Machine-I**, the list of experiments is given below to be performed (at least 10) in the laboratory.

1. To perform Open circuit and short circuit tests on a single phase transformer and hence find equivalent circuit, voltage regulation and efficiency.
2. To perform Load test on a single phase transformer.
3. To separate core losses of single phase transformer at no-load.
4. To perform parallel operation of two single phase transformers.
5. To study the various connections of three phase transformer.

6. To perform Scott connections on three phase transformer to get two phase supply.
7. To study the constructional details of direct current (DC) machine.
8. To measure armature and field resistance of direct current (DC) machine.
9. To draw the open circuit characteristics (OCC) of DC shunt generator.
10. To draw the Load characteristic of DC shunt generator.
11. To perform speed control of a DC motor using field control and armature control method.
12. To perform Swinburne's test (no load test) to determine losses of direct current (DC) shunt motor.
13. To perform Hopkinson Test on DC machine.

**Subject Code : PCEE-515**
**Title of the course : Electrical Circuits Laboratory**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 0 | 0 | 2 | 1 | 2 |

**Course Outcomes:**

After successful completion of course, the students should be able to
**CO 1:** Analyze waveforms, signals, signal superposition and Fourier transform.
**CO 2:** Apply Laplace transforms for analyzing the networks in time and frequency domain.
**CO 3:** Learn the characteristics of Attenuators and various types of Filters.
**CO 4:** Understand the fundamental concepts of network analysis and synthesis of two-port passive networks.
**CO 5:** To synthesize an electrical network from a given impedance/admittance function.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL4 | BL3, BL4 | BL2 | BL1, BL2 | BL5 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | 2 | 3 | - | 2 | 1 | - | 1 | 2 | - | 2 | 1 | 1 |
| CO2 | 2 | - | 2 | 3 | 2 | 2 | - | - | - | 2 | 2 | 2 | 1 | 2 |
| CO3 | 3 | 1 | 2 | 3 | 2 | 2 | - | 1 | 1 | 2 | 2 | 2 | 1 | 1 |
| CO4 | 3 | 2 | - | 3 | 2 | 2 | 1 | - | - | 2 | 2 | - | 1 | 1 |
| CO5 | 3 | 2 | 2 | 3 | 2 | - | - | - | 1 | 2 | 2 | 1 | 1 | 2 |

**LIST OF EXPERIMENTS**

1. Experimental verification of Kirchhoff's voltage and current laws
2. Experimental verification of Thevenin theorem,
3. Experimental verification of Reciprocity Theorem.
4. Experimental verification of Superposition Theorem.
5. Experimental verification of maximum power transfer Theorem

6. Experimental determination of time constant of series R-C electric circuits.
7. Experimental determination of frequency response of RLC circuits.
8. Design and Simulation of series resonance circuit.
9. Design and Simulation of parallel resonant circuits.
10. Simulation of low pass passive filters.
11. Simulation of high pass passive filters.
12. Determination of two port network parameters.

**Subject Code : PCEE-521**
**Title of the course : Digital Electronics**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** exercise various number systems, binary operation and error correction.
**CO 2:** interpret Boolean algebra, encoders, decoders and code conversion.
**CO 3:** know about working of latch, flip-flops, registers, counters and their types.
**CO 4**: learn A/D converter and D/A converter
**CO 5**: know about digital ICs, logic families, memories and programmable logic arrays.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL2 | BL2 | BL2 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | 2 | 2 | - | 1 | - | - | 1 | 1 | 2 | 2 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 1 | - | - | - | - | 3 | 3 | 3 | 3 | 2 |
| CO3 | 3 | - | 3 | - | 3 | 1 | - | - | - | 3 | - | 3 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 2 | - | - | - | 3 | 3 | - | 3 | 3 | 3 |
| CO5 | 3 | - | 3 | - | 2 | 1 | - | - | 3 | 3 | 1 | 2 | 2 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Number System & Codes:** Review of number systems, binary number systems, octal number system, hexadecimal number system, signed & unsigned numbers, 1's & 2's complement of a number, different types of codes & their conversions, binary operations- addition, subtraction, multiplication, division. | 08 |
| | **Combinational Logic:** Concept of positive & negative logic, introduction to Boolean variables, Logical functions using Karnaugh map &Quine-Macluskey methods, multiplexers, demultiplexers, encoders, decoders, adders, subtractors, parity generators, parity checkers, code converter. | 06 |

| | | |
|---|---|---|
| | **Sequential logic concepts and components:** Flip flops - SR, JK, D and T flip flops – Level triggering and edge triggering, Shift registers, type of registers, circuit diagrams, synchronous& asynchronous counters, excitation tables, design with state equation state diagram counters, up & down counters, ring counters & mod, counters. Introduction to finite state machines. | 10 |
| **Unit-2** | **Digital to Analog (D/A) and Analog to Digital (A/D) Converters:** Digital to analog converters: weighted resistor/converter, R-2R Ladder D/A converter, specifications for D/A converters, examples of D/A converter ICs, sample and hold circuit, analog to digital converters: quantization and encoding, parallel comparator A/D converter, successive approximation A/D converter, counting A/D converter, dual slope A/D converter, A/D converter using voltage to frequency and voltage to time conversion, specifications of A/D converters, example of A/D converter ICs | 10 |
| | **Digital Logic Families:** Introduction, characteristics of digital ICs, integrated injection logic, direct coupled transistor, transistor-transistor logic, emitter coupled logic, MOS & CMOS logic, and high threshold logic families. | 06 |
| | **Semiconductor Memories:** Introduction, memory organization, classification & characteristics of memories, sequential memories, read only memories, read & write memories, content addressable memories, programmable array logic and programmable logic arrays, flash memory.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 08 |

**Recommended Books-**

1. Albert Paul Malvino, "Principles of Digital Electronics", 4th Edition, Tata McGraw Hill, 1991.
2. Anand Kumar, "Fundamentals of Digital Circuits", 3rd Edition, Prentice Hall of India, 2014.
3. D.P. Kothari and J.S. Dhillon, Digital Circuits and Design, Pearson Education, 2016
4. Morris Mano, "Digital Logic and Computer Design", 2nd Edition, Prentice Hall of India, 1991.
5. R.P. Jain, Modern digital Electronics, Tata McGraw Hill, 1999.
6. R.J.Tocci, Neal S. Widmer and Gregory L.Moss, "Digital Systems: Principles and Applications", 11th Edition, Prentice Hall of India, 2010
7. S. Floyd Thomas, "Digital Fundamentals", 10th Edition, Pearson Education, 2013.
8. Natarajan, Dhanasekharan. Fundamentals of Digital Electronics. Germany, Springer International Publishing, 2020.
9. Zappa, Franco. Digital Electronics: Logic Gates and Families, Design Methodologies, Combinational Logic and Devices, Sequential Networks and Components, Memories. Italy, Società Editrice Esculapio, 2019.
10. Prof. Goutam Saha, Digital Electronic Circuits, IIT Kharagpur, NPTEL course code 108105132.

**Subject Code : PCEE-522**
**Title of the course : Electrical Machines – II (Asynchronous Machines and Synchronous Machines)**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 1 | 0 | 4 | 4 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1:** interpret the basics of Induction machine, rotating field, torque etc.
**CO 2:** know the construction, operation and characteristics of poly-phase induction machine.
**CO 3:** simulate the steady-state and transient state performance of synchronous machines to identify performance measures.
**CO 4:** analyse the operation, use and characteristics of induction generator.
**CO 5:** select the appropriate AC motor for different large power application

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **Cos** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL2, BL4 | BL6 | BL4 | BL5 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cos | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | - | - | 2 | 3 | 3 | 2 | 2 |
| CO2 | 3 | 3 | 2 | 3 | - | 3 | - | - | - | 2 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | - | 1 | 2 | 3 | - | 2 | 3 |
| CO4 | 3 | 2 | 2 | 3 | - | 2 | - | 1 | 1 | 2 | 2 | 2 | 2 | 1 |
| CO5 | 3 | 1 | 3 | 3 | 2 | 3 | - | - | 2 | 2 | 2 | - | 3 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Fundamentals of AC Machine Windings:** Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single turn coil, full-pitch coils, concentrated winding, distributed winding, winding distribution factor, magnetic field produced by a single winding - fixed current and alternating current pulsating fields produced by spatially displaced windings, revolving magnetic field. | 08 |
| | **Induction Machines:** Construction, types (squirrel cage and slip-ring), principle of | 10 |

| | | |
|---|---|---|
| | operation, torque and slip, torque slip characteristics, equivalent circuit. phasor diagram, torque speed characteristics (variation of rotor and stator resistances), methods of starting, braking and speed control for induction motors. effect of varying supply voltage and frequency on torque and speed, starting torque, full load torque and max. torque, , torque speed curves and operating region, power loss and efficiency, rotor output, synchronous watt, max power output, induction motor testing, double cage and deep bar motor. | |
| | **Single-Phase Induction Motors:** Constructional features, double revolving field theory, equivalent circuit, determination of parameters. split-phase starting methods and applications | 06 |
| **Unit -2** | **Synchronous Machines:** Constructional features, cylindrical rotor synchronous machine and salient pole machine, principle of operation, EMF equation, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. operating characteristics of synchronous machines, V-curves. Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division. | 18 |
| | **Special Machine:** Introduction to various PM motors, BLDC and PMSM, reluctance motor, Hysteresis motor, linear induction motor (LIM).<br><br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 06 |

**Recommended Books-**

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. E.H. Langsdorff, Principles of A.C. Machines, Tata McGraw Hill, 2004.
3. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
4. P.S. Bimbhra, Electrical Machinery, 7th Edition, Khanna Publishers, 2011.
5. R. Krishnan, "Permanent Magnet Synchronous and Brushless DC motor Drives", CRC Press, 2009.
6. Bakshi, Uday A., and Bakshi, Mayuresh V.. Electrical Machines - II. India, UNICORN Publishing Group, 2020.
7. Boldea, Ion. Induction Machines Handbook: Steady State Modeling and Performance. United States, CRC Press, 2020.
8. Prof. Tapas Kumar Bhattacharya, Electrical Machines – II by IIT Kharagpur, NPTEL course.

**Subject Code : PCEE-523**
**Title of the course : Signals and Systems**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 1 | 0 | 4 | 4 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1:** interpret signals, convolution and learn various properties.
**CO 2:** understand noise, interference and their reduction methods.
**CO 3:** be conversant in Fourier Series, Fourier Transform along with their basic properties
**CO 4:** analyze sampling, restructuring, sampling theorem, aliasing, digital signal processing.
**CO 5:** study Laplace and Z-transform, their basic properties, region of convergence, inverse Laplace and Z-transform, rational system functions.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL2 | BL1, BL2 | BL4 | BL1, BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | 2 | 3 | 2 | 2 | - | - | 1 | 2 | 2 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | - | 1 | 2 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | - | 3 | 3 | 1 | - | - | 2 | 3 | - | 3 | 3 |
| CO4 | 3 | 3 | 2 | - | 3 | 3 | - | 1 | - | 2 | 3 | 1 | 2 | 3 |
| CO5 | 3 | 2 | 2 | 2 | 2 | - | - | - | 1 | 2 | 3 | - | 2 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Introduction to Signals and Systems:** Signals and systems as seen in everyday life, and in various branches of engineering and science. signal properties: periodicity, absolute integrability, determinism and stochastic character. some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. system properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, | 10 |

| | | |
|---|---|---|
| | realizability. examples. | |
| | **Behaviour of Continuous And Discrete-Time LTI Systems:** Impulse response and step response, convolution, input-output behaviour with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. system representation through differential equations and difference equations. state-space representation of systems. state-space analysis, multi-input, multi-output representation. state transition matrix and its role. periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response. | 14 |
| **Unit-2** | **Fourier, Laplace and Z - Transforms:** Fourier series representation of periodic signals, waveform symmetries, calculation of Fourier coefficients. Fourier transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. the discrete time Fourier transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's theorem. review of the laplace transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, laplace domain analysis, solution to differential equations and system behaviour. the z-transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis. | 12 |
| | **Sampling and Reconstruction:** The sampling theorem and its implications. spectra of sampled signals. reconstruction: ideal interpolator, zero-order hold, first-order hold. aliasing and its effects. relation between continuous and discrete time systems. introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems. | 12 |

**Recommended Books:**

1. V. Oppenheim, A. S. Willsky and S. H. Nawab, “Signals and systems”, Prentice Hall India, 1997.
2. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson, 2006.
3. Hsu, Hwei P.. Schaum's Outline of Signals and Systems, Fourth Edition. Greece, McGraw-Hill Education, 2019.
4. S. Haykin and B. V. Veen, “Signals and Systems”, John Wiley and Sons, 2007.
5. Alan Victor Oppenheim Prentice Hall India Learning Private Limited; 2 editions, 1997.
6. Hsu, Hwei Piao. Signals and Systems. United States, McGraw Hill Education, 2020.
7. Prof. Aditya K. Jagannatham, Principles of Signals and Systems, IIT Kanpur course code 108104100.

**Subject Code : PCEE-524**
**Title of the course : Analog and Digital Electronics Lab**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 0 | 0 | 2 | 1 | 2 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1:** basic knowledge about digital components.
**CO 2:** implement the Boolean algebra, coding-decoding, Multiplexing, de-multiplexing etc.
**CO 3:** acquire knowledge to rectify various digital circuits with logics.
**CO 4:** practical approach for designing of digital.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **Cos** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL1 | BL3 | BL2 | BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 1 | - | - | 2 | 2 | - | - | 1 | - | 2 | 2 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 2 | 3 | - | - | 1 | 2 | 2 | 2 | 2 | 2 | 1 |
| CO3 | 3 | 2 | 2 | - | 3 | 3 | - | - | 1 | - | 3 | 2 | 2 | 1 |
| CO4 | 3 | 2 | 2 | 2 | 2 | 3 | 1 | - | 3 | 3 | 3 | - | 3 | 3 |

To understand the practicability of **Digital Electronics**, the list of experiments is given below to be performed (at least 10) in the laboratory.

1. Verification of the truth tables of TTL gates.
2. Verify the NAND and NOR gates as universal logic gates.
3. Design and verification of the truth tables of Half and Full adder circuits.
4. Design and verification of the truth tables of Half and Full subtractor circuits.
5. Verification of the truth table of the Multiplexer 74150.
6. Verification of the truth table of the De-Multiplexer 74154.
7. Design and test of an S-R flip-flop using NOR/NAND gates.
8. Verify the truth table of a J-K flip-flop (7476)
9. Verify the truth table of a D flip-flop (7474)
10. Operate the counters 7490, 7493.
11. Design of 4-bit shift register (shift right).

**Subject Code : PCEE-525**

**Title of the course : Electrical Machines – II Laboratory**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 0 | 0 | 2 | 1 | 2 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1:** interpret the basics of Induction machine, rotating field, torque etc.

**CO 2:** know the construction, operation and characteristics of poly-phase induction machine.

**CO 3:** simulate the steady-state and transient state performance of synchronous machines to identify performance measures.

**CO 4:** analyse the operation, use and characteristics of induction generator.

**CO 5:** select the appropriate AC motor for different large power application

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL2 | BL6 | BL4 | BL5 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | - | - | 2 | 2 | 2 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 2 | 3 | 2 | - | 1 | 1 | 2 | 2 | 2 | 2 | 1 |
| CO3 | 3 | 3 | - | 3 | 3 | 3 | 1 | 1 | - | 3 | 3 | 2 | 2 | 1 |
| CO4 | 3 | 3 | 2 | - | 2 | - | - | - | 2 | 3 | 3 | - | 3 | 3 |
| CO5 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | - | - | 2 | 2 | 2 | 3 | 2 |

To understand the practicability of **Electrical Machines**, the list of experiments is given below to be performed (at least 10) in the laboratory.

1. To perform no-load and blocked–rotor tests on three-phase Induction motor to obtain equivalent circuit. Parameters and to draw circle diagram.
2. To perform load-test on three-phase Induction motor and to plot torque versus speed characteristics.
3. To study star- delta starters physically and a) to draw electrical connection diagram b) to start the three-phase Induction motor using it. c) to reverse the direction of three-phase Induction motor.
4. To start a three-phase slip –ring induction motor by inserting different levels of resistance in the rotor circuit and to plot torque –speed characteristics.
5. To perform no-load and blocked–rotor test on single-phase Induction motor and to determine the parameters of equivalent circuit.

6. To perform load –test on single-phase. Induction motor and plot torque –speed characteristics.
7. To perform no load test on the alternator and draw open circuit characteristics (OCC).
8. To perform short circuit test on the alternator and draw short circuit characteristics (SCC).
9. To perform load test on the alternator and draw terminal voltage characteristics
10. To find voltage regulation of an alternator by zero power factor (ZPF.) method.
11. To draw "V" and inverted "V" curves of synchronous motor.
12. To measure negative sequence and zero sequence reactance of Synchronous Machines.
13. Parallel operation of three phase alternators using • Dark lamp method • Two-Bright and one dark lamp method.

**Subject Code : TPID-521**

**Title of the course : Industrial Training**

| L | T | P | Credits | Load |
|---|---|---|---|---|
| - | - | - | 1 | Two weeks(80hrs.) |

**Course Outcomes:**

After successful completion of industrial training, the students should be able to

**CO 1**: implement the project requiring individual and teamwork skills.

**CO 2:** correlate the theoretical concepts with the real life industrial environment.

**CO 3:** gather and analyze the scientific information.

**CO 4:** communicate their work effectively through writing and presentation.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL3 | BL4 | BL4 | BL5 |

| CO/PO Mapping:(Strong (3) / Medium (2) / Weak (1) indicates strength of correlation) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | COs Program Outcomes (POs)/ Program Specific Outcomes (PSOs) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 3 | 1 |
| CO2 | 3 | - | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | - | 2 | 3 | 1 |
| CO3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 2 | 3 | 3 |
| CO4 | 1 | 1 | 1 | 1 | - | - | - | 1 | 1 | 3 | 2 | 3 | 1 | 3 |

Objective of the Program is to

1. enrich the students with a basic understanding of Electrical Engineering, towards developing a holistic perspective to understand various practical issues and latest trends in the field.
2. familiarize and provide "hands on" training experience with the requisite simulation, design, and analytical tools and techniques.
3. achieve a long-term goal of transforming themselves into a brilliant blend of theoretician and practicing engineer.
4. introduce the way of troubleshooting various engineering faults related to respective fields.
5. make the students able to present work in written, oral or formal presentation formats.

**Subject Code : PCEE-611**
**Title of the course : Electrical Power System -1**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** understand the concepts of power system components.
**CO 2:** evaluate fault currents for different types of faults.
**CO 3:** understand the generation of over-voltages and insulation coordination.
**CO 4:** understand basic protection schemes.
**CO 5:** understand concepts of HV dc power transmission and renewable energy generation.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL5 | BL2 | BL2 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | 2 | - | 2 | - | 2 | - | 1 | 2 | - | 3 | 2 | 1 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 1 | - | - | 3 | - | 2 | 3 | 1 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 1 | 1 | - | 3 | 2 | 2 | 3 | 3 | 2 |
| CO4 | 3 | 2 | 3 | - | 1 | - | - | 1 | 3 | - | 2 | 3 | 2 | 1 |
| CO5 | 3 | 3 | 3 | 2 | 2 | 2 | - | - | 3 | 3 | 3 | 2 | 2 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Basic Concepts:** Evolution of power systems and present-day scenario. structure of a power system: bulk power grids and micro-grids. generation: conventional and renewable energy sources. distributed energy resources. energy storage. transmission and distribution systems: line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). synchronous grids and asynchronous (DC) interconnections. review of three-phase systems. analysis of simple three-phase circuits. power transfer in AC circuits and reactive power. | 08 |
| | **Power System Components:** Overhead transmission lines and cables: electrical and magnetic fields around conductors, corona. parameters of lines and cables. capacitance and inductance calculations for simple configurations. travelling-wave equations. sinusoidal steady state representation of lines: short, medium and long lines. power transfer, voltage profile and | 16 |

| | | |
|---|---|---|
| | reactive power. characteristics of transmission lines. surge impedance loading. series and shunt compensation of transmission lines. transformers: three-phase connections and phase-shifts. three-winding transformers, autotransformers, neutral grounding transformers. tap-changing in transformers. transformer parameters. single phase equivalent of three-phase transformers. synchronous machines: steady-state performance characteristics. operation when connected to infinite bus. real and reactive power capability curve of generators. typical waveform<br>under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. loads: types, voltage and frequency dependence of loads. per-unit system and per-unit calculations. | |
| **Unit-2** | **Over-Voltages and Insulation Requirements:** Generation of over-voltages: lightning and switching surges. protection against over-voltages, insulation coordination. propagation of surges. voltages produced by traveling surges. Bewley diagrams | 07 |
| | **Fault Analysis and Protection Systems:** Method of symmetrical components (positive, negative and zero sequences). balanced and unbalanced faults. representation of generators, lines and transformers in sequence networks. computation of fault currents. neutral grounding. switchgear: types of circuit breakers. attributes of protection schemes, back-up protection. protection schemes (over-current, directional, distance protection, differential protection) and their application. | 10 |
| | **Introduction to DC Transmission & Renewable Energy Systems:** DC transmission systems: line-commutated converters (LCC) and voltage source converters (VSC). LCC and vsc based dc link, real power flow control in a dc link. comparison of ac and dc transmission. solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. wind energy systems: power curve of wind turbine. fixed and variable speed turbines. permanent magnetic synchronous generators and induction generators. power electronics interfaces of wind generators to the grid.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 07 |

**Recommended Books-**

1. J. Grainger and W. D. Stevenson, “Power System Analysis”, McGraw Hill Education,1994.
2. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill Education, 1995.
3. A. R. Bergen and V. Vittal, “Power System Analysis”, Pearson Education Inc., 1999.
4. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis”, McGraw Hill Edu.2003.
5. B. M. Weedy, B. J. Cory, N. Jenkins and G. Strbac, “Electric Power Systems”, Wiley, 2012.
6. Kani, A. Nagoor. Power System Analysis. India, CBS Publishers & Distributors, 2020.
7. Shertukde, Hemchandra Madhusudan. Power Systems Analysis Illustrated with MATLAB and ETAP. United Kingdom, CRC Press, 2019.

**Subject Code : PCEE-612**
**Title of the course : Control Systems**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 1 | 0 | 4 | 4 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** acquire the basic knowledge of control engineering and its scope.
**CO2:** analyze the mathematical model of a system and determine the response of different order systems for standard inputs.
**CO3:** solve the steady state and transient analysis of a system for standard inputs.
**CO4:** analyze the stability analysis of a system.
**CO5:** be competent to analyze closed loop control design problems and design compensating networks.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL4 | BL5 | BL4 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | 3 | 2 | 2 | - | - | - | 1 | 2 | 2 | 2 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 3 | - | 1 | 2 | - | 3 | - | 3 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | - | - | 3 | 3 | 2 | 2 | 3 | 2 |
| CO4 | 2 | 2 | 2 | 2 | 3 | 3 | - | 1 | 2 | - | 3 | - | 3 | 2 |
| CO5 | 3 | 3 | 3 | 2 | 2 | 2 | - | - | 3 | 3 | - | 2 | 3 | 2 |

| Unit | Main Topics and Course Outline | Hour(s) |
|---|---|---|
| Unit-1 | **Introductory Concept:** plant, systems, servomechanism, regulating systems, disturbances, open loop control system, closed loop control system, linear and non- linear systems, time variant and invariant, continuous and sampled-data control systems, concept of feedback, block diagrams. | 06 |
| | **Modelling:** Formulation of equation of linear electrical, mechanical, thermal, pneumatic and hydraulic system, electrical mechanical analogies, use of Laplace transforms, transfer function, concept of state variable modelling, block diagram representation, block diagram simplification for linear systems, signal flow graphs, mason gain rules. | 12 |
| | **Time Domain Analysis:** Typical test-input signals, transient and steady state response of the first order systems, second order systems and higher order systems, transient response | 12 |

| | | |
|---|---|---|
| | analysis with MATLAB, steady state error and coefficients, pole zero location and stability, Routh-Hurwitz criterion. | |
| **Unit-2** | **Root Locus Analysis:** Introduction, general rules for constructing Root Loci, root-locus plots, positive feedback systems, conditionally stable systems, root loci for systems with transport lag. | 06 |
| | **Frequency Domain Analysis:** Introduction, the sensing and digitalizing function in machine vision bode diagrams, plotting bode diagrams with MATLAB, polar plots, drawing Nyquist plots with MATLAB, Log-Magnitude- versus-phase plots, Nyquist stability criterion, stability analysis, relative stability, closed-loop frequency response of unity-feedback systems. | 08 |
| | **Compensation:** Necessity of compensation, series and parallel compensation, compensating networks, application of lag and lead compensation. | 05 |
| | **Control Components:** Proportionate, derivative and integral control, feedback control, Error detectors, tacho-generators, potentiometers and synchro's, AC and DC servomotors. Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 05 |

**Recommended Books-**

1. C. Kuo Benjamin, "Automatic Control System", 8th Edition, John Wiley & Sons,2002.
2. J.J. Distefano, A.R. Stuberud and I.J. Williams, "Schaum's Outlines of Theory and problems of Feedback and control Systems", 2nd Edition., Tata McGrawHill,2007.
3. J. Nagrath and M. Gopal, "Control System Engineering", New Age,2009.
4. K. Ogata, "Modern Control Engineering", 5th Edition, Prentice Hall (PHI),2010.
5. Richard C.Dorf and Robert H. Bishop,"ModernControlSystem",12th Edition, Addison–Wesley, Pearson, New Delhi,2011.
6. Control System Theory. N.p., Technical Publications, 2020.
7. Ayyagari, Ramakalyan, and Raol, Jitendra R.. Control Systems: Classical, Modern, and AI-Based Approaches. United Kingdom, CRC Press, 2019.

**Subject Code : PCEE-613**
**Title of the course : Control System Lab.**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 0 | 0 | 2 | 1 | 2 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** analyse the performance of various controllers
**CO2:** analyse the mathematical model of a system and determine the response of different order systems.
**CO3:** solve the steady state and transient analysis of a system.
**CO4:** study the characteristics of AC Servomotor, Synchro-Transmitter and Receiver.
**CO5:** be competent in using MATLAB or LAB VIEW software to analyse closed loop control design problems
**CO6:** design compensating networks.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | | |
|---|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 | CO6 |
| **BLs** | BL2, BL4 | BL4 | BL4 | BL2 | BL6 | BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | 2 | - | 1 | 1 | - | - | 1 | 1 | 2 | 2 | 3 | 1 |
| CO2 | 3 | 2 | 2 | - | 2 | - | - | 1 | 1 | - | 2 | 3 | 1 | 1 |
| CO3 | 2 | 2 | 3 | 1 | 2 | - | - | - | - | 1 | 2 | 2 | 2 | 1 |
| CO4 | 1 | 2 | 2 | 3 | 2 | 1 | - | - | 1 | - | 2 | 3 | 1 | 1 |
| CO5 | 1 | 2 | 3 | 1 | 2 | - | 1 | - | - | 1 | 2 | 2 | 2 | 1 |
| CO6 | 1 | 2 | 3 | - | 2 | 1 | - | - | 1 | 1 | 2 | 3 | 2 | 2 |

To understand the practicability of **Control System**, the list of experiments is given below to be performed (at least 10) in the laboratory.

1. To determine response of first order and second order systems for step input for various values of constant 'K' using linear simulator unit and compare theoretical and practical results.
2. To analyse and compare the performance of P, PI and PID temperature controller for an oven.
3. To study and calibrate temperature using resistance temperature detector (RTD)
4. To design Lag, Lead and Lag-Lead compensators using Bode plot.
5. To study DC position control system
6. To obtain output V/S input characteristics of synchro-transmitter and receiver.
7. To determine speed-torque characteristics of an A.C. servomotor.
8. To analyse the performance of servo voltage stabilizer at various loads using load bank.

9. To study behaviour of separately excited dc motor in open loop and closed loop conditions at various loads.
10. To implement PID Controller

**Software based experiments** (Use MATLAB, LABVIEW software etc.)

11. To determine time domain response of a second order system for step input and obtains performance parameters.
12. To convert transfer function of a system into state space form and vice-versa.
13. To plot root locus diagram of an open loop, transfer function and determine range of gain 'k' for stability.
14. To plot a Bode diagram of an open loop transfer function.
15. To draw a Nyquist plot of an open loop transfers functions and examine the stability of the closed loop system.

**Subject Code : PCEE-621**
**Title of the course : Electrical and Electronics Measurements**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** acquire knowledge of the characteristics of measuring instruments and their classification.
**CO2:** be conversant in construction, working of measuring instruments and their proficient use.
**CO3:** acquire knowledge various methods of electrical parameters measurement.
**CO4:** be competent to handle various instruments for the measurement of electrical quantities.
**CO5**: demonstrate Cathode Ray Oscilloscope (CRO) and recorders.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL2 | BL2 | BL2, BL3 | BL3 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | 1 | 2 | 2 | 2 | - | - | 1 | 3 | 2 | 1 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | - | - | 2 | 2 | - | 2 | 2 |
| CO3 | 2 | 3 | 3 | 2 | 1 | 2 | - | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| CO4 | 1 | 2 | - | - | 2 | 2 | 1 | - | 1 | - | - | 2 | 2 | 2 |
| CO5 | 2 | 3 | 2 | 3 | 1 | - | - | 1 | - | 1 | - | 1 | 1 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Introduction Basic Indicating Instruments:** Elements of generalized measurement system, characteristics of instruments, accuracy, precision, sensitivity, range span. Classification of analog instruments, concept of deflecting, controlling and damping torque, control and damping system, construction and principle of moving iron and moving coil instruments, construction of ammeter and voltmeter and extension of their range and Electro dynamometer instruments, Principles of operation Permanent Magnet Moving Coil (PMMC) ohm meters and their types, Digital voltmeters and multimeters | 10 |
| | **Measurement of Resistance:** Potentiometers: basic principles, types of potentiometers, their functions and applications, classification of resistance, measurement of low, medium and high resistance, ammeter-voltmeter method, wheat-stone bridge, digital LCR meter for measurement of resistance, insulation tester. | 08 |

| | | |
|---|---|---|
| | **Measurement of Various Electrical Quantities:** Measurement of current, voltage, power, energy and power factor, phase time and frequency | 08 |
| **Unit-2** | **Bridges:** Sources and detectors, general equation for bridge balance, measurement of resistance, inductance, capacitance, mutual inductance, frequency etc. by Wheatstone, Kelvin, Maxwell, Hay's, Anderson, Owen, Heaviside, Campbell, Schering, Wien bridges. Bridge sensitivity. Errors, Wagner Earthing Device. | 08 |
| | **Magnetic Measurements:** Flux meter, B-H curve, Hysteresis loop, permeameters, AC testing of magnetic materials, separation of iron losses, iron loss measurement by wattmeter and bridge methods. | 06 |
| | **Instrument Transformers:** Theory and construction of current transformer (CT) and potential transformer (PT), ratio and phase angle errors and their minimization, characteristics of CT's. &PT's., testing of CT's & PT's. | 04 |
| | **Cathode Ray Oscilloscope (CRO) and Recorders:** Construction and working of cathode ray tube (CRT), block diagram of CRO, measurement of voltage and frequency with CRO, basic CRO circuit, measurement of voltage, current, phase, frequency, time period. dual track oscilloscope, specification of a CRO and their significance, front panel controls. Study of various recorders.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 06 |

**Recommended Books-**

1. A.K. Sawhney and Puneet Sawhney, A course in Electrical and electronic measurement and instrumentation, Dhanpat Rai and Co., 2012.
2. J.B Gupta, A Course in Electronic and Electrical Measurements & Instrumentation, S K Kataria and Sons, 1996.
3. R. Prasad, Electronic Measurements and Instrumentation, S. Chand, 1984.
4. Alan S Morris, Measurement and Instrumentation Principles, 3rd/e, Butterworth Hienemann, 2001.
5. S. Tumanski , Principle of Electrical Measurement, Taylor & Francis, 2006.
6. Narasimha, S., and Srinivas, G N. Electrical and Electronic Measurements and Instrumentation. India, BS Publications, 2018.
7. Bakshi, Uday A., and Bakshi, Late Ajay V.. Electrical Measurements and Instrumentation. India, UNICORN Publishing Group, 2020.

**Subject Code : PCEE-622**
**Title of the course : Electrical Power Systems-II**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 1 | 0 | 4 | 4 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** use numerical methods to analyze a power system in steady state.
**CO2**: understand stability constraints in a synchronous grid.
**CO3:** understand methods to control the voltage, frequency and power flow.
**CO4:** understand the monitoring and control of a power system.
**CO5**: understand the basics of power system economics.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL3, BL4 | BL2 | BL2 | BL2 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 3 | 1 | 2 | 3 | 2 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 3 | - | 1 | - | 3 | - | 2 | 2 | 1 | 1 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 1 | - | 1 | 2 | 2 | - | 2 | 1 | 1 |
| CO4 | 3 | 1 | 3 | 3 | 3 | - | 1 | - | 3 | 2 | 2 | 2 | 2 | 1 |
| CO5 | 2 | 2 | 3 | 2 | 3 | 1 | - | - | 3 | - | 3 | 3 | 2 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Power Flow Analysis:** Review of the structure of a power system and its components. analysis of power flows: formation of bus admittance matrix. real and reactive power balance equations at a node. load and generator specifications. application of numerical methods for solution of nonlinear algebraic equations – Gauss Seidel and Newton-Raphson methods for the solution of the power flow equations. computational Issues in large-scale power systems. | 08 |
| | **Stability Constraints in Synchronous Grids:** Swing equations of a synchronous machine connected to an infinite bus. power angle curve. description of the phenomena of loss of synchronism in a single-machine infinite bus system following a disturbance like a three--phase fault. analysis using numerical integration of swing equations (using methods like forward Euler, Runge-Kutta 4th order methods), as well as the equal area criterion. impact of stability constraints on power system operation. effect of generation rescheduling and series compensation of transmission lines on stability. | 08 |

| | | |
|---|---|---|
| **Unit-2** | **Control of Frequency and Voltage:** Turbines and speed-governors, frequency dependence of loads, droop control and power sharing. automatic generation control. generation and absorption of reactive power by various components of a power system. excitation system control in synchronous generators, automatic voltage regulators. shunt compensators, Static VAR compensators and STATCOMs. tap changing transformers. power flow control using embedded dc links, phase shifters and | 12 |
| | **Monitoring and Control:** Overview of energy control centre functions: SCADA systems. phase measurement units and wide-area measurement systems. state-estimation. system security assessment. normal, alert, emergency, extremis states of a power system. contingency analysis. preventive control and emergency control. | 08 |
| | **Power System Economics and Management:** Basic pricing principles: generator cost curves, utility functions, power exchanges, spot pricing. electricity market models (vertically integrated, purchasing agency, whole-sale competition, retail competition), demand side-management, transmission and distributions charges, ancillary services. regulatory framework.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 12 |

**Recommended Books:**

1. J. Grainger and W. D. Stevenson, “Power System Analysis”, McGraw Hill Education, 1994.
2. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill Education, 1995.
3. A.R. Bergen and V. Vittal, “Power System Analysis”, Pearson Education Inc., 1999.
4. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis”, McGraw Hill Education, 2003
5. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, “Electric Power Systems”, Wiley, 2012.
6. D. P. Kothari and I. J. Nagrath, “Power System Engineering”, McGraw Hill Education, 2019
7. Patrick, Dale R., and Fardo, Stephen W.. Electrical Power Systems Technology, Third Edition. United Kingdom, River Publishers, 2020.
8. Optimization Methods Applied to Power Systems II. Switzerland, MDPI - Multidisciplinary Digital Publishing Institute, 2021.

**Subject Code : PCEE-623**
**Title of the course : Power System Laboratory**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 0 | 0 | 2 | 1 | 2 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** analyze the performance of transmission line
**CO 2:** analyze the performance of various protective devices like relays and circuit breakers.
**CO 3:** be competent in use of static and digital relays.
**CO 4:** analyse the radial feeder performance.
**CO 5:** learn about different types of faults on transmission line.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL4 | BL4 | BL2, BL3 | BL4 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | 2 | 3 | 2 | 1 | - | - | 3 | - | 3 | 3 | 2 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | - | 1 | - | 3 | 3 | 2 | 2 | 1 | 1 |
| CO3 | 3 | 3 | 2 | 3 | 2 | 1 | 1 | - | 2 | 2 | - | - | 1 | 1 |
| CO4 | 3 | 2 | 3 | 3 | 2 | - | - | - | 3 | 2 | - | 2 | 2 | 1 |
| CO5 | 3 | 2 | 3 | 2 | - | 1 | - | - | 3 | - | 3 | 3 | 2 | 2 |

To understand the practicability of Electrical Power System. At least 10 experiments are to be performed out of the following list:

1. To analyse the performance of a transmission line and compute ABCD parameters.
2. To study the Ferranti effect in long transmission line using transmission line model.
3. To study the voltage distribution along the length of transmission line.
4. To study and plot the characteristics of IDMT over current and earth fault relay.
5. To study and plot the characteristics of IDMT under voltage and over voltage relay.
6. To determine the sequence impedance of a three phase transformer.
7. To determine the sequence impedance of an alternator by fault analysis and power angle characteristics.
8. To determine the phase sequence of 3 phase circuit using RC and two lamp method.
9. To analyse the radial feeder performance when
   (a) Fed at one end. (b) Fed at both ends
10. To study the performance of directional over current relay.

11. To study protection schemes used for feeder protection.
12. To study protection schemes used for transformer protection.
13. To study protection schemes used for generator protection.
14. To test the performance of Air circuit breaker under over current and earth fault conditions.
15. To test the performance of Vacuum circuit breaker under over current and earth fault conditions.

**Subject Code : TPID-621**
**Title of the course : Industrial Training**

| L | T | P | Credits | Load |
|---|---|---|---|---|
| - | - | - | 2 | Two weeks(80hrs.) |

**Course Outcomes:**
After successful completion of industrial training, the students should be able to
**CO 1**: implement the project requiring individual and teamwork skills.
**CO 2:** correlate the theoretical concepts with the real life industrial environment.
**CO 3:** gather and analyze the scientific information.
**CO 4:** communicate their work effectively through writing and presentation.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL3 | BL4 | BL4 | BL5 |

| CO/PO Mapping:(Strong (3) / Medium (2) / Weak (1) indicates strength of correlation) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | COs Program Outcomes (POs)/ Program Specific Outcomes (PSOs) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | - | 2 | 2 | - | - | 3 | 3 | 3 | - | 3 | 3 | 1 |
| CO2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 1 | 3 | 3 | 1 |
| CO3 | 3 | 3 | 2 | 3 | - | 2 | 2 | - | 1 | 3 | - | 3 | 3 | 3 |
| CO4 | 1 | - | 1 | 1 | 1 | - | - | - | 1 | 3 | 1 | 3 | 1 | 3 |

Objective of the Program is to

1. enrich the students with a basic understanding of the Electrical Engineering, towards developing a holistic perspective to understand various practical issues and latest trends in the field
2. familiarize and provide "hands on" training experience with the requisite simulation, design, and analytical tools and techniques
3. achieve a long-term goal of transforming themselves into a brilliant blend of theoretician and practicing engineer
4. introduce the way of troubleshooting various engineering faults related to respective fields.
5. make the students able to present work in written, oral or formal presentation formats.

**Subject Code : PCEE-711**
**Title of the course : Microprocessors and Microcontrollers**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 1 | 0 | 4 | 4 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** acquire the knowledge about history, architecture of 8, 16, 32 & 64-bit Microprocessor.
**CO 2:** know about 8085 microprocessor, architecture and timing diagrams.
**CO 3:** develop the programming applications of microprocessors.
**CO 4:** interfacing of peripheral devices with 8085.
**CO 5:** be conversant in 8051 microcontrollers, its architecture and program.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL2 | BL3 | BL3 | BL2, BL3, BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | - | - | 3 | 2 | - | - | 1 | - | 3 | 2 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 2 | - | - | - | - | 2 | 2 | 2 | 2 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 2 | - | - | 1 | 1 | 2 | 3 | 2 | 3 | 2 |
| CO4 | 3 | 2 | 3 | 2 | - | 1 | 1 | - | - | 2 | - | 2 | 3 | 2 |
| CO5 | 3 | 2 | 3 | 2 | 3 | 3 | - | 1 | 2 | 3 | 2 | 3 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Introduction to Microprocessors:** Types of computers, microprocessor evolution and types, CPU operation and terminology, idea of 8- bit, 16-bit, 32-bit and 64- bit Microprocessors from Intel, Motorola and Zilog and their comparisons. | 08 |
| | **Introduction to 8-Bit Microprocessor:** 8085 Microprocessor architecture and pin diagram of 8085, ALU timing and control unit, registers, data and address bus, timing and control signals, fetch and execute operations, Instruction format, addressing techniques, classification of instructions instruction and data flow, system timing diagram, transition state diagram, system configuration for 8085. | 08 |

| | | |
|---|---|---|
| | **8085 Programming**: Instruction types, classification of instructions, addressing modes, instruction format, over view of instruction set, writing assembly language programs, data manipulations, fixed point arithmetic, data conversion, sorting numeric data, look-up table and time delays, concepts of stack, interrupts, interrupt service subroutine. | 08 |
| **Unit-2** | **Interfacing Memory with 8085**: Memory interfacing, I/O interfacing – memory mapped and peripheral mapped I/O, Data transfer schemes – programmed, interrupt driven and direct memory access (DMA) data transfers, block diagram representation, control word formats, modes. | 08 |
| | **Peripheral Devices:** Interfacing of 8255A PPI, 8251 USART, 8254 programmable interval timer, 8259a programmable interrupt controller and 8279 with 8085, block diagram representation, control word formats, modes, simple programs. | 08 |
| | **Introduction to Embedded Systems:** The 8051 Architecture: Introduction, 8051 micro-controller hardware, input/ output, pins, ports and circuits, external memory, counters and timers, serial data input/ output, interrupts.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 08 |

**Recommended Books-**

1. A.K. Ray and K.M. Bhurchandi, "Advanced Microprocessors and Peripherals", 2nd Edition, Tata McGraw Hill, 2006.
2. B. Bray, "The INTEL Microprocessors 8086/88, 80186, 286, 386, 486, Pentium Pro Processors, Architecture, Programming and Interfacing", 8th Edition, Prentice Hall (India), 2008.
3. V. Douglas Hall, "Microprocessors and interfacing: Programming and Hardware", 2nd Edition, Tata McGraw Hill, 2007.
4. Gaonkar, S. Ramesh, "Microprocessor Architecture, Programming and Applications with the 8085", 5th Edition, Penram International, 2011.
5. B. Ram, "Fundamentals of Microprocessors and Microcomputers", 8th Edition, Dhanpat Rai & Sons, 2012.
6. Digital Electronics and Introduction to Microprocessors and Microcontrollers. India, UNICORN Publishing Group, 2020.

**Subject Code : PCEE-712**
**Title of the course : Power Electronics and Drives**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** explain the need and role of power electronic switches, their properties and characteristics.
**CO 2:** analysis and design of AC-DC converters, AC-AC converters and DC-DC converters.
**CO 3:** analysis and design of inverters which consist of half and full bridge, single and three phase etc.
**CO 4:** know topologies of voltage source inverters.
**CO 5:** study of power electronics with drives.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL2, BL4 | BL2, BL4 | BL2 | BL2, BL3 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 2 | - | 2 | 2 | - | - | 2 | 1 | 1 | 3 | 1 | 2 |
| CO2 | 3 | 2 | 3 | 2 | 3 | 3 | - | - | 2 | 1 | 3 | 2 | 1 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | - | - | 2 | 1 | 3 | 2 | 2 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 1 | - | - | 2 | 1 | 3 | 2 | 2 | 1 |
| CO5 | 3 | 2 | 3 | 3 | 2 | 2 | - | - | 3 | 1 | 3 | 2 | 2 | 1 |

| Unit | Main Topics and Course outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Basics Concepts:** Introduction to relevant standards, general specification and need of switching and role of power electronic switches, properties and characteristics of various power electronic switches i.e. power diode, Thyristor, gate turn off (GTO), power transistor, power metal oxide semiconductor field effect transistor (MOSFET), insulated gate bipolar transistor (IGBT), metal oxide semiconductor (MOS) controlled Thyristor, static induction devices, gate triggering circuit and protection circuits, selection criteria of these switches for various applications, basic concept of phase control. | 09 |
| | **Phase Controlled Converters:** Single phase half wave and full wave controlled rectifiers with R, RL, RLC and RLE load, with and without freewheeling diode, three phase half controlled and full controlled converter, different loads, with and without freewheeling diode, effect of source impedance, principle of dual converters. | 09 |
| | **Chopper:** Chopper classification, operation, control strategies, chopper configurations, thyristor chopper circuit, Jone's chopper, Morgan chopper, A.C. chopper, source filter, | 06 |

| | | |
|---|---|---|
| | multiphase chopper, fly back converters. | |
| **Unit-2** | **Cycloconverter:** Basic principle, single phase to single phase cycloconverter, three phase half wave cycloconverter, control circuits, comparison between cycloconverter and DC link converter | 09 |
| | **DC-AC Converters (Inverters):** Classification, single phase half bridge voltage source inverter, single phase full bridge inverter voltage control of single phase inverter PWM inverter. | 06 |
| | **Drives:** Control of DC drives, scheme for DC motor speed control, single phase separately excited drive, single phase series DC motor drives, DC chopper drives, PLL control of DC drives principle of operation , speed control of induction motor , stator voltage control, variable frequency control, rotor resistance control , drive selection.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 09 |

**Recommended Books:**

1. B. K. Bose, Modern Power Electronics and AC drives, 1st edition, PHI, 2001
2. M. H. Rashid, Power Electronics Handbook, Academic Press, 2001
3. N. Mohan, Undeland & Robbins, Power Electronics: Converters, Applications and Design, 3rd edition, John Wiley and Sons, 2002
4. Nihal Kularatna, Power Electronics design handbook, 1st edition, Newnes Publishers, 1998
5. R. W. Erickson, Fundamentals of Power Electronics, 2nd edition, Kluwer Academic Publishers, 2000.
6. M.D. Singh, K.B. Khanchandani, Power Electronics, McGraw Hill,2007.
7. Bose, Bimal K.. Power Electronics and Motor Drives: Advances and Trends. Netherlands, Elsevier Science, 2020.
8. Joshi, Dheeraj, et al. Power Electronics, Drives, and Advanced Applications. United States, CRC Press, 2020.

**Subject Code : PCEE-713**
**Title of the Course : Microprocessor and Microcontroller Lab**.

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 0 | 0 | 2 | 1 | 2 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** create program for addition, subtraction of numbers in decimal, hexadecimal and BCD system.
**CO2:** write program to perform multiplication, division of 8-bit numbers, obtain largest, smallest number from an array and arrange data in ascending, descending order.
**CO3:** write a program to convert hexadecimal number into ASCII number and vice versa.
**CO4:** develop a program to initiate and check transmission, reception of 8251, interfacing of 8253 timer and verify operation of 8253 in six modes.
**CO5:** create interfacing of DAC with 8085 for generation of square, sawtooth and triangular waves, implement serial communication through RS-232 C port.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL2, BL4 | BL2, BL4 | BL3, BL4 | BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | 1 | - | 3 | 2 | - | - | 1 | - | 3 | 2 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 2 | - | - | - | - | 2 | 2 | 2 | 2 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 2 | 1 | - | - | 1 | 2 | 2 | 2 | 3 | 2 |
| CO4 | 3 | 2 | 3 | 2 | - | 1 | - | - | 1 | 2 | - | 2 | 3 | 2 |
| CO5 | 3 | 2 | 3 | 2 | 3 | 3 | - | - | 2 | 3 | 2 | 3 | 3 | 2 |

To understand the practicability of **Microprocessor and Applications**, the list of experiments to be performed in the laboratory is given below

1. Write a program using 8085 Microprocessor for Decimal, Hexadecimal addition and subtraction of two Numbers.
2. Write a program using 8085 Microprocessor for addition and subtraction of two BCD numbers.
3. To perform multiplication and division of two 8-bit numbers using 8085.
4. To find the largest and smallest number in an array of data using 8085 instruction set.
5. To write a program to arrange an array of data in ascending and descending order.
6. To convert given Hexadecimal number into its equivalent ASCII number and vice versa using 8085instruction set.
7. To write a program to initiate 8251 and to check the transmission and reception of character.
8. To interface 8253 programmable interval timer to 8085 and verify the operation of 8253 in six different modes.
9. To interface DAC with 8085 to demonstrate the generation of square, saw tooth and triangular wave.
10. Serial communication between two 8085 through RS-232 C port.

**Subject Code : PCEE-714**
**Title of the course : Power Electronics and Drives**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 0 | 0 | 2 | 1 | 2 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** explain the need and role of power electronic switches, their properties and characteristics.
**CO 2:** familiarize design and operation of AC-DC converters, AC-AC converters and DC-DC converters.
**CO 3:** train to handle half and full bridge, single and three phase convertors.
**CO 4:** understand characteristics and applications of industrial drives.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL2 | BL2, BL3, BL4 | BL2, BL3 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 2 | 1 | 2 | 1 | - | - | 2 | - | 1 | 3 | 1 | 2 |
| CO2 | 3 | 2 | 3 | 2 | 3 | 1 | 1 | - | 2 | 1 | 2 | 2 | 1 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | - | - | 1 | - | 1 | 2 | 2 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 2 | - | - | - | 2 | 1 | 3 | 2 | 2 | 1 |

To understand the practicability of **Power Electronics and applications**, the list of experiments is given below to be performed (at least 10) in the laboratory.

1. To draw V-I Characteristics of SCR
2. To draw V-I Characteristics of DIAC
3. To draw V-I Characteristics of TRIAC
4. To measure the values of IG, IL, & IH for a given SCR
5. To study the operation of a single-phase half-controlled bridge converter
6. To study the operation of a single-phase full-controlled bridge converter
7. To study the operation of a three-phase half controlled bridge converter
8. To study the operation of a three-phase full-controlled bridge converter
9. To study the operation of a single-phase half bridge inverter
10. To study the operation of Jones and Morgan's Chopper circuits.
11. Control the speed of DC Motor Drive using chopper.
12. V/f control of Induction motor drive.
13. PWM control of Induction Motor drive.
14. To start and control the speed of PMBLDC.
15. To start and control speed of PMSM.

**Subject Code : PRIE-711**
**Title of the course : Project Stage I and Seminar**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| - | - | 4 | 2 | 4 |

**Course Outcomes:**
After successful completion of industrial training, the students should be able to
**CO 1**: communicate their work effectively through writing and presentation.
**CO 2:** use research based knowledge in the latest area of technology.
**CO 3:** engage in independent and life-long learning.
**CO 4:** implement the project requiring individual and teamwork skills.
**CO 5:**carry out design calculations and implementations in the area of project.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2, BL3 | BL3 | BL3 | BL3 | BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | - | - | 2 | 2 | - | - | 3 | 3 | - | 3 | 3 | 1 |
| CO2 | 3 | 2 | 3 | 3 | 3 | 3 | - | - | 2 | 3 | 1 | 3 | 3 | 1 |
| CO3 | 3 | 3 | 2 | 3 | 2 | 2 | - | - | - | 3 | - | 3 | 3 | 3 |
| CO4 | 3 | 1 | 1 | - | - | 1 | - | - | 1 | 3 | 1 | 3 | 1 | 3 |
| CO5 | 3 | 2 | 3 | 3 | 2 | 3 | - | - | 2 | - | 1 | 3 | 3 | 1 |

Objective of the Program is to
1. familiarize the students with the outside professional environment.
2. make the students able to use the resources for the given problem/assignment.
3. update the students with modern trends of Electrical engineering.
4. develop own opinions, particularly on issues, based on critical and reasonable. approach to the information available.
5. make the students able to present work in written, oral or formal presentation formats.

**Subject Code : INID-721**
**Title of the course : Internship in Industry**

| L | T | P | Credits | Load |
|---|---|---|---|---|
| - | - | - | 6 | 4months(640hrs.) |

**Course Outcomes:**
After successful completion of industrial training, the students should be able to
**CO 1**: correlate the theoretical concepts with the real-life industrial environment.
**CO 2:** implement strategies like time management, multi-tasking in an industrial setup.
**CO 3:** gather and analyze the scientific information.
**CO 4:** communicate their work effectively through writing and presentation.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL2, BL3 | BL3 | BL4 | BL5 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | - | 2 | 2 | - | - | - | 2 | - | - | 3 | 3 | 1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | - | 2 | 2 | 3 | 3 | 1 | 3 | 3 | 1 |
| CO3 | 3 | - | 2 | 3 | 2 | - | 1 | 2 | - | 3 | 2 | 3 | 3 | 3 |
| CO4 | 3 | 1 | 1 | - | 1 | 1 | - | 2 | - | 3 | 2 | 3 | 1 | 3 |

Objective of the Program is to

1. provide possible opportunities to learn, understand and sharpen the real time technical /managerial skills required at the job.
2. familiarize and provide "hands on" training experience with the requisite simulation, design, and analytical tools and technique.
3. achieve a long-term goal of transforming themselves into a brilliant blend of theoretician and practicing engineer.
4. understand the social, economic and administrative considerations that influence the working environment of industrial organizations.
5. make the students able to present work in written, oral or formal presentation formats.

**Subject Code : PRIE-721**
**Title of the course : Project Stage II**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| - | - | 12 | 6 | 12 |

**Course Outcomes:**
After successful completion of industrial training, the students should be able to
**CO 1**: implement the project requiring individual and teamwork skills.
**CO 2:** update recent knowledge in the area of project.
**CO 3:** carry out design calculations and implementations in the area of project.
**CO 4:** communicate their work effectively through writing and presentation.
**CO 5:** handle professional responsibilities and respect for ethics.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2, BL3 | BL2 | BL3 | BL3 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 1 | 3 | 1 | 3 | 3 | 1 |
| CO4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 3 | 1 | 3 |
| CO5 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |

The objective of Project Work is to enable the student to take up investigative study in the broad field of Electrical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis or two/three students in a group, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work.

The assignment normally includes

1. survey and study of published literature on the assigned topic.
2. working out a preliminary approach to the problem relating to the assigned topic.
3. conducting preliminary analysis/modelling/simulation/experiment/design/feasibility.
4. preparing a written report on the study conducted for presentation to the department.
5. final seminar, as oral presentation before a departmental committee including external expert.

**Subject Code : OEEE-611A**
**Title of the course : Electrical Circuits**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** apply network theorems for the analysis of electrical circuits.
**CO2:** obtain the transient and steady-state response of electrical circuits.
**CO3:** analyse circuits in the sinusoidal steady-state (single-phase and three-phase).
**CO4:** analyse two port circuit behavior.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL3 | BL5 | BL4 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | 1 | - | - | 1 | - | - | 3 | - | 1 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 3 | - | - | - | - | 1 | - | - | 3 | 2 | 1 |
| CO3 | 3 | 2 | 2 | 3 | 1 | - | - | - | 2 | 1 | - | 2 | 3 | 1 |
| CO4 | 3 | 3 | 2 | - | 1 | 1 | - | - | 2 | 1 | 1 | 3 | 2 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Network Theorems:** Superposition theorem, Thevenin theorem, norton theorem, maximum power transfer theorem, reciprocity theorem, compensation theorem. analysis with dependent current and voltage sources. Node and Mesh Analysis. concept of duality and dual networks. | 08 |
| | **Solution of First and Second Order Networks:** Solution of first and second order differential equations for Series and parallel R-L, R-C, RLC circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response. | 08 |
| | **Sinusoidal Steady State Analysis:** Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. three-phase circuits. mutual coupled circuits, dot convention in coupled circuits, ideal transformer. | 08 |
| Unit-2 | **Electrical Circuit Analysis Using Laplace Transforms:** Review of Laplace Transform, Analysis of electrical circuits using Laplace transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions. transfer function representation. poles and zeros. frequency response (magnitude and phase plots), series and | 12 |

| | | |
|---|---|---|
| | parallel resonances | |
| | **Two Port Network and Network Functions:** Two port networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks. | 12 |

**Recommended Books:**

1. M. E. Van Valkenburg, "Network Analysis", Prentice Hall, 2006.
2. D. Roy Choudhury, "Networks and Systems", New Age International Publications,1998.
3. W. H. Hayt and J. E. Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education, 2013.
4. C. K. Alexander and M. N. O. Sadiku, "Electric Circuits", McGraw Hill Education, 2004.
5. K. V. V. Murthy and M. S. Kamath, "Basic Circuit Analysis", Jaico Publishers, 1999.
6. ELECTRICAL CIRCUIT ANALYSIS. N.p., PHI Learning Pvt. Ltd., 2018.
7. Ergul, Ozgur. Introduction to Electrical Circuit Analysis. Germany, Wiley, 2017.

**Subject Code : OEEE-611B**
**Title of the course : Electrical Engineering Materials**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** acquire an in depth knowledge about the conducting materials.
**CO2:** acquire of knowledge of properties of dielectric and insulator materials.
**CO3:** understand the selection of magnetic materials for electrical devices.
**CO4:** recognize the material for economically and eco-friendly fabrication of electrical equipment.
**CO5:** acquire the knowledge of materials for special applications in electrical equipment.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL1, BL2 | BL2 | BL1, BL2 | BL1, BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | 1 | - | 1 | 2 | 1 | - | - | 1 | - | 3 | 3 | 1 |
| CO2 | 3 | 1 | 2 | - | - | 2 | 1 | - | - | 1 | - | 3 | 3 | 1 |
| CO3 | 2 | - | 1 | 1 | - | 2 | - | 1 | 1 | 1 | 1 | 3 | 3 | 1 |
| CO4 | 2 | - | 1 | - | 1 | 2 | 3 | 2 | 1 | 1 | 1 | 3 | 3 | 1 |
| CO5 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | - | 1 | 1 | 1 | 3 | 3 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Conducting Materials:** Review of metallic conduction on the basis of free electron theory. Fermi-Dirac distribution – variation of conductivity with temperature and composition, materials for electric resistors-general electric properties; material for brushes of electrical machines, lamp filaments, fuses and solder. | 08 |
| | **Insulating Materials:** Inorganic materials (mica, glass, porcelain, asbestos), organic materials (paper, rubber, cotton silk fibre, wood, plastics and Bakelite), resins and varnishes, liquid insulators (transformer oil) gaseous insulators (air, SF6 and nitrogen) and ageing of insulators. | 08 |
| | **Dielectric:** Dielectric, polarization under static fields- electronic ionic and dipolar polarizations, behaviour of dielectrics in alternating fields, Factors influencing dielectric strength and capacitor materials. Insulating materials, complex dielectric constant, dipolar | 08 |

| | | |
|---|---|---|
| | relaxation and dielectric loss. | |
| **Unit-2** | **Magnetic Materials:** Classification of magnetic materials- origin of permanent magnetic dipoles, ferromagnetism, hard and soft magnetic materials, magneto materials used in electrical machines, instruments and relays. | 08 |
| | **Semiconductors Materials:** Semiconductors: Mechanism of conduction in semiconductors, density of carriers in intrinsic semiconductors, the energy gap, types of semiconductors. Hall effect, compound semiconductors, basic ideas of amorphous and organic semiconductors. | 08 |
| | **Materials for Special Applications:** Materials for solar cells, fuel cells and battery. materials for coatings for enhanced solar thermal energy collection and solar selective coatings, cold mirror coatings, heat mirror coatings, antireflection coatings, sintered alloys for breaker and switch contacts. | 08 |

**Recommended Books-**

1. R. K. Rajput, "Electrical Engineering Materials", Laxmi Publications, 2006
2. B. P. Pokharel, Nava Raj Karki, "Electrical Engineering Materials", Alpha Science International, 2007
3. C. S. Indulkar, "An Introduction to Electrical Engineering Materials", S. Chand Publishing, 2008
4. A. J. Dekker, "Electrical Engineering Materials", Prentice-Hall, 1959
5. G. K. Banerjee, "Electrical and Electronics Engineering material", PHI, 2015
6. A Course in Electrical Engineering Materials. India, Laxmi Publications Pvt Limited, 2009.

**Subject Code : OEEE-611C**
**Title of the course : Renewable Energy Source**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** knowledge of India's power scenario, power system structure and related agencies.
**CO2:** acquire the knowledge of solar power utilization.
**CO3:** gain the knowledge of electric power generation from wind power.
**CO4:** acquire the knowledge of system of transfer of electrical power from renewable source.
**CO5:** **k**now the harnessing power from bio and other renewable sources.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL1, BL2 | BL2 | BL1, BL2 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | 1 | - | 1 | 2 | 1 | - | 2 | 1 | - | 2 | 2 | 1 |
| CO2 | 3 | 3 | 3 | 1 | 2 | 3 | - | 2 | 2 | - | 3 | 2 | 3 | 3 |
| CO3 | 2 | 3 | 3 | - | 2 | 3 | 3 | - | 3 | 1 | - | 2 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 1 | 2 | - | 3 | 2 | 3 | 3 |
| CO5 | 2 | 2 | - | - | 1 | 2 | 3 | 2 | 3 | 1 | 3 | 2 | 1 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Renewable Energy (RE) Sources:** Environmental consequences of fossil fuel use, importance of renewable sources of energy, sustainable design and development, types of RE sources, limitations of RE sources, present Indian and international energy scenario of conventional and RE sources. | 10 |
| | **Wind Power Generation:** wind surveys, basic principles of wind energy conversion, wind data and energy estimation, site selection, basic components of wind energy conversion systems (WECS), wind machines, schemes of wind power generation and control, different types of WPPs and maintenance | 14 |
| **Unit-2** | **Solar Power Generation:** Solar radiations, solar energy collectors; flat plate and focusing type, energy balance equation and collector efficiency, photovoltaic cells, MPPT techniques, applications of solar energy; solar pumping, solar furnace, solar cooking solar green houses | 10 |

| | | |
|---|---|---|
| | **Biomass Energy:** Introduction-Bio mass resources –energy from bio mass: conversion process-biomass cogeneration-environmental benefits. geothermal energy: basics, direct use, geothermal electricity. mini/micro hydro power: classification of hydropower schemes, classification of water turbine, turbine theory, essential components of hydroelectric system. | 7 |
| | **Other Energy Sources:** Tidal Energy: Energy from the tides, barrage and non barrage tidal power systems. wave energy: energy from waves, wave power devices. ocean thermal energy conversion (OTEC)- hydrogen production and storage- fuel cell: principle of working-various types – construction and applications. energy storage system- hybrid energy systems. Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 7 |

**Recommended Books:**

1. A. Chakrabarti, M. L. Soni, P. V. Gupta and Bhatnagar U. S., Power System Engineering, Dhanpat Rai & Co. Pvt Ltd, 2009.
2. B. R. Gupta, Generation of Electrical Energy, S. Chand Publishing, New Delhi, 2011
3. C. A. Simon, Alternate Source of Energy, Rowman and Little Field Publishers Inc., 2007.
4. G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers, 2005.
5. S. Rao and B.B. Parulekar, Energy Technology: Non-Conventional, Renewable and Conventional, Khanna Publishers, 2005.
6. V.A. Venikov and E.V. Putyain, Introduction to Energy Technology, Mir Publishers, 1990.
7. Tiwari, Gopal Nath, and Kumar Mishra, Rajeev. Advanced Renewable Energy Sources. United Kingdom, Royal Society of Chemistry, 2015.
8. Nadeem, Farwa, et al. Renewable and Alternative Energy Resources. Netherlands, Elsevier Science, 2021.

**Subject Code : OEEE-611D**
**Title of the course : Electrical Machines**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1: Discuss** construction and operation of D.C. machine & transformers.
**CO 2:.Describe** the construction and principle of induction machine
**CO 3: Describe** the different types of single phase induction motors
**CO 4: Construct and illustrate** the concept of synchronous machines

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL2 | BL2 | BL1, BL2 | BL2, BL3 |

| CO/PO Mapping:(Strong(S) / Medium(M) / Weak(W) indicates strength of correlation) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Programme Outcomes (POs)/ Program Specific Outcomes (PSOs) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 2 | 2 | - | 1 | 1 | - | - | - | 2 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 2 | 2 | 1 | - | 1 | - | 2 | - | 2 | 3 | 3 | 2 |
| CO3 | 3 | 1 | 2 | 1 | 2 | - | - | - | 2 | 2 | - | 3 | 2 | 2 |
| CO4 | 3 | 3 | 3 | 3 | - | 2 | 1 | - | 3 | 2 | 2 | 3 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **D.C. machines:** Working principle, construction of DC machines, , Electro Motive Force (E.M.F.) and torque equations, armature reaction, c methods of excitation of DC. Generators and their characteristics, working principle characteristics, starting of shunt and series motor, starters, speed control methods: field and armature control,. | 10 |
| | **Transformers:** Working principle, construction of single phase transformer, EMF equation, phasor diagrams on no-load and on loaded conditions, open circuit and short circuit tests, , voltage regulation and efficiency,. | 10 |

| | | |
|---|---|---|
| **Unit-2** | **Induction machines:** Construction, Types (squirrel cage and slip-ring), torque and slip, torque slip characteristics, losses and efficiency, methods of starting, starting torque, full load torque and maximum torque, , power loss and efficiency, rotor output, synchronous watt, max power output. | 10 |
| | **Single Phase Induction Motors**<br>Basic principle of single phase induction motor, Split phase induction motor, construction and working of shaded pole single induction motor, Construction and working of capacitor start single phase induction motor, types of capacitor motors, principle of operation of reluctance motor, hysteresis motor, Construction operation of universal moto, applications | 09 |
| | **Synchronous machines:** Constructional features, principle of operation, cylindrical rotor synchronous machine generated EMF, voltage regulation, salient pole machine construction. Principle of synchronous motor, starting methods, applications.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 09 |

**Recommended Books:**

1. A E Fitzgerald, C Kingsley and S D Umans, "Electric Machinery", 6th edition, McGraw Hill, 2005.
2. E H Langsdorff, "Principles of D.C. machines", McGraw Hill, 2013.
3. I J Nagrath and D P Kothari, "Electrical Machines", 5th edition, McGraw Hill Education, 2018.
4. M G Say, Alternating Current Machines, 3rd edition, CBS, 2002.
5. P S Bimbhra, "Electric Machines", 2nd edition, Khanna Publishers, 2017.
6. Ashfaq Husain, "Electric Machines", 3rd edition, Dhanpat Rai & Co. (P) Ltd., 2020

**Subject Code : OEEE-612A**
**Title of the course : Energy Conservation and Practice**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** acquire an in depth knowledge about the energy conservation
**CO2:** know how energy can be conserved and managed in industries.
**CO3:** acquire a comprehensive idea on tariffs in Transmission &Distribution systems.
**CO4:** be conversant in utilization and effects of energy on Environment.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| CO's | CO1 | CO2 | CO3 | CO4 | CO5 |
| BL | BL1,BL2 | BL3,BL5 | BL4 | BL1,BL2 | BL5,BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO2 |
| CO1 | 3 | 2 | - | - | - | 2 | 3 | - | 2 | 1 | 1 | 2 | 2 | 1 |
| CO2 | 3 | 3 | 2 | 2 | 1 | 3 | - | 1 | 3 | 2 | 1 | 3 | 3 | 2 |
| CO3 | 2 | 3 | 2 | 3 | - | 3 | - | - | 3 | - | - | 3 | 3 | 2 |
| CO4 | 3 | 3 | 2 | - | - | 3 | - | - | 3 | 2 | 2 | 3 | 3 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Energy Conservation:** Energy Scenario in India, Renewable and non-renewable energy sources. principles of energy conservation, motivation for energy conservation and its importance energy conservation planning, Energy security, energy strategy for the future, Energy Conservation Act 2001 and its features. Agenda for sustainable development. | 10 |
| | **Energy Conservation in Electrical Installation system:** Technical losses, caused and measure to reduce by controlling $I^2$ R losses, optimizing distribution voltage, balancing phase currents. Significance of Power Factor in energy conservation. Energy conservation equipment's: Maximum Demand controller, KVAR Controller, Automatic Power Factor controller (APFC)), automatic star delta convertor. Energy Conservation in Lighting System: Replacing Lamp Sources, using energy efficient luminaries, using light controlled gears, installation of separate servo stabilizer for | 14 |

| | | |
|---|---|---|
| | lighting, periodic survey an adequate maintenance programs. Energy conservation techniques in fans, Electronic regulators and amorphous core transformer. | |
| **Unit-2** | **Cogeneration and Tariff:** Definition and scope, topping and bottoming cycles, benefits, industries suitable for cogeneration, agricultural uses of waste heat, use of power plant reject heat for waste water treatment, integrated energy system, potential of cogeneration in India. Need of tariff, Types of Tariff structure LT and HT, Special tariffs, time off day tariff, peak off day tariff, power factor tariff, maximum demand tariff, load factor tariff and availability based tariff. Application of tariff system to reduce energy bill. | 14 |
| | **Environmental Aspects of Electric Energy Generation:** environment and its quality, man's right to modify environment, energy and environment, air pollution, stack emissions, cooling tower impacts, aquatic impacts, nuclear plant impacts, hydro-plant impacts, social and economic impacts.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 10 |

**Recommended Books-**

1. Bureau of Energy Efficiency, Bureau of Energy Efficiency Handbooks.
2. C.L.Wadhwa, “Generation Distribution & Utilization of Electrical Energy”, New Age international,1989
3. G Petrecca , “Industrial Energy Management: Principles & applications”, Kluwer Academic Publisher,1993
4. Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2003
5. James Larminie, John Lowry, “Electric Vehicle Technology Explained, 2nd Edition, Wiley, 2003.
6. Yinliang Xu and Wei Zhang, "Distributed Energy Management of Electrical Power Systems" Wiley-IEEE Press, 2021

**Subject Code : OEEE-612B**
**Title of the course : Energy Auditing and Management**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** acquire an in depth knowledge about the energy management and auditing
**CO2:** recognize how energy can be conserved and managed in industries.
**CO3:** acquire a comprehensive idea on tariffs in Transmission &Distribution systems.
CO4: be competent to handle the Energy auditing procedure.
CO5: be competent to handle the Energy Management project
.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| CO's | CO1 | CO2 | CO3 | CO4 | CO5 |
| BL | BL1,BL2 | BL3 | BL4 | BL6 | BL5,BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 1 | 1 | - | 2 | - | - | 2 | 1 | 2 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | - | 3 | 3 | 1 | - | 2 | - | 3 | 3 | 3 | 2 |
| CO3 | 2 | - | 2 | - | 2 | 3 | 2 | - | 2 | 2 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 2 | 2 | 2 | 2 | 3 | - | 3 | 2 | - | 3 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | - | 3 | 3 | - | - | 3 | 2 | 3 | 2 | 2 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Energy Audit Methodology and Instruments:** General philosophy, need of energy audit, economics of implementation of energy optimization projects, it's constraints, barriers and limitations, report-writing, preparations and presentations of energy audit reports, post monitoring of energy conservation projects, MIS, case-studies / report studies of energy audits. guidelines for writing energy audit report, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations, Instruments for audit and monitoring energy and energy savings, types and accuracy, | 12 |
| | **Energy Conservation in Electrical Installation system:** Technical losses, caused and measure to reduce by controlling $I^2$ R losses, optimizing distribution voltage, balancing | 12 |

| | | |
|---|---|---|
| | phase currents. Significance of Power Factor in energy conservation. Energy conservation equipment's: Maximum Demand controller, KVAR Controller, Automatic Power Factor controller (APFC)), automatic star delta convertor. Energy Conservation in Lighting System: Replacing Lamp Sources, using energy efficient luminaries, using light controlled gears, installation of separate servo stabilizer for lighting, periodic survey an adequate maintenance programs. Energy conservation techniques in fans, Electronic regulators and amorphous core transformer. | |
| **Unit-2** | **Energy Management:** Need of energy management. definition and objective of energy management, general principles of energy management, energy management skills, energy management strategy in respect of electrical power plants. | 8 |
| | **Cogeneration and Tariff:** Definition and scope, topping and bottoming cycles, benefits, industries suitable for cogeneration, agricultural uses of waste heat, use of power plant reject heat for waste water treatment, integrated energy system, potential of cogeneration in India. Need of tariff, Types of Tariff structure LT and HT, Special tariffs, time off day tariff, peak off day tariff, power factor tariff, maximum demand tariff, load factor tariff and availability based tariff. Application of tariff system to reduce energy bill. | 10 |
| | **Financial Management**: 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)<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 6 |

**Recommended Books**

1. C.L. Wadhwa, "Generation Distribution & Utilization of Electrical Energy", New Age international,1989.
2. G Petrecca, "Industrial Energy Management: Principles & applications", Kluwer Academic Publisher,1993
3. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003
4. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 2nd Edition, Wiley, 2003.
5. Bureau of Energy Efficiency India, "General Aspects of Energy Management and Energy Audit", Bureau of Energy Efficiency India, 2015
6. Shapiro, Ian M, "Energy audits and improvements for commercial buildings : a guide for energy managers and energy auditors" John Wiley & Sons, 2016

**Subject Code : OEEE-612C**
**Title of the course : Utilization of Electrical Energy**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** acquire the knowledge of different type of electrical heating and welding methods.
**CO 2:** understand the construction and working principle of control devices, need.
**CO 3:** fulfill the objective of utilization application of electrical energy in electrochemical process.
**CO 4:** know about various electrical circuits used in refrigeration, air conditioning and water Coolers.
**CO 5:** analyze the various methods of illumination and electric traction system.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL2 | BL3 | BL2 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | 2 | 2 | 2 | - | - | - | 3 | 2 | 2 | - | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 2 | - | - | 3 | 2 | 2 | 2 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 2 | 2 | 2 | - | - | 3 | - | - | - | 3 | 3 |
| CO4 | 2 | 2 | 3 | 2 | 2 | 2 | - | - | 3 | 2 | 2 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | - | - | 3 | 2 | 2 | - | 3 | 3 |

| Unit | Main Topics &Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Electric Heating:** Introduction, advantages of electrical heating, heating methods like resistance heating – direct resistance heating, indirect resistance heating, electric ovens, different types of heating materials, temperature control of resistance furnaces, design of heating element, domestic water heaters and other heating appliances. induction heating – principle, core type and coreless induction furnaces. electric arc heating – direct and indirect arc heating, arc furnaces. dielectric heating –principle and applications in various industrial fields. | 06 |
| | **Electric Welding:** Welding methods–electric arc wielding and resistance wielding. modern wielding techniques, ultrasonic wielding and laser welding, welding transformer. | 06 |
| | **Electrochemical Process:** Need of electro-deposition. applications of Faraday's laws in electro-deposition. factors governing electro-deposition. objectives of electroplating. equipment's and accessories for electroplating plant, electroplating on non-conducting material, principle of anodizing and its applications. | 05 |

| | | |
|---|---|---|
| | **Control Devices:** Construction and working of push button, limit switches, float switches pressure switches, contactors, thermostats, timers, relays application of above devices in automatic water level controller, reverse forward operation of 3-ph induction motor, temperature controller in electric furnace, air compressor circuit. | 07 |
| **Unit-2** | **Electrical Circuits of Appliances:** Used in refrigeration, air conditioning & water coolers: - brief description of vapour compression refrigeration cycle. description of electrical circuits used in –refrigerator, air conditioner, water cooler | 10 |
| | **Illumination:** Definitions of flux, solid angle, luminous intensity, illumination, luminous efficiency, depreciation factor, coefficient of utilization, space to height ratio, reflection factor; laws of illumination. calculation of number of light points for interior illuminations; calculation of illumination at different points, simple design problems and illumination schemes, indoor and outdoor illumination level. different sources of light: differences in incandescent and discharge lamps – their construction and characteristics.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 14 |

**Recommended Books-**

1. Manak Bhavan, "IEC standards for Lamps, Lighting Fixtures and Lighting", 2nd Edition, New Delhi, 2000.
2. C. L. Wadhwa, "Generation, Distribution and Utilization of Electrical Energy", Eastern Wiley Ltd, 1989.
3. E. O. Taylor and V.V.L. Rao, "Utilization of Electrical Energy", Orient Longman,1971.
4. J.B Gupta, "Utilization of Electric Power and Electric Traction" S. K Kataria & Sons,2009.
5. G. C. Garg, "Utilization of Electric Power & Electric Traction", Khanna Publishers, New Delhi,2003.
6. Bureau of Energy Efficiency India, "Energy Efficiency in Electrical Utilities", 2015

**Subject Code : OEEE-612D**
**Title of the course : Electric Vehicles Technology**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** understand the models to describe hybrid vehicles and their performance.
**CO 2:** identify the different possible ways of energy storage.
**CO 3:** understand the different strategies related to energy storage systems.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | |
|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 |
| **BLs** | BL2 | BL1, BL2 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | - | - | 2 | 2 | 1 | - | - | 2 | - | - | 2 | 2 |
| CO2 | 3 | - | 2 | - | 2 | 2 | 2 | - | 2 | 2 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | - | 2 | 2 | 3 | 2 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Introduction:** Conventional vehicles: basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.<br>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.<br>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. | 10 |
| | **Electric Trains:** 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.<br>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, configuration and control of permanent magnet motor drives, configuration and control of switch reluctance motor drives, drive system efficiency. | 14 |

| | | |
|---|---|---|
| **Unit-2** | **Energy Storage:** 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, super capacitor based energy storage and its analysis, flywheel based energy storage and its analysis, hybridization of different energy storage devices.<br>sizing the drive system: matching the electric machine and the internal combustion engine (ICE), sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, communications, supporting subsystems | 12 |
| | **Energy Management Strategies:** 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, implementation issues of energy management strategies.<br>case studies: design of a hybrid electric vehicle (HEV), design of a battery electric vehicle (BEV).<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 12 |

**Recommended Books-**

1. C. Mi, M. A. Masrur and D. W. Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical perspectives”, John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.
3. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
4. T. Denton, “Electric and Hybrid Vehicles”, Routledge, .
5. K T Chau, " Emerging Technologies for Electric and Hybrid Vehicles", 2018

**Subject Code : OEEE-621A**
**Title of the course : Microprocessors and applications**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**

After successful completion of course, the students should be able to
**CO 1:** acquire the knowledge about history, architecture of 8, 16, 32 & 64-bit Microprocessor.
**CO 2:** know about 8085 microprocessor, its architecture and timing diagrams.
**CO 3:** develop the programming applications of microprocessors.
**CO 4:** interfacing of peripheral devices with 8085.
**CO 5:** be conversant in 8051 microcontroller, its architecture and program.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL2 | BL3 | BL3, BL6 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | - | - | 3 | 2 | - | - | 1 | - | 3 | 2 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 2 | - | 1 | 1 | - | 2 | 2 | 2 | 2 | 3 | 1 |
| CO3 | 3 | 1 | 2 | 3 | 2 | - | - | 1 | 1 | 2 | 3 | 2 | 3 | 1 |
| CO4 | 3 | 2 | 3 | 2 | - | 1 | - | - | 1 | 2 | - | 2 | 3 | 1 |
| CO5 | 3 | 2 | 3 | 2 | 3 | 3 | - | - | 2 | 3 | 2 | 3 | 3 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Introduction to Microprocessors:** Types of computers, microprocessor evolution and types, CPU operation and terminology, idea of 8- bit, 16-bit, 32-bit and 64- bit Microprocessors from Intel, Motorola and Zilog and their comparisons. | 08 |
| | **Introduction to 8-Bit Microprocessor:** 8085 microprocessor architecture and pin diagram of 8085, ALU timing and control unit, registers, data and address bus, timing and control signals, fetch and execute operations, Instruction format, addressing techniques, classification of instructions instruction and data flow, system timing diagram, transition state diagram, system configuration for 8085. | 08 |

| | | |
|---|---|---|
| | **8085 Programming**: Instruction types, classification of instructions, addressing modes, instruction format, over view of instruction set, writing assembly language programs, data manipulations, fixed point arithmetic, data conversion, sorting numeric data, look-up table and time delays, concepts of stack, interrupts, interrupt service subroutine. | 08 |
| **Unit-2** | **Interfacing Memory with 8085**: Memory interfacing, I/O interfacing – memory mapped and peripheral mapped I/O, data transfer schemes – programed, interrupt driven and direct memory access(DMA) data transfers, block diagram representation, control word formats, modes | 12 |
| | **Peripheral Devices:** Interfacing of 8255A PPI, 8251 USART, 8254 programmable interval timer, 8259a programmable interrupt controller and 8279 with 8085,block diagram representation, control word formats, modes, simple programs.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 12 |

**Recommended Books**

1. B. Ram., "Fundamentals of Microprocessors and Microcomputers", Dhanpat Rai & Sons,1998.
2. B. Bray Barry, "The INTEL Microprocessors 8086/88, 80186, 286, 386, 486, Pentium Pro Processors, Architecture, Programming and Interfacing", Prentice Hall(India).
3. V. Hall Douglas, "Microprocessors and interfacing: Programming and Hardware", Tata McGraw Hill, 2007.
4. Gaonkar and S. Ramesh, "Microprocessor Architecture, Programming and Applications with the 8085", Penram International.
5. A.K. Ray and K.M. Bhurchandi, "Advanced Microprocessors and Peripherals", Tata McGraw Hill.
6. Ayala, J. Kenneth "The 8051 Microcontroller - Architecture, Programming and Application", Penram International Publication
7. M. Mahalakshmi, "8051 Microcontroller Architecture, Programming and Application", Laxmi Publications, 2012.
8. M. A. Mazidi, J. G. Mazidi, "The 8051 Micro-controller & Embedded System", Pearson Education, 2008.
9. Peatman, B. John, "Design with Micro Controller", Tata McGraw Hill,1988.
10. A. Nagoor Kani, "8086 Microprocessors and its Applications", 2013

**Subject Code : OEEE-621B**
**Title of the course : Elements of Power System**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** acquire knowledge of basic transmission system.
**CO 2:** line parameter calculations.
**CO 3:** gain the knowledge of mechanical components of line
**CO 4**: performance and losses awareness.
**CO 5**: acquire the knowledge of cable materials.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL5 | BL2 | BL4 | BL2 |

CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation):

| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | 1 | 1 | - | 3 | - | - | 2 | 2 | - | 3 | 1 | 1 |
| CO2 | 3 | 2 | 2 | - | 1 | 3 | - | - | 3 | - | 3 | 2 | 2 | 2 |
| CO3 | 3 | 2 | 2 | 1 | 2 | 2 | - | - | 3 | 1 | 3 | 2 | 3 | 2 |
| CO4 | 3 | 2 | 2 | - | 2 | 3 | 1 | - | 3 | - | 2 | - | 3 | 1 |
| CO5 | 3 | 3 | 3 | 1 | 2 | 2 | 1 | - | 3 | 3 | 3 | 2 | 3 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Supply System:** Introduction to transmission and distribution systems, comparison between DC and AC systems for transmission and distribution, comparison of cost of conductors, choice of working voltage for transmission & distribution, economic size of conductors- Kelvin's law, radial and mesh distribution networks, voltage regulation. | 06 |
| | **Components of Line:** Conductor materials; solid, stranded, ACSR, hollow and bundle conductors, different types of supporting structures for overhead lines. elementary ideas about transmission line construction and erection. stringing of conductors, spacing, sag and clearance from ground, overhead line insulators, concept of string efficiency. | 12 |
| | **Transmission Line Parameters:** Introduction to line parameters, resistance Inductance, concept of G.M.D., Inductance of three phase line, use of bundled conductor, transposition of power lines, capacitance of 1-phase and 3-phase lines. effect of earth on capacitance of conductors. | 10 |

| | | |
|---|---|---|
| **Unit-2** | **Performance of Transmission Lines:** Representation of short transmission line, medium length line (nominal T and II circuits) long length line by hyperbolic equations and equivalent T & II circuits. power flow through transmission lines, ABCD constants, voltage regulation. | 12 |
| | **Underground Cables:** Classification of cables based upon voltage and dielectric material, insulation resistance and capacitance of single core cable, dielectric stress, capacitance of 3 core cables, method of laying, heating effect, maximum current carrying capacity, cause of failure, comparison with overhead transmission lines.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 08 |

**Recommended Books-**

1. J. Grainger and W. D. Stevenson, “Power System Analysis”, McGraw Hill Education,1994.
2. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill Education, 1995.
3. A. R. Bergen and V. Vittal, “Power System Analysis”, Pearson Education Inc., 1999.
4. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis”, McGraw Hill Edu.2003.
5. B. M. Weedy, B. J. Cory, N. Jenkins and G. Strbac, “Electric Power Systems”, Wiley, 2012.
6. Sadhu, Pradip Kumar, "Elements Of Power Systems" Crc Press, 2017

**Subject Code : OEEE-621C**
**Title of the course : Biomedical Instrumentation**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** know about basic nervous, circulatory and respiratory system and origin of bio-potentials.
**CO 2:** utilize the concept of various bioelectric signals and electrodes for EEG, EMG and ECG.
**CO 3:** have competency to acquire the data of cardiovascular, electrical activity of brain and respiratory system.
**CO 4:** exercise knowledge of medical imaging, computerized ultrasonic diagnosis and types, X-Rays and computerized tomography and use them in diagnosis of disease.
**CO 5:** learn physiological parameters and components of biotelemetry system and their applications in medical field.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL3 | BL3 | BL4, BL5 | BL2 |

CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation):

| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 2 | - | - | 3 | - | 1 | 1 | 2 | 2 | 3 | 3 | 2 |
| CO2 | 3 | - | 2 | - | - | 2 | 1 | 1 | 2 | - | 2 | 2 | 3 | 2 |
| CO3 | 3 | 2 | 2 | 2 | - | 2 | 2 | - | 2 | 2 | - | - | 3 | 2 |
| CO4 | 2 | 3 | 2 | - | 3 | 2 | 3 | - | 1 | - | 2 | 3 | 3 | 2 |
| CO5 | 3 | 2 | - | 2 | 3 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Un | **Physiological Systems of Body:** Brief description of nervous, circulatory and respiratory systems, the body as a control system, the nature of bioelectricity, the origin of bio-potentials. | 06 |

| | | |
|---|---|---|
| | **Bio Electric Signals and Electrodes:** Electro conduction system of the heart, the ECG Waveform, neuron potential, muscle potential, electrodes for biophysical sensing, Skin-contact-impedance, electrodes for EEG, EMG and ECG, electrical conductivity of electrode jellies and creams. | 06 |
| | **Cardiovascular Measurements:** The standard lead system, the electrocardiography(ECG) preamplifier; ECG machines, cardiac monitors, blood pressure measurements, direct and indirect, blood flow measurements, phonocardiography, defibrillators, pacemakers | 06 |
| | **Measurements of Electrical Activity in Brain:** Anatomy of human brain and nerve cell, electroencephalography (EEG) electrodes and the 10-20 system, EEG amplitude and frequency bands, simplified block diagram, preamplifiers and EEG system specifications, EEG diagnostic uses and sleep patterns, visual and auditory evoked potential recordings, EEG system arte facts. | 06 |
| **Unit-2** | **Electromyography (EMG ):** Muscular system, electrical signals of motor unit and gross muscle, human motor coordination system, electrodes, signal conditioning and processing, block diagram & description of Electromyography (EMG). | 04 |
| | **Respiratory System Measurements:** Respiratory anatomy, parameters of respiration, regulation of respiration, respiratory system measurements, respiratory transducers and instruments, spirometry. | 08 |
| | **Hospital Data Management:** Hospital information system, functional capabilities of computerized hospital information system, efficiency, security and cost effectiveness of computer records, computerized patient data management. | 08 |
| | **Biotelemetry:** Physiological parameters adaptable to bio-telemetry, components of a biotelemetry system, implantable units, applications of telemetry system in patient care, introduction to telemedicine. | 04 |

**Recommended Books:**

1. John G. Webster, "Medical Instrumentation", 3rd Edition WSE,2007
2. Joseph J Carr, John M. Brown, "Introduction to Biomedical Equipment Technology", 4thEdition PE,2000.
3. L Cromwell, "Biomedical instrumentation and measurement", 2nd Edition, Prentice Hall (India), 1990.
4. R.S.Khandpur, "Handbook of Biomedical Instrumentation", Tata McGraw Hill,2003.
5. Carr JJ and Brown JM., "Introduction to Biomedical Equipment Technology," Pearson Education,2000.
6. Mesut Sahin and Howard Fidel, "Instrumentation Handbook for Biomedical Engineers", CRC Press, 2021

**Subject Code : OEEE-621D**
**Title of the course : Electrical Estimation and Costing**

| L | T | P | Credits | Weekly load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
**After successful completion of course, the students should be able to**
**CO1:** study about Electrical Installation and Electrical Engineering Drawing
**CO2:** learn general rules, wiring design, procedure and design Electrical Installations.
**CO3:** know to estimate and costing of commercial Electrical Installations.
**CO4:** understand Industrial Electrical Installation and testing.
**CO5:** understand the procedures of contracts, tender and tender documentation

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL1, BL2 | BL2 | BL2 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 2 | - | - | 3 | 2 | 2 | - | 1 | 1 | 2 | - | 2 | 2 | 2 |
| CO2 | 2 | - | 3 | 3 | - | 2 | - | 3 | - | 2 | 2 | 2 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | - | 2 | 2 | 3 | 3 | 3 |
| CO4 | 2 | 3 | 3 | - | 2 | 1 | 1 | - | 1 | - | 2 | 2 | 3 | 3 |
| CO5 | 2 | - | 2 | - | 2 | 3 | - | 2 | 2 | 2 | 2 | 2 | 1 | 3 |

| Unit | Topics | Hours |
|---|---|---|
| UNIT-1 | **Introduction, Drawing and IE rules**<br>Meaning of estimation, purpose of estimating and the factors to be considered while preparing estimations Classification of Electrical Installation. General requirement of Electrical Installation. Reading and Interpretation of Electrical Engineering Drawings. Various diagrams, plans and layout Important definitions related to Installation IE rules related to Electrical Installation & Testing. Importance / purpose of IE Act and IE Rules. | 06 |
| | **Service Connection:**<br>Concept of service connection, code of Practice for service mains Types of service connection & their features. Methods of Installation of service connection. Estimates of underground & overhead service connections, materials and specifications Quantity calculation, schedules of materials and estimates for single phase OH service connection, three phase OH service connection, single phase | 08 |

| | | |
|---|---|---|
| | UG service connection and three phase UG service connection. | |
| | **Residential Building Electrification**:<br>Differentiate between electrification of Residential and commercial Installation General rules guidelines for wiring of Residential Installation and positioning of equipment. Principles of circuit design in lighting and power circuits. Procedures for designing the circuits and deciding the number of circuits. Method of drawing single line diagram Selection of type of wiring and rating of wires & cables. Load calculations and selection of size of conductor. Selection of rating of main switch, distributions board, protective switchgear ELCB and MCB and wiring accessories. Earthing of Residential Installation. Sequence to be followed for preparing Estimate Preparation of detailed estimates and costing of Residential Installation. | 10 |
| **UNIT-2** | **Electrification of commercial Installation**<br>Concept of commercial Installation.. Fundamental considerations for planning of an electrical Installation system for commercial building. Load calculations & selection of size of service connection and nature of supply. Deciding the size of cables, busbar and busbar chambers. Mounting arrangements and positioning of switchboards, distribution boards main switch etc. Earthing of the electrical Installation Selection of type wire, wiring system & layout. Sequence to be followed to prepare estimate. Preparation of detailed estimate and costing of commercial Installation | 08 |
| | **Electrification of factory unit Installation**<br>Concept of Motor wiring circuit and single line diagram. Important guidelines about power wiring and Motor wiring. Motor current calculations. Selection and rating of wire, cable size & conduct. Deciding fuse rating, starter, distribution boards main switch etc. Deciding the cable route, determination of length of wire, cable, conduit, earth wire, and earthing. Sequence to be followed to prepare estimate. Preparations of detailed estimate and costing of small factory unit/ workshop. | 08 |
| | **Testing of Installation**<br>Testing of wiring Installation for verification of current; earthing, insulation resistance and continuity as per IS | 02 |
| | **Contracts, Tenders and Execution**<br>Meaning of overhead charges, stock incidental charges, contingencies, supervision charges, labour charges, Inspection/Inspectorate charges, transportation charges and miscellaneous charges. Concept of contracts and tenders, types of contracts, contractors. Valid Contracts, Contract documents. Tender and tender notices. Procedure for submission and opening tenders. Comparative statements, criteria for selecting contractors, General conditions in order form. Principles of execution of works, administrative approval, Technical sanctions. Billing of executed work. | 06 |

Recommended Books:

1. Electrical Design;Estimating and costing — K.B. Raina S.K.Bhattacharya
2. Electrical Estimating and costing — Surjit Singh
3. Electrical Estimating and costing — N. Alagappan S. Ekambaram
4. Electrical wiring Estimating and costing — S.L. Uappal
5. Electrical wiring, Estimating and costing — B.D.Arora

**Subject Code : OEEE-622A**
**Title of the course : Control System**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**

After successful completion of course, the students should be able to
**CO1:** acquire the basic knowledge of control engineering and its scope.
**CO2:** analyze the mathematical model of a system and determine the response of different order systems for standard input inputs
**CO3:** solve the steady state and transient analysis of a system for standard input inputs
**CO4:** analyze the stability analysis of a system.
**CO5:** be competent to analyze closed loop control design problems and design compensating networks.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **Cos** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL4, BL5 | BL3 | BL4, BL5 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | 3 | 2 | 2 | - | - | 2 | 3 | 2 | 2 | 2 | 3 | 1 |
| CO2 | 3 | 3 | - | 3 | 3 | 3 | 1 | 1 | 2 | - | 3 | - | 3 | 1 |
| CO3 | 3 | 2 | 3 | 2 | - | 1 | - | - | 3 | 3 | 2 | 2 | 3 | 1 |
| CO4 | 2 | 2 | - | 2 | 3 | 3 | - | - | 2 | 3 | 3 | - | 3 | 1 |
| CO5 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | - | 3 | 3 | - | 2 | 3 | 1 |

| Unit | Main Topics and Course Outline | Hour(s) |
|---|---|---|
| Unit-1 | **Introductory Concept:** Plant, systems, servomechanism, regulating systems, disturbances, open loop control system, closed loop control system, linear and non- linear systems, time variant and invariant, continuous and sampled-data control systems, concept of feedback, block diagrams. | **06** |
| | **Modeling:** formulation of equation of linear electrical, mechanical, thermal, pneumatic and hydraulic system, electrical mechanical analogies, use of laplace transforms, transfer function, concept of state variable modeling, block diagram representation, block diagram simplification for linear systems, signal flow graphs, mason gain rules. | **09** |
| | **Time Domain Analysis:** Typical test-input signals, transient and steady state response of the first order systems, second order systems and higher order systems, Steady state error and coefficients, pole zero location and stability, Routh-Hurwitz Criterion. | **09** |

| | | |
|---|---|---|
| | **Root Locus Analysis:** Introduction, Root-Locus plots, general , positive feedback systems, conditionally stable systems, Root Loci for systems with transport lag. | **06** |
| **Unit-2** | **Frequency Domain Analysis:** Introduction, Bode diagrams, polar plots, drawing Nyquist , Log-Magnitude- versus-phase plots, Nyquist stability criterion, stability analysis, relative stability. | **06** |
| | **Compensation:** Necessity of compensation, series and parallel compensation, compensating networks, application of lag and lead compensation. | **06** |
| | **Control Components:** Proportionate, derivative and integral control, feedback control, error detectors, potentiometers and synchro, AC &DC servomotors, tacho-generators | **06** |

**Recommended Books-**

1. Benjamin C. Kuo, "Automatic Control System", 8th edition, John Wiley & Sons,2002.
2. Distefano JJ, Stuberud AR and Williams IJ, "Schaum's Outlines of Theory and problems of Feedback and control Systems", 2nd ed., Tata McGrawHill,2007.
3. I. J. Nagrath and M. Gopal, "Control System Engineering", New Age,2009.
4. K. Ogata, "Modern Control Engineering", 5th edition, Prentice Hall (PHI),2010.
5. Robert H. Bishop, Richard C. Dorf, "Modern control systems", 14th ed., Pearson, 2022

**Subject Code : OEEE-622B**
**Title of the course : Microcontrollers and Applications**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
CO 1: study 8051 microcontroller along with its the internal architecture.
CO 2: develop knowledge of programming of 8051 microcontroller using assembly language.
CO 3: analyze 8051 microcontroller design, memory mapping and serial data transmission.
CO 4: be conversant in application of 8051 microcontroller.
CO 5: implement PLDs and FPGA with knowledge of their architecture and design.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL2 | BL4 | BL3 | BL3, BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | - | - | 3 | 2 | - | - | 1 | - | 3 | 2 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 2 | - | 1 | - | - | 2 | 2 | 2 | 2 | 3 | 1 |
| CO3 | 3 | 3 | 2 | 3 | 2 | 1 | 1 | - | - | 2 | 3 | 2 | 3 | 1 |
| CO4 | 3 | 2 | 3 | 2 | - | 1 | 1 | - | - | 2 | - | 2 | 3 | 1 |
| CO5 | 3 | 2 | 3 | 2 | 3 | 3 | - | - | 2 | 3 | 2 | 3 | 3 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Introduction:** Microprocessor, Micro-controllers and their comparison. The 8051 Architecture: Introduction, 8051 micro-controller hardware, input/ output, pins, ports and circuits, external memory, counters and timers, serial data input/ output, interrupts | 12 |
| | **8051 Assembly Language Programming:** Instruction format and addressing techniques, instruction set (data moving, logical operations, arithmetic operations, jump and call instructions), The mechanics of programming, assembly language programming process, programming tools and techniques, | 12 |
| Unit-2 | **8051 Microcontroller Design:** Micro-controller specification, external memory and memory space decoding, reset and clock circuits, expanding Input/output (I/O), memory mapped I/O, memory address decoding, memory access times, testing the design, timing subroutines, lookup tables for the 8051, serial data transmission | 12 |
| | **Microcontroller Applications:** Interfacing keyboards, displays, Digital to Analog (D/A) | 12 |

| | | |
|---|---|---|
| | and Analog to Digital (A/D), multiple interrupts, serial data communications, introduction to the use of assemblers and simulators Embedded Systems: Introduction to Programmable Logic Devices (PLDs) and Field Programmable Gate Array (FPGA) - architecture, technology and design issues, implementation of 8051 core.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | |

**Recommended Books-**

1. K J Ayala, "The 8051 Micro Controller- Architecture, Programming and Application", 2nd Edition, Penram International,2007.
2. M Mahalakshmi, "8051 Microcontroller Architecture, Programming and Application", Laxmi Publications 2012.
3. B Ram, "Fundamentals of Microprocessors and Microcontrollers", Dhanpat Rai, Publications, 2012.
4. M A Mazidi and J G Mazidi, "The 8051 Micro-controller and Embedded System", 2nd edition, Pearson Education, 2013.
5. S Ghoshal, "The 8051 Microcontroller: Internals, Instructions, Programming and Interfacing", 2nd edition, Pearson Education India,2014.
6. Salvador Pinillos Gimenez, "8051 Microcontrollers: Fundamental Concepts, Hardware, Software and Applications in Electronics" Springer, 201

**Subject Code : OEEE-622C**
**Title of the course : Electrical Safety and Standards**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1**. Describe electrical hazards and safety equipment.
**CO2**. Analyze and apply various grounding and bonding techniques.
**CO3.** Select appropriate safety method for low, medium and high voltage equipment.
**CO4.** Participate in a safety team.
**CO5**. Carry out proper maintenance of electrical equipment by understanding various standards.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL3, BL4 | BL3 | BL3 | BL3 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 2 | - | 3 | 3 | - | - | 2 | 2 | 3 | 3 | 2 | 2 |
| CO2 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | - | 2 | - | - | 2 | 3 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 3 | - | 2 | 2 | - | 2 | 3 | 2 | 3 |
| CO4 | 3 | - | 2 | - | - | 2 | - | 2 | 3 | 3 | 2 | - | 2 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 2 | - | 2 | 3 | 3 | 2 | 3 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Electrical Hazards:** Review of Electrical concept, Electrostatic – Electro magnetism – Electrical Hazards – Energy leakage – Clearance and insulation– Current surges – Electrical causes of fire and explosion – Human interface with electricity – Human resistance to electricity | 08 |
| | **Electrical Protection and Maintenance:** Primary and secondary hazards- arc, blast, shocks-causes and effects-safety equipment- flash and thermal protection, head and eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers and signs, safety tags, locking devices- voltage measuring instruments- proximity and contact testers-safety electrical one line diagram- electrician's safety kit. | 08 |
| | **Grounding and Bounding Safety Measure:** General requirements for grounding and bonding- definitions- grounding of electrical equipment bonding of electrically conducting materials and other equipment-connection of grounding and bonding equipment- system grounding- purpose of system grounding- grounding electrode system grounding conductor | 08 |

| | | |
|---|---|---|
| | connection to electrodes-use of grounded circuit conductor for grounding equipment-grounding of low voltage and high voltage systems. | |
| **Unit-2** | **Power System Operation Safety Measure:** The six step safety methods- pre job briefings - hot-work decision tree-safe switching of power system- lockout-tag out- flash hazard calculation and approach distances- calculating the required level of arc protection-safety equipment, procedure for low, medium and high voltage systems- the one-minute safety audit | 08 |
| | **Company Safety Structure:** Electrical safety Program structure, development- company safety team- safety policy Program implementation- employee electrical safety teams- safety meetings- safety audit accident prevention- first aid- rescue techniques-accident investigation | 08 |
| | **Standards and Requirements:** Safety related case for electrical maintenance- reliability centered maintenance (RCM) - eight step maintenance Program- frequency of maintenance-maintenance requirement for specific equipment and location- regulatory bodies- national electrical safety code- standard for electrical safety in work place- occupational safety and health administration standards, Indian Electricity Acts related to Electrical Safety.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 08 |

**Recommended Books-**

1. John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, Al Winfield, “Electrical Safety Handbook”, McGraw-Hill Education, 4thEdition, 2012.
2. Maxwell Adams.J, “Electrical Safety- a guide to the causes and prevention of electric hazards”, The Institution of Electric Engineers, IET 1994.
3. Ray A. Jones, Jane G. Jones, “Electrical Safety in the Workplace”, Jones & Bartlett Learning, 2000.
4. S. Rao, R. K. Jain and H. L. Saluja, “Electrical Safety, Fire Safety Engineering and Safety Management” Khanna Publishers,1997.
5. J. Maxwell Adams, “Electrical Safety a guide to the causes and prevention of electrical hazards” The Institution of Electrical Engineers, London, U K,2004.
6. El-Sharkawi, Mohamed A, "Electric safety : practice and standards", CRC Press, 2014

**Subject Code : OEEE-622D**
**Title of the course : Electric Drives and Traction Systems**

| L | T | P | Credits | Hrs |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** To understand theoretical concepts of dynamics of electric drives.
**CO2:** Analyze the performance of dc motor drives.
**CO3:** Analyze the performance of induction motor drives for various operating conditions.
**CO4:** Estimate energy consumption and decide rating of motor for traction application.
**CO5:** To acquire the knowledge of drives in industry and traction.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL4 | BL4 | BL4 | BL2 |

| CO/PO Mapping : (Strong(1) / Medium(2) / Weak(3) indicates strength of correlation): | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Programme Outcomes (POs) | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | - | 2 | 3 | 3 | 2 | - | - | 3 | 3 | 3 | 2 |
| CO2 | 2 | 2 | 3 | - | 2 | 3 | - | - | 3 | 3 | 3 | 3 |
| CO3 | 2 | 2 | 3 | 3 | 2 | - | 1 | - | 3 | 3 | 3 | 2 |
| CO4 | 3 | 2 | 3 | 3 | - | 3 | 1 | - | 3 | 3 | 3 | 3 |
| CO5 | 3 | - | - | 3 | 2 | 3 | - | - | 3 | 2 | 3 | - |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Fundamental of Electric Drives:** Basic concepts, Characteristics and operating modes of drive motors, Starting, braking and speed control of motors, Four quadrant drives, Nature and classification of load torque and associated controls used in process industries, Selection of motors and rating. | 8 |
| | **DC Motor Drives:** Starting, braking and speed control, Analysis of separately excited dc motor with continuous armature current and discontinuous armature current, Analysis of dc series motor drives, Comparative evaluation of phase angle control, Semi-converter operation of full converter, Single phase half controlled and fully controlled rectifier fed dc motors, Sequence control, Three phase half controlled and fully controlled rectifier fed dc motors, Dual converter with circulating and non-circulating current controlled drives, Closed loop control system of dc motor drives, Reversible drives, Analysis and performance characteristics of chopper fed dc motors, Motoring and braking operations, Multiphase chopper, Phase locked loop control of dc drive. | 16 |
| Unit-2 | **Induction Motor Drives:** Operation with unbalanced source voltages and unbalanced rotor impedances, Effect of time harmonics on the motor performance, Braking, Stator | 12 |

| | | |
|---|---|---|
| | voltage control of induction motor, Variable voltage variable frequency (VVVF) operation, Voltage source inverter (VSI) fed induction motor drive, Static rotor resistance control, Slip power recovery systems, closed loop control of ac drives, Introduction to field oriented control of ac motors, Comparison of ac and dc drive, Their selection for particular application. | |
| | **Electric Traction:** General features of electrical traction, Mechanics of train movement, Nature of traction load, Speed-time curves, Calculations of traction drive rating and energy consumption, Train resistance, Adhesive weight and coefficient of adhesion, Tractive effort for acceleration and propulsion, Power and energy output from driving axles, Methods of speed control and braking of motors for traction load, Electric drive systems for electric traction. | 12 |

**Recommended Books: -**

1. G. K. Dubey, *Fundamental of Electrical Drives*, CRC Press.
2. Subramanyam, *Electric Drives– Concepts and Applications*, Tata McGraw Hill.
3. B.K. Bose, *Power Electronics & Variable Frequency drive*, WILEY Press.
4. G. C. Garg, *Utilization of Electric Power and Electric Traction*, Khanna Publication.
5. Abad, Gonzalo, "Power electronics and electric drives for traction applications", Wiley, 2016
6. Richard Crowder, "Electric Drives and Electromechanical Systems", 2nd Edition,Butterworth-Heinemann, 2019

**Subject Code : OEEE-711A**
**Title of the course : Signals and Systems**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**

After successful completion of course, the students should be able to
**CO 1:** interpret signals, convolution and learn various properties.
**CO 2:** to gain knowledge to reduce noise, interference and their reduction methods.
**CO 3:** be conversant in Fourier Series, Fourier Transform along with their basic properties
**CO 4:** analyze sampling, restructuring, sampling theorem, aliasing, digital signal processing.
**CO 5:** study Laplace and Z-transform, their basic properties, region of convergence, inverse Laplace and Z-transform, rational system functions

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1, BL2 | BL3 | BL2 | BL4 | BL1, BL2 |

| CO/PO Mapping:(Strong(3) / Medium(2) / Weak(1) indicates strength of correlation) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/ Program Specific Outcomes (PSO) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | 3 | 2 | 3 | 2 | - | - | - | 1 | 2 | - | 3 | 1 |
| CO2 | 3 | - | 3 | - | 3 | 2 | - | - | 1 | - | 2 | - | 3 | 1 |
| CO3 | 2 | 3 | 3 | 3 | - | - | 1 | - | 2 | - | 3 | 2 | 3 | 1 |
| CO4 | - | 3 | 3 | 3 | - | 2 | - | - | 2 | 2 | 3 | 2 | 3 | 1 |
| CO5 | 3 | 3 | 3 | - | 3 | 3 | - | - | 3 | 2 | 2 | 2 | 3 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Introduction to Signals and Systems:** Signals and systems as seen in everyday life, and in various branches of engineering and science. Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability. | 6 |
| | **Behavior of Continuous and Discrete-Time LTI Systems**: Impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. State-space representation of systems. State-Space analysis, Multi-input, multi-output representation. State transition matrix and its role. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse | 10 |

| | | |
|---|---|---|
| | response | |
| | **Effect of Noise:** Convolution of Signals, correlation, effects of noise and interference on the measurement system, noise sources and coupling mechanism, method of reducing effects, reliability, choice and economics of the measurement system. | 8 |
| **Unit-2** | **Introduction to Transforms:** Fourier series representation of periodic signals, waveform symmetries, calculation of Fourier coefficients. Fourier transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). | 8 |
| | **Sampling and Reconstruction of The Signal:** The Sampling Theorem and its implications. Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems. Introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems. | 6 |
| | **Laplace and Z-Transforms:** Review of the laplace transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, laplace domain analysis, solution to differential equations and system behavior. the z-transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis. Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 10 |

**Recommended Books:**

1. AllanV. Oppenheim, AS Willsky and S H Nawab, “Signals and Systems”, Prentice Hall India, 1997.
2. J.G. Proakis and D G Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson, 2006.
3. H.P.Hsu, “Signals and Systems”, Schaum’s series, McGraw Hill Education, 2010.
4. S.Haykin and B.V. Veen, “Signals and Systems”, John Wiley and Sons, 2007.
5. Allan V.Oppenheim, S.Wilsky and S.H.Nawab, “ Signals and Systems”, Pearson Education,2007.
6. Edward W Kamen& Bonnie’s Heck, “Fundamentals of Signals and Systems”, Pearson Education, 2007.
7. S. Palani, "Signals and Systems", 2nd edition, 2021

**Subject Code : OEEE-711B**
**Title of the course : Sensors and Transducers**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students will be
**CO1:** exposed to various sensors and transducers for measuring mechanical quantities.
**CO2:** familiar with the specifications of sensors and transducers.
**CO3:** able to design signal conditioning circuits for various sensors and transducers.
**CO4:** exposed to advancements in sensor technology and able to identify or use a transducer for a specific measurement application.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL2 | BL6 | BL6 | BL3 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | 2 | - | - | 2 | - | - | 1 | 2 | 2 | - | 2 | 3 |
| CO2 | 3 | 3 | 2 | - | 3 | 2 | 1 | - | 1 | - | 2 | 2 | 2 | 3 |
| CO3 | 3 | - | 3 | 3 | 3 | - | 1 | 1 | - | 2 | 3 | 2 | 2 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | - | - | 1 | 2 | 3 | - | 1 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **General Concepts**–Basic block diagram of generalized instrumentation system, definition of transducer, classification of transducers, general input-output configuration, static and dynamic characteristics of a measurement system, statistical analysis of measurement data. | 12 |
| | **Resistive Transducers**: Potentiometers, metal and semiconductor strain gauges, strain gauge applications: load and torque measurement, digital displacement sensors, RTDs, thermistors. | 12 |
| Unit-2 | **Inductive and Capacitive Transducers**- Measurement of self and mutual inductance, capacitive transducers, eddy current transducers, proximity sensors, tacho-generators and stroboscope. | 08 |
| | **Miscellaneous Measurements:** Seismic transducer and its dynamic response, photoelectric transducer, hall effect sensors, magneto-strictive transducer, smart sensors, fiber optic sensors. | 06 |

| | | |
|---|---|---|
| | **Introduction to Signal Conditioning:** Concept of signal conditioning, Op-amp circuits used in instrumentation, Instrumentation amplifiers, analogue-digital sampling, introduction to A/D and D/A conversion, signal filtering, averaging, grounding, and shielding.<br><br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 10 |

**Recommended Books-**

1. A.K. Sawhney and Puneet Sawhney, "A course on electrical and electronic measurements and Instrumentation", Dhanpat Rai,2012.
2. D. A. Bell, "Electronic Instrumentation and measurement", 3rd Edition, Oxford University Press
3. J. B. Gupta, "A Course in Electronic and Electrical Measurements & Instrumentation", S K Kataria and Sons,1996.
4. S.M. Sze, "Semiconductors sensors", John Wiley & Sons Inc., 3rdEdition,2006.
5. Patranabis, "Sensors and Transducers", Prentice Hall, 2nd Edition,2003.
6. Ezzat G. Bakhoum, "Micro- and Nano-Scale Sensors and Transducers", CRC Press, 2015

**Subject Code : OEEE-712A**
**Title of the course : Soft Computing Techniques**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** apply a soft computing methodology for a particular problem.
**CO 2:** exercise fuzzy logic and reasoning to handle uncertainty and solve engineering problems.
**CO 3:** implement genetic algorithms to combinational optimization problems.
**CO 4:** utilize neural networks to pattern classification and regression problems.
**CO 5:** implement various neuro fuzzy applications.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL3 | BL6 | BL3, BL6 | BL3 | BL3, BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | - | 3 | 3 | 2 | - | - | 1 | 2 | 2 | - | 3 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 2 | - | 1 | - | 2 | 2 | 2 | 3 | 2 |
| CO3 | 3 | 3 | 3 | - | 3 | - | 1 | - | - | 2 | 3 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | - | 2 | - | 2 | 1 | 2 | 3 | 2 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 2 | - | - | 1 | 2 | - | 2 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Fuzzy Logic-I (Introduction):** Basic concepts of fuzzy logic, fuzzy sets and crisp sets, fuzzy set theory and operations, properties of fuzzy sets, fuzzy and crisp relations, fuzzy to crisp conversion. | 08 |
| | **Fuzzy Logic-II (Fuzzy Membership, Rules):** Membership functions, interference in fuzzy logic, fuzzy if-then rules, fuzzy implications and fuzzy algorithms, fuzzifications and defuzzifications, fuzzy controller, industrial applications. | 08 |
| | **Genetic Algorithm(GA):** Basic concepts, working principle, procedures of GA, flowchart of GA, genetic representations, (encoding) initialization and selection, genetic operators, mutation, generational cycle, applications. | 08 |
| **Unit-** | **Neural Networks-1(Introduction & Architecture): N**euron, nerve structure and synapse, artificial neuron and its model, activation functions, neural network architecture: single layer and multilayer feed forward networks, recurrent networks, various learning techniques; perception and convergence rule, auto-associative and hetro-associative memory. | 08 |

| | | |
|---|---|---|
| 2 | **Neural Networks-II (Back Propagation Networks):** Architecture: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient; back propagation algorithm, factors affecting backpropagation training. | 08 |
| | **Neuro Fuzzy Modelling:** Adaptive neuro-fuzzy inference systems, architecture, hybrid learning algorithm, learning methods that cross-fertilize ANFIS and RBFN, coactive neuro fuzzy modelling, framework neuron functions for adaptive networks, neuro fuzzy spectrum. | 08 |

**Recommended Books-**


1. E. Goldberg Davis, “Genetic Algorithms: Search, Optimization and Machine Learning”, Addison Wesley, N.Y., 1989.
2. J. Ross Timothy, “Fuzzy Logic with Engineering Applications”, McGraw-Hill, International Editions, Electrical Engineering Series, Singapore, 1997.
3. J. S. R. Jang, C. T. Sun and E. Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI, 2004, Pearson Education 2004.
4. R. Eberhart, P. Simpson and R. Dobbins, “Computational Intelligence - PC Tools”, AP Professional, Boston, 1996.
5. S. Raja sekaran and G. A. V. Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms”, PHI, 2003.
6. Pradip Debnath, S. A. Mohiuddine, "Soft Computing Techniques in Engineering, Health, Mathematical and Social Sciences (Edge AI in Future Computing)", CRC Press, 2021.

**Subject Code : OEEE-711D**
**Title of the course : SPECIAL ELECTRICAL MACHINES**

| L | T | P | Credits | Hrs |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** Learn about AC DC servomotors construction, operation and application
**CO 2:** Study single phase special purpose motors
**CO 3:** Basics, operation applications of stepping motors
**CO 4:** Introduction to Permanent magnet machines
**CO 5:** Elementary idea of linear motors

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL2 | BL2 | BL2 | BL2 |

| CO/PO Mapping : (Strong(1) / Medium(2) / Weak(3) indicates strength of correlation): | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Programme Outcomes (POs) | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 1 | 1 | 1 | 1 | - | 2 | - | 1 | - | 2 | 2 | 1 |
| CO2 | 1 | - | - | 2 | 1 | 2 | 1 | - | 1 | 2 | 2 | - |
| CO3 | 1 | 2 | 1 | 2 | - | 2 | 1 | - | 1 | - | 2 | 2 |
| CO4 | 1 | 2 | 2 | 2 | - | 2 | 1 | - | 1 | 2 | 2 | 2 |
| CO5 | 1 | 2 | 2 | 2 | 1 | 2 | - | 1 | - | - | 2 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | A C Servomotors- Construction-principle of operation – performance characteristics – damped AC servomotors – Drag cup servomotor – applications. DC servomotors – field and armature controlled DC servomotors – permanent magnet armature controlled – series split field DC servomotor. | 8 |
| | Single phase special electrical machines – AC series motor construction – principle of working – phasor diagram – universal motor<br>Hysteresis motor- constructional details- principle of operation –torque-slip characteristics – applications. | 8 |
| | Stepper motors – Basic principle – different types – variable reluctance- permanent magnet – hybrid type – comparison – theory of operation – monofilar and bifilar windings – modes of excitation – drive circuits – static and dynamic characteristics – applications | 8 |
| Unit-2 | Reluctance motors – principle of operation – torque equation – torque slip characteristics-applications. Switched reluctance motors – principle of operation – power converter circuits – torque equation – different types – comparison – applications. | 8 |
| | Permanent Magnet DC Motors – construction – principle of working. Brushless dc motor – construction – trapezoidal type-sinusoidal type – comparison – applications. | 8 |
| | Linear motors – different types – linear reluctance motor – linear synchronous motors – construction – comparison. Linear induction motors – Expression for linear force – equivalent circuit – applications. | 8 |

**Recommended Books: -**

1. E. G. Janardhanan, ‘Special Electrical Machines’ PHI Learning Private Limited
2. Irving L. Kosow.’Electrical Machinery and Transformers’, Oxford Science Publications.
3. T. J. E. Miller, ‘Brushless PM and Reluctance Motor Drives’.C.Larendon Press, Oxford.
4. Theodore Wildi, ‘Electric Machines, Drives and Power Systems’, Prentice Hall India Ltd.
5. Veinott & Martin,’Fractional & Subfractional hp Electric Motors’.McGraw Hill International Edn.
6. Ion Boldea, Lucian N. Tutelea, "Electric Machines: Steady State and Performance with MATLAB®" 2nd edition, CRC Press, 2021.

**Subject Code : PEEE-611A**
**Title of the course : Biomedical Instrumentation**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** know about basic nervous, circulatory and respiratory system and origin of bio potentials.
**CO 2:** utilize the concept of various bioelectric signals and electrodes for EEG, EMG and ECG.
**CO 3:** have competency to acquire the data of cardiovascular, electrical activity of brain and respiratory system.
**CO 4:** exercise knowledge medical imaging, computerized ultrasonic diagnosis and types, X-Rays use them in diagnosis of disease.
**CO 5:** learn physiological parameters and components of biotelemetry system and their applications in medical field.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL3 | BL3 | BL3, BL5 | BL2, BL3 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | 2 | - | 2 | 3 | 1 | - | - | 2 | 2 | 3 | 3 | 2 |
| CO2 | 3 | - | 2 | 2 | 2 | 2 | 1 | - | 2 | - | 2 | 2 | 3 | 2 |
| CO3 | 3 | 2 | 2 | 2 | - | 2 | 1 | 1 | 2 | 2 | - | - | 3 | 2 |
| CO4 | 2 | 3 | 2 | 2 | 3 | 2 | - | 1 | 1 | - | 2 | 3 | 3 | 2 |
| CO5 | 3 | 2 | - | 2 | 3 | 2 | - | - | 2 | 2 | 2 | 3 | 3 | 2 |

| Unit | Main Topics and Course Outline | Hour(s) |
|---|---|---|
| **Unit-1** | **Physiological Systems of Body:** Brief description of nervous, circulatory and respiratory systems, the body as a control system, the nature of bioelectricity, the origin of bio-potentials. | 06 |
| | **Bio Electric Signals And Electrodes:** Electro conduction system of the heart, the ECG Waveform, Neuron potential, muscle potential, electrodes for biophysical sensing, skin-contact-impedance, electrodes for EEG,EMG and ECG, electrical conductivity of electrode jellies and creams. | 06 |
| | **Cardiovascular Measurements:** The standard lead system, the electrocardiography(ECG) preamplifier; ECG machines, cardiac monitors, blood pressure measurements, direct and indirect, blood flow measurements, phonocardiography, defibrillators, pacemakers. | 06 |
| | **Measurements of Electrical Activity in Brain:** Anatomy of human brain and nerve cell, electroencephalography (EEG) electrodes and the 10-20 system, EEG amplitude and frequency bands, simplified block diagram, preamplifiers and EEG system specifications, EEG diagnostic uses and sleep patterns, visual and auditory evoked potential recordings, EEG system arte facts. | 06 |

| | | |
|---|---|---|
| **Unit 2** | **Electromyography (EMG):** Muscular system, electrical signals of motor unit and gross muscle, human motor coordination system, electrodes, signal conditioning and processing, block diagram & description of electromyography (EMG). | 04 |
| | **Respiratory System Measurements:** Respiratory anatomy, parameters of respiration, regulation of respiration, respiratory system measurements, respiratory transducers and instruments, spirometry. | 08 |
| | **Hospital Data Management:** Hospital information system, functional capabilities of computerized hospital information system, efficiency, security and cost effectiveness of computer records, computerized patient data management. | 08 |
| | **Medical Imaging:** Introduction to medical imaging, computers in medical imaging, computerized ultrasonic diagnosis and types, x-rays, computerized tomography(ct), computerized emission tomography(CET).<br>Projects related to this course should be given to students (in groups) in order to promote team work and ethical values. | 04 |

**Recommended Books:**


1. J.G.Webster, "Medical Instrumentation", 4th Edition WSE, 2009.
2. J Carr Joseph, John M. Brown, "Introduction to Biomedical Equipment Technology" , 4th Edition PE,2000.
3. L Cromwell, "Biomedical instrumentation and measurement", 2nd Edition, Prentice Hall (India), 1990.
4. R.S.Khandpur, " Handbook of Biomedical Instrumentation", 3rd Edition Tata McGraw Hill,2014.
5. J.J. Carr and Brown JM., "Introduction to Biomedical Equipment Technology," 4th Edition Pearson Education, 2002.

**Subject Code : PEEE-611B**
**Title of the course : Electromagnetic Field Theory**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** understand vector analysis, curl, gradient, divergence and laws of static electric field.
**CO 2:** analyse steady and time varying magnetic field, basic laws, vector representation, steady state equation, Poynting Vector etc.
**CO 3:** interpret EM wave propagation in homogeneous, conducting and dielectric mediums.
**CO 4:** differentiate reflection & refraction of EM waves by perfect conductor, dielectric and insulator.
**CO 5:** analyse Transmission line travelling & standing waves, characteristic impedance, reflection coefficient.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL4 | BL2 | BL2 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 2 | - | - | 1 | 2 | - | 1 | 1 | 3 | 1 | 3 | 1 | 1 |
| CO2 | 3 | 2 | - | 1 | 2 | - | 1 | - | - | 3 | - | 3 | 1 | 1 |
| CO3 | 3 | 3 | 2 | 3 | - | 3 | 1 | - | 2 | 3 | - | 3 | 2 | 3 |
| CO4 | 3 | 3 | 2 | 3 | 2 | 3 | - | - | 2 | 3 | 1 | 3 | 2 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 2 | 3 | - | - | 2 | 3 | 1 | 3 | 3 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Review of Vector Analysis:** Vector analysis, Physical interpretation of gradient, divergence and curl; vector relations in other coordinate systems, integral theorems: divergence theorem, stoke's theorem, green's theorem and Helmholtz theorem. | 06 |
| | **Static Electric Field:** Introduction to fundamental relations of electrostatic field; Gauss's law and its applications; potential function; Field due to continuous distribution of charges; Equipotential surfaces; Divergence theorem; Poisson's equation and Laplace's equation, capacitance, electrostatic energy, Conditions at Boundary between dielectrics, Uniqueness theorem. | 06 |
| | **Steady Magnetic Field:** Magnetic induction and Faraday's laws Ampere's work Law in differential vector form, magnetic field due to volume distribution of current and the Dirac-delta function, ampere's force law magnetic vector potential, Analogies between electric and magnetic fields, steady state equation of continuity. | 06 |
| | **Time Varying Fields Maxwell's Equations:** Equation of continuity for time varying fields, Inconsistency of ampere's law, Maxwell's equations in integral and differential form for static and time varying fields, conditions at a Boundary surface, Concept of Poynting vector, | 06 |

| | | |
|---|---|---|
| | Poynting Theorem, Interpretation of E x H. | |
| **Unit-2** | **Electromagnetic Waves Propagation:** Solutions for free-space conditions, electromagnetic waves in a homogeneous medium, propagation of uniform plane-wave, relation between E & H in a uniform plane-wave, wave equations for conducting medium, Maxwell's equations using phasor notation, wave propagation in a conducting medium, conductors, dielectrics, wave propagation in good conductor and good dielectric, depth of penetration, polarization | 06 |
| | **Reflection Of Electromagnetic Waves:** Electromagnetic wave Reflection by Perfect Conductor -normal and oblique incidence, Perfect Dielectric-normal incidence, Perfect Insulator –Oblique incidence, reflection at the surfaces of a conductive medium, surface impedance | 06 |
| | **Refraction of Electromagnetic Waves:** Electromagnetic wave refraction at the surface of a perfect conductor & perfect dielectric (both normal incidence as well as oblique incidence), Brewester's angle and Total internal reflection, and applications | 06 |
| | **Transmission Line Theory:** Transmission line as a distributed circuit, transmission line equation, travelling & standing waves, characteristic impedance, input impedance of terminated line, reflection coefficient, voltage standing wave ratio (VSWR), Smith's chart and its applications. | 06 |

**Recommended Books-**


1. Jordan C. Edward and Balmain G. Keith, "Electromagnetic Waves and Radiating Systems",2nd Edition, Prentice-Hall Inc, 1968.
2. John D. Kraus, "Electromagnetics", 5th Edition, McGraw-Hill Publishers, 2005.
3. Joseph A. Edminister, Schaum's "Theory and Problems of Electromagnetics", 4th Edition, McGraw-Hill, 2013.
4. Narayan N. Rao, "Elements of Engineering Electromagnetics", 6th Edition, Pearson Education, 2004.
5. Hayt, "Engineering Electromagnetics", 7th Edition, Tata McGraw-Hill, 2012.

**Subject Code : PEEE-611C**
**Title of the course : Electrical Safety and Standards**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1**. describe electrical hazards and safety equipment.
**CO2**. analyze and apply various grounding and bonding techniques.
**CO3.** select appropriate safety method for low, medium and high voltage equipment.
**CO4.** participate in a safety team.
**CO5**. carry out proper maintenance of electrical equipment by understanding various standards.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL3, BL4 | BL3 | BL3 | BL3 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | - | 2 | - | 2 | - | - | 1 | - | - | 3 | 1 | 1 |
| CO2 | 2 | 2 | - | 2 | 2 | 3 | - | - | 2 | 2 | 2 | 3 | 1 | 1 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | - | 2 | - | 2 | 3 | 2 | 3 |
| CO4 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | - | 2 | 3 | 3 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 2 | 3 | 3 | - | - | 2 | 3 | 2 | 3 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Electrical Hazards :** review of electrical concept, electrostatic – electro magnetism – electrical hazards – energy leakage – clearance and insulation– current surges – electrical causes of fire and explosion – human interface with electricity – human resistance to electricity | 06 |
| | **Electrical Protection and Maintenance:** Primary and secondary hazards- arc, blast, shocks-causes and effects-safety equipment- flash and thermal protection, head and eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers and signs, safety tags, locking devices- voltage measuring instruments- proximity and contact testers-safety electrical one line diagram- electrician's safety kit. | 10 |
| | **Grounding and Bounding Safety Measure:** General requirements for grounding and bonding- definitions- grounding of electrical equipment bonding of electrically conducting materials and other equipment-connection of grounding and bonding equipment- system grounding- purpose of system grounding- grounding electrode system grounding conductor connection to electrodes-use of grounded circuit conductor for grounding equipment-grounding of low voltage and high voltage systems. | 08 |

| | | |
|---|---|---|
| **Unit-2** | **Power System Operation Safety Measure:** The six step safety methods- pre job briefings - hot-work decision tree-safe switching of power system- lockout-tag out- flash hazard calculation and approach distances- calculating the required level of arc protection-safety equipment, procedure for low, medium and high voltage systems- the one minute safety audit | 10 |
| | **Company Safety Structure:** Electrical safety program structure, development- company safety team- safety policy program implementation- employee electrical safety teams- safety meetings- safety audit accident prevention- first aid- rescue techniques-accident investigation | 06 |
| | **Standards and Requirements:** Safety related case for electrical maintenance- reliability centered maintenance (RCM) - eight step maintenance program- frequency of maintenance- maintenance requirement for specific equipment and location- regulatory bodies- national electrical safety code- standard for electrical safety in work place- occupational safety and health administration standards, indian electricity acts related to electrical safety.<br><br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 08 |

**Recommended Books-**


1. John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, Al Winfield, 'Electrical Safety Handbook' McGraw-Hill Education, 4th Edition, 2012.
2. A. J. Maxwell, 'Electrical Safety- a guide to the causes and prevention of electric hazards', The Institution of Electric Engineers, IET 1994.
3. A. Ray Jones, G. Jones Jane, 'Electrical Safety in the Workplace', Jones & Bartlett Learning, 2000.
4. S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating & Costing", Khanna publishers, 2008.
5. K. B. Raina, "Electrical Design, Estimating & Costing", 2nd edition New age International, 2007.

**Subject Code : PEEE-611D**
**Title of the course : Group Chain Technology and Distribution System**

| L | T | P | Credits | Hrs |
|---|---|---|---|---|
| **3** | **1** | **0** | **4** | **4** |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1**: To understand the basic concepts of block chain technology.
**CO 2**: To define the applications of block chain technology for power distribution System.
**CO 3**: To study about challenges and security issues of block chain technology in power distribution System.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | |
|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 |
| **BLs** | BL2 | BL1 | BL2 |

| CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation): | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Programme Outcomes (POs) | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 1 | - | 1 | - | 2 | - | - | 1 | 2 | - | 1 | 2 |
| CO2 | 1 | 1 | 2 | 2 | 2 | 2 | - | - | 2 | 2 | 2 | 3 |
| CO3 | 2 | - | 2 | 2 | 2 | 1 | - | 1 | 2 | 2 | 3 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Introduction:**<br>The changing electric power sector, Block chain basics, Different blockchains, Blockchain Architecture, Distribution of Blockchain initiatives in the Electric Power Sector and Category of Application. | 10 |
| | **Applications:**<br>Electricity trading markets, Peer-to-Peer Transactions, Grid Transactions, Energy Financing, Sustainability Attribution, Electric vehicles, Grid management, Device automation for metering and billing, other applications. | 10 |
| **Unit-2** | **Challenges of blockchain applications in power distribution systems:**<br>Implementation costs, Consumer participation, Data-processing constraints, Legal support and regulations, Scalability Issues, Chances of Centralization, Commercial Implementations of Blockchain in the Smart Grid. | 10 |
| | **Security and privacy issues in blockchains:**<br>Privacy threat through transaction link ability, Privacy leakage through P2P network traffic analysis, Theft attack on a blockchain wallet, Attacks on Ethereum smart contracts, non-erasable data in blockchains, Quantum-computing threat to blockchains, Security issues in blockchain integration with constrained devices, Blockchain interoperability. | 10 |

**Recommended Books-**

1. Blockchain meets Energy, Digital Solutions for a Decentralized and Decarbonized Sector.
2. Applying Blockchain Technology to Electric Power Systems, David Livingston, Varun Sivaram, Madison Freeman, and Maximilian Fiege July 2018.
3. Blockchain in Smart Grids: A Review on Different Use Cases, Tejasvi Alladi Sept. 2019
4. Emergence of blockchain-technology application in peer-to-peer electrical-energy trading: a review, Manish Kumar Thukral 2021

**Subject Code : PEEE-621A**
**Title of the course : Electrical Energy Conservation and Auditing**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** to acquire the basic knowledge about the energy management and auditing
**CO2:** recognize how energy can be conserved and managed in industries.
**CO3:** acquire a comprehensive idea on tariffs in Transmission &Distribution systems.
**CO4:** be conversant in utilization and effects of energy on Environment.
**CO5:** be competent to handle the Energy auditing procedure.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL4 | BL4 | BL6 | BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | - | 1 | 2 | - | 1 | - | - | 1 | 2 | - | 3 | 3 | 1 |
| CO2 | 3 | 2 | - | 2 | 2 | 1 | - | 2 | 2 | 2 | - | 3 | 3 | 2 |
| CO3 | 3 | - | 3 | 3 | 2 | - | - | 1 | 2 | 3 | 1 | 3 | 3 | 2 |
| CO4 | 3 | 2 | 3 | 2 | 2 | - | 2 | 2 | 3 | 2 | - | 3 | 2 | 3 |
| CO5 | 2 | 1 | - | 2 | 2 | 1 | - | 2 | 3 | 3 | 3 | 3 | 2 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Energy Audit Methodology and Recent Trends:** General philosophy, need of energy audit, economics of implementation of energy optimization projects, it's constraints, barriers and limitations, report-writing, preparations and presentations of energy audit reports, post monitoring of energy conservation projects, MIS, case-studies / report studies of energy audits. guidelines for writing energy audit report, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations, energy cost and recent electricity board tariffs, energy conservation by improving load factor, power factor, demand factor, plant utilization factor etc. | 12 |
| | **System Audit of Utilities:** Boilers: performance evaluation, loss analysis, water treatment and its impact on boiler losses, furnaces: types and classifications, applications, pumps: types and application, unit's assessment, energy saving in pumps & pumping systems, energy saving in compressors & compressed air systems cooling towers, its types and performance assessment & limitations<br><br>**Energy Audit Instruments:** Instruments for audit and monitoring energy and energy savings, types and accuracy, | 12 |

| | | |
|---|---|---|
| | Indian Electricity Act 1956, Distribution Code and Electricity Bill Act 2003. | |
| **Unit-2** | **Electrical Distribution and Utilization:** Electrical systems, transformers loss reductions, parallel operations, transmission & distribution losses, power factor improvements, demand side management (DSM), load management, harmonics & its improvements, energy efficient motors and soft starters, automatic power factor controllers, variable speed drives, electronic lighting ballasts for lighting, LED lighting, trends and approaches. | 12 |
| | **Energy Management:** Need of energy management. definition and objective of energy management, general principles of energy management, energy management skills, energy management strategy in respect of electrical power plants.<br><br>Projects related to this course should be given to students (in groups) in order to promote team work and ethical values. | 12 |

**Recommended Books-**


1. Bureau of Energy Efficiency, Bureau of Energy Efficiency Handbooks.
2. C.L.Wadhwa, "Generation Distribution & Utilization of Electrical Energy", 3rd edition New Age international, 2015
3. G. Petrecca, "Industrial Energy Management: Principles & applications", Kluwer Academic Publisher, 2012
4. L.C. Witte, P.S. Schmidt, D.R. Brown, "Industrial Energy Management and Utilization", Hemisphere Publication, Washington, 1988
5. J.G.Rau, D.C.Wood ,"Environmental Impact Analysis" Handbook by McGraw Hill.
6. Kumar, Anil, et al. Energy Management: Conservation and Audits. United States, CRC Press, 2020.

**Subject Code : PEEE-621B**
**Title of the course : Non-Linear and Optimal Control**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** access the controllability and observability of a control system.
**CO2:** solve linear time-invariant and time varying control system.
**CO3:** analyze optimal control problems, their classification along with performance indices &their selection, dynamic optimization
**CO4:** recognize features of nonlinear system and analysis of non-linear systems using describing function and phase plane method.
**CO5:** to characterize the Lyapunov stability properties of state space systems.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL3 | BL4 | BL1, BL4 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
| CO1 | 3 | 3 | 3 | - | - | 2 | - | - | 3 | 2 | 2 | 2 | 3 | 2 |
| CO2 | 3 | 3 | - | 3 | 3 | 3 | - | - | 2 | - | 3 | - | 3 | 2 |
| CO3 | 3 | 2 | 3 | - | 2 | 2 | 1 | 1 | 3 | 3 | 2 | 2 | 3 | 2 |
| CO4 | 2 | - | 2 | 2 | 3 | 3 | 1 | - | 2 | 3 | 3 | - | 3 | 2 |
| CO5 | 3 | 3 | 3 | 2 | 2 | 2 | - | 1 | 3 | 3 | - | 2 | 3 | 2 |

| Unit | Main Topics & Course Outline | Hour(s) |
|---|---|---|
| **Unit-1** | Non-Linear Control Systems: Introduction to non-linear feedback control system, different types of non-linearities, special features of non-linear systems: limit cycles, jump resonance and sub harmonics resonance etc., definition of describing function. (D.F.), D.F.'s for various non-linearities, D.F. analysis of non-linear control systems, stability analysis using Limit cycles, and jump resonance. | **08** |
| | Phase Plane Analysis: Phase-plane analysis for nonlinear systems, singular points, construction of phase-plane plots for non -linear systems. | **08** |
| | Lyapunov's Stability Analysis: Introduction, concept of local, global and asymptotic stability, Lyapunov's Stability criterion, the direct method of Lyapunov and the linear systems, methods of constructing Lyapunov function for non-linear system. | **08** |
| | Introduction to Optimal Control: Introduction to optimal control problems, classification of optimal control problems, performance indices for optimal control and their selection, problem formulation using calculus of variation. | **12** |
| | Parametric Optimization: Regulator problem, tracking problem, convex set and convex function, convex optimization problem, quadratic optimization problem, projects related to this course should be given to students (in groups) in order to promote team work and ethical values. | **06** |

| | | |
|---|---|---|
| **Unit-2** | Recorders: Working principle, construction, operation and salient features of strip chart recorder, X-Y recorder and magnetic recorders.<br>Projects related to this course should be given to students (in groups) in order to promote team work and ethical values. | **06** |

**Recommended Books :**


1. Kuo, Benjamin C., and Golnaraghi, Farid. Automatic Control Systems, Tenth Edition. Singapore, McGraw-Hill Education, 2017.
2. J. Nagrath and M. Gopal, "Control System Engineering", New Age, 2009.
3. K.Ogata, "Modern Control Engineering", 5th Edition, Prentice Hall (PHI), 2010.
4. R.C. Dorf and R. H.Bishop, "Modern Control System", 12th Edition, Addison –Wesley, Pearson, New Delhi, 2011.
5. J.G. Proakis and D.G. Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", Pearson Prentice Hall,2007.

**Subject Code : PEEE-621C**

**Title of the course : Telemetry and Data Acquisition**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** analyze various data acquisition systems, their components and applications.
**CO 2:** learn methods of data transmission, transmission channels and different type of modulation.
**CO 3:** describe construction and working principle of digital to analog converters and analog to digital converters.
**CO 4:** acquire knowledge of block diagram, classification and working principle of different telemetry system.
**CO 5:** know about the construction and working principle of display system and recorders.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL4 | BL2 | BL2, BL4 | BL1, BL2 | BL1, BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 2 | 2 | - | 3 | - | 1 | 3 | 3 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 2 | 2 | - | 2 | 3 | - | - | 3 | 3 | 2 | 2 | 3 | 2 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 3 | 1 | - | 2 | 2 | 2 | 2 | 3 | 2 |
| CO4 | 3 | - | 2 | 2 | 3 | 2 | 1 | - | 1 | 3 | 2 | - | 3 | 2 |
| CO5 | 3 | 2 | - | 2 | - | 2 | - | - | 2 | 3 | 2 | - | 3 | 2 |

| Unit | Main Topics and Course Outline | Hour(s) |
|---|---|---|
| Unit-1 | Data Acquisition Systems (DAS): Block diagram of data acquisition system, analog and digital acquisition systems, review of signal conditioning circuits using op amp, single channel data acquisition, multi-channel DAS, computer based DAS, data logger, applications of DAS. | **8** |
| | Data Transmission System: Methods of data transmission, transmission channels and media, analog modulation and demodulation, amplitude, frequency and phase modulation and their circuits, comparison between frequency & amplitude, introduction to ASK, FSK,PSK, pulse modulation (PAM, PDM, PPM, PCM), delta modulation, adaptive data modulation, digital data codes, error correcting and error detecting codes, pulse code formats used in data transmission, radio link, frequency division and time division multiplexing, time division multiplexing using mechanical commutator and electronic time division multiplexing system. | **8** |
| Unit-2 | Signal Converters: Digital to analog(D/A) converters, R-2R and binary weighted type D/A and analog to digital (A/D) converters, flash type, successive approximation type, dual slope type and counting converter type A/D. | **8** |
| | Introduction to Telemetry Principles: Definition, generalized block diagram of telemetry system, classification of telemetry system, working principle, salient features and applications of the following telemetry systems: dc voltage, current and position telemetry system, pulse telemetry system, force balance telemetry system Introduction to satellite telemetry and fiber optic telemetry system, introduction to WDM (wavelength division multiplexing). | **08** |

| | | |
|---|---|---|
| | Display Systems: Construction, principle of operation and salient features of various kinds of display devices. | **08** |
| | Recorders: Working principle, construction, operation and salient features of strip chart recorder, X-Y recorder and magnetic recorders.<br>Projects related to this course should be given to students (in groups) in order to promote team work and ethical values. | **08** |

**Recommended Books-**


1. A K Sawhney, "Electrical and Electronic Measurement and Instrumentation", Dhanpat Rai, 2016.
2. D Patranabis, "Telemetry Principles", Tata McGraw Hill., 1999.
3. E L Gruenberg, "Handbook of Telemetry & Remote Control", Tata McGraw Hill, digitized 2007.
4. H S Kalsi, "Electronic Instrumentation and Measurement",4th Edition, Tata McGraw Hill, 2019.
5. F Carden, R Henry and R Jedlica, "Telemetry system Engineering",2nd Edition, Artech House, 2002.
6. R N Baral, "Telemetry and Data Transmission", S K Kataria and Sons, 2012.

**Subject Code : PEEE-621D**

**Title of the course : Smart Metering and Security System**

| L | T | P | Credits | Hrs |
|---|---|---|---|---|
| 3 | 1 | 0 | 4 | 4 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1**: Understand the key technical threat types, communication protocols and resilient smart grid architectures
**CO 2**: Deploy risk management, operational security and secure development of Smart Grid.
**CO 3**: Assess static and dynamic security analysis techniques to validate.
**CO 4**: Verify smart grid security and resiliency.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL2 | BL3 | BL4 | BL6 |

| CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation): | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs) | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 1 | 1 | 1 | 1 | 1 | 1 | - | - | 2 | 2 | 1 | 2 |
| CO2 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | - | 3 | 2 | 2 | 2 |
| CO3 | 1 | 2 | 2 | 2 | 2 | 1 | - | 1 | 3 | 3 | 2 | 2 |
| CO4 | 1 | 3 | 2 | 2 | 3 | 2 | - | 1 | 3 | 3 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Smart Grid Security Challenges:** Security Goals and Challenges, Importance of security, Classification of the threats, Security Analytics for AMI and SCADA, Security Analytics for EMS Modules, Overview of SMT and Probabilistic Model Checking | 12 |
| | **Security and Data Privacy in Smart Grid:** Security Challenges in Smart Grid Implementation, Legal Protection of Personal Data in Smart Grid and Smart Metering Systems, Phases of smart grid system development cycle, Smart Grid Security and Privacy of Customer-Side Networks, Smart Grid Security Protection against False Data Injection (FDI) Attacks, Smart Grid Security, Secure V2G Connections, End-to-End security with devices/equipment, sensors, controllers, actuators, communication and systems. | 12 |
| **Unit-2** | **Smart Grid Threat and Cross-Domain Risk:** Smart Grid threat Landscape, Smart Grid Risk Assessment, Challenges and solutions, Emerging methods and techniques for the smart grid security. | 12 |
| | **Smart Grid Resiliency and Cyber-attack:** Types of physical attack on smart grid devices, Hardware security modules, Analytics for Smart Grid Security and Resiliency, Cyber security solutions for control and monitoring system, Control centric security tools and risk assessment methodology, Secure Communications in Smart Grid: Networking and Protocols | 12 |

**Recommended Books-**

1 Al-Shaer, Ehab, Rahman and Mohammad Ashiqur, "Security and Resiliency Analytics for Smart Grids', Springer Intr., 1st Edition, 2016.
2 S. Goel, Goel, Y. Hong, V. Papakonstantinou, D. Kloza, "Smart Grid Security", Springer-Verlag, 1st Edition, 2015

3 A. Abdallah and X. Shen, “Security and Privacy in Smart Grid”, Springer Intr., 1st Edition, 2018.
4 Abdul Rahaman et al., ‘Smart grids security challenges: Classification by sources of threat’, Journal of Electrical Systems and Information Technology, 5 (3), pp. 468-483, 2018.
5 A. Abur and A. G. Exposito, “Power System State Estimation: Theory and Implementation”, CRC Press, 1st Edition, 2004.
6 Roy D. Yates, David J. Goodman, “Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers”, Wiley, 3rd Edition, 2014.
7 J. A. Momoh, “Smart Grid: Fundamentals of Design and Analysis” Wiley India, 1st Edition, 2015

**Subject Code : PEEE 711A**

**Title of the course : Wind and Solar Energy Systems**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1**: understand the energy scenario and the consequent growth of the power generation from renewable energy sources.
**CO2**: understand the basic physics of wind and solar power generation.
**CO3**: understand the power electronic interfaces for wind and solar generation.
**CO4**: understand the issues related to the grid-integration of solar and wind energy systems.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL2, BL4 | BL2, BL3 | BL2 | BL2, BL5 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | - | - | 1 | 2 | - | - | 2 | 3 | - | 2 | 3 | 1 |
| CO2 | 2 | - | 1 | - | - | 3 | 2 | - | 2 | 3 | 3 | - | 3 | 2 |
| CO3 | 3 | 2 | 3 | - | 1 | 3 | - | - | 2 | 3 | 3 | 2 | 2 | 2 |
| CO4 | 3 | 2 | 3 | 1 | - | 3 | 2 | - | 2 | 3 | 3 | 2 | 2 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Physics of Wind Power:** History of wind power, Indian and global statistics, wind physics, tip speed ratio, stall and pitch control, wind speed statistics-probability distributions, wind speed and power-cumulative distribution functions. | 06 |
| | **Wind Generator Topologies:** Review of modern wind turbine technologies, fixed and variable speed wind turbines, induction generators, doubly-fed induction generators and their characteristics, permanent-magnet synchronous generators, power electronics converters. generator-converter configurations, converter control. | 10 |
| | **Solar Resources:** Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability. | 08 |
| Unit-2 | **Solar Photovoltaic Generation:** Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, power electronic converters for solar systems, maximum power point tracking (MPPT) algorithms. converter control. | 08 |

| | | |
|---|---|---|
| | **Network Integration Issues:** overview of grid code technical requirements. fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. power quality issues. power system interconnection experiences in the world. hybrid and isolated operations of solar PV and wind systems. | 08 |
| | **Solar Thermal Power Generation:** Technologies, parabolic trough, central receivers, parabolic dish, fresnel, solar pond, elementary analysis.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 08 |

**Recommended Books-**


1. T. Ackermann, "Wind Power in Power Systems", John Wiley and Sons Ltd., 2005.
2. G. M. Masters, "Renewable and Efficient Electric Power Systems**",** John Wiley and Sons, 2004.
3. S. P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", McGraw Hill,1984.
4. H. Siegfried and R. Waddington, "Grid integration of wind energy conversion systems" John Wiley and Sons Ltd.
5. G. N. Tiwari and M. K. Ghosal, "Renewable Energy Applications", Narosa Publications, 2004.
6. J. A. Duffie and W. A. Beckman, "Solar Engineering of Thermal Processes", John Wiley & Sons,1991.
7. Patel, Mukund R., and Beik, Omid. Wind and Solar Power Systems: Design, Analysis, and Operation. United States, CRC Press, 2021.

**Subject Code : PEEE 711**B

**Title of the course : Computational Electromagnetic**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO1:** to refresh the fundamentals of Electromagnetic Field Theory.
**CO2:** to provide foundation in formulation of Electromagnetic Fields using analytical and numerical methods.
**CO3:** to impart in-depth knowledge on Finite Element Method in solving Electromagnetic field problems.
**CO4:** to introduce the concept of mathematical modelling and design of electrical apparatus.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL1 | BL2, BL3 | BL3, BL4 | BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | - | 2 | 2 | 1 | - | 1 | 1 | 2 | - | 2 | 3 | 1 |
| CO2 | 3 | 2 | 2 | 3 | 3 | 2 | - | - | 2 | - | 1 | 2 | 3 | 2 |
| CO3 | 3 | 3 | 3 | - | 3 | 2 | 1 | - | 2 | 2 | 3 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | - | 2 | 2 | 3 | 2 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour |
|---|---|---|
| Unit-1 | **Introduction:** Review of basic field theory – Maxwell's equations – constitutive relationships and continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation. | 06 |
| | **Basic Solution Methods for Field Equations:** Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- finite difference method. | 09 |
| | **Formulation of Finite Element Method (FEM):** Vibrational formulation – energy minimization – discretization – shape functions –stiffness matrix –1D and 2D planar and axial symmetry problems. | 09 |
| Unit-2 | **Computation of Basic Quantities Using Fem Packages:** Basic quantities – energy stored in electric field – capacitance – magnetic field – linked flux – inductance – force – torque – skin effect – resistance. | 12 |
| | **Design Applications:** Design of insulators – cylindrical magnetic actuators – transformers – rotating machines.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 12 |

**Recommended Books-**


1. N.O. Sadiku Matthew, “Elements of Electromagnetics”, Fourth Edition, Oxford University Press, First Indian Edition 2007.
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, “The analytical and numerical solution of Electric and magnetic fields”, John Wiley & Sons, 1993.
3. Nicola Biyanchi , “Electrical Machine analysis using Finite Elements”, Taylor and Francis Group, CRC Publishers, 2005.
4. Nathan Ida, P.A.Bastos Joao, “Electromagnetics and calculation of fields”, Springer Verlage, 1992.
5. S.J Salon, “Finite Element Analysis of Electrical Machines” Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India.
6. Silvester and Ferrari, “Finite Elements for Electrical Engineers” Cambridge University press, 1983.
7. Rylander, Thomas, et al. Computational Electromagnetics. Germany, Springer, 2005.
8. Applied Computational Electromagnetics: State of the Art and Future Trends. Germany, Springer Berlin Heidelberg, 2012.

**Subject Code : PEEE-711C**

**Title of the course : Reliability Engineering**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** study reliability fundamentals and learn the various methods.
**CO2:** understand how the complex system can be reduced to simpler by using reliability methods.
**CO3:** to identify and correct the causes of failures that do occur, despite the efforts to prevent them.
**CO4:** apply the methods for estimate reliability of new designs, and for analyzing reliability data.
**CO5:** to learn the concepts of Reliability, Failure modes, Maintainability and safety aspects.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL2 | BL4 | BL3 | BL1, BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | - | 3 | - | 3 | 2 | - | 1 | - | - | 2 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 3 | - | 3 | 1 | - | 1 | 1 | - | 2 | 3 | 1 |
| CO3 | 3 | 2 | 3 | 2 | 2 | 2 | - | - | 2 | - | 2 | 2 | 3 | 2 |
| CO4 | 2 | 2 | - | 3 | 2 | 2 | - | 1 | 2 | - | 2 | 2 | 3 | 1 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 1 | 3 | 1 | - | 2 | 2 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Reliability Fundamentals:** Introduction, importance of reliability, reliability functions, failure and failure modes, causes of failure, instantaneous failure rate, general reliability function. | 06 |
| | **Component Reliability and Hazard Model:** component reliability from test data, failure data (failure density, failure rate, reliability, probability of failure) mean failure rate MTTF, hazard models (time dependent hazard models, constant hazard model, linear hazard model, on-linear hazard model. | 06 |
| | **System Reliability:** Reliability evaluation of non-maintained systems, series, parallel, series- parallel, non-series, standby configuration, k out of n configuration, complex system, Markov's method, fault tree technique, event space, path tracing methods, cut-set and tie set method. | 12 |
| Unit-2 | **Reliability Improvement:** Introduction, improvement of components, redundancy: standby with perfect and imperfect switching. comparison of component redundancy to system/unit redundancy, mixed redundancy, stand by redundancy. | 06 |
| | **Reliability Allocation:** Introduction, redundancy allocation and techniques for reliability allocation. | 06 |
| | **Availability and Maintainability:** Concepts of reliability ,availability and maintainability, types of availability, objectives of maintenance, classification and factor effecting maintenance, maintenance levels, inventory control of spare parts, preventive maintenance of some electrical appliances. | 12 |

**Recommended Books-**


1. Elsayed, Elsayed A.. Reliability Engineering. United States, Wiley, 2020.
2. A.K. Govil, “Reliability Engineering”, Tata McGraw Hill,1983
3. D.W. Patterson, “Introduction to Artificial Intelligence and Expert Systems”, Prentice Hall,2002.
4. E. Balagurusamy, Reliability Engineering, Tata McGraw Hill,1984
5. Elaine Rich, Kevin Knight, “Artificial Intelligence”, Tata McGraw-Hill,2003
6. K.K.Aggarwal, “Reliability Engineering”, Kluwer academic Publications,1993
7. Reliability Engineering: Methods and Applications. United States, CRC Press, 2019.

**Subject Code : PEEE-711D**

**Title of the course : Computer relaying and phasor unit**

| L | T | P | Credits | Hrs |
|---|---|---|---|---|
| **3** | **1** | **0** | **4** | **4** |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1**: acquaint with the concept of computer relaying of power system.
**CO2:** apply important tools and techniques related with computer relaying of power system.
**CO3:** conceptualize various effects of phase and frequency on power system protection.
**CO4:** assess the results obtained by solving above problems.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL1, BL2 | BL3 | BL4 | BL6 |

| CO/PO Mapping: (Strong (3) / Medium (2) / Weak (1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program specific outcomes (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 1 | - | 2 | - | - | 1 | 1 | - | 1 | 1 | 3 | 2 |
| CO2 | 3 | 1 | 2 | 1 | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 | 3 | 1 |
| CO3 | 3 | 3 | 1 | - | 2 | 1 | 1 | - | 1 | 1 | - | 1 | 1 | 2 |
| CO4 | 3 | 3 | - | 1 | 2 | 1 | - | - | 1 | 1 | 1 | - | 2 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Overview of Relaying practices:** Introduction to protection systems, Functions of a protection system, Magnitude Relays, Directional Relays, Ratio Relays, Differential Relays and Pilot Relays. | 6 |
| | **Introduction to computer relaying:** Development of computer relaying, Historical background, Expected benefits of computer relaying, Computer relay architecture, Substation computer hierarchy | 6 |
| | **Tools and techniques for computer relaying:** Analog to digital converters, Anti-aliasing filters, Fourier series, Walsh functions, Fourier transform, Discrete Fourier transform, probability, and random process, Kalman filter, Digital filters, artificial neural networks, and decision trees | 12 |
| **Unit-2** | **Transmission line relaying:** Introduction, Sources of error, Curve fitting algorithms, Fourier algorithms, Fourier algorithms with shorter windows, Recursive forms, Walsh function algorithms, Differential-equation algorithms, Kalman filter algorithms, Removal of the DC offset, Relay programs based upon fault classification | 10 |
| | **Protection of transformers, machines, and buses:** Power transformer algorithms, Generator protection, Digital bus protection | 06 |
| | **Measurement of frequency and phase:** Introduction, Sampling clock synchronization, Application of phasor measurements to state estimation, Phasor measurements in dynamic state estimation, Wide area measurement systems (WAMS) | 08 |

**Recommended Books-**

1. Phadke, Arun G., and James S. Thorp. Computer relaying for power systems. John Wiley & Sons, 2009.
2. Horowitz, Stanley H., and Arun G. Phadke. Power system relaying. John Wiley & Sons, 2014.
3. Elmore, Walter A. Protective relaying: theory and applications. Vol. 1. CRC press, 2003.
4. Phadke, Arun G., and James S. Thorp. Synchronized phasor measurements and their applications. Vol. 1. New York: Springer, 2008.
5. Wide Area Power Systems Stability, Protection, and Security. Germany, Springer International Publishing, 2020.

**Subject Code : PEEE-712A**

**Title of the course : Soft Computing Techniques**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1:** apply a soft computing methodology for a particular problem.
**CO 2:** exercise fuzzy logic and reasoning to handle uncertainty and solve engineering problems.
**CO 3:** implement genetic algorithms to combinational optimization problems.
**CO 4:** utilize neural networks to pattern classification and regression problems.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL3 | BL6 | BL3, BL6 | BL3 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | - | 3 | 3 | 2 | - | - | - | 2 | 2 | - | 2 | 3 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 2 | - | - | 1 | 2 | 2 | 2 | 2 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | - | - | 2 | 3 | 2 | 2 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | - | 1 | 2 | 3 | 2 | 1 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Fuzzy Logic-I (Introduction):** Basic concepts of fuzzy logic, fuzzy sets and crisp sets, fuzzy set theory and operations, properties of fuzzy sets, fuzzy and crisp relations, fuzzy to crisp conversion. | 08 |
| | **Fuzzy Logic –II (Fuzzy Membership, Rules):** Membership functions, interference in fuzzy logic, fuzzy if-then rules, fuzzy implications and fuzzy algorithms, fuzzy fictions and defuzzificataions, fuzzy controller, industrial applications. | 08 |
| | **Genetic Algorithm(GA):** Basic concepts, working principle, procedures of GA, flow chart of GA, genetic representations, (encoding) Initialization and selection, genetic operators, mutation, generational cycle, applications. | 08 |
| Unit-2 | **Neural Networks-1(Introduction & Architecture):** Neuron, nerve structure and synapse, artificial neuron and its model, activation functions, neural network architecture: single layer and multilayer feed forward networks, recurrent networks. various learning techniques; perception and convergence rule, auto-associative and hetro-associative memory. | 08 |

| | | |
|---|---|---|
| | **Neural Networks-II (Back Propagation Networks):** Architecture: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting back propagation training, applications. | 08 |
| | **Neuro Fuzzy Modelling:** Adaptive neuro-fuzzy inference systems – architecture – hybrid learning algorithm – learning methods that cross-fertilize ANFIS and RBFN – coactive neuro fuzzy modeling – framework neuron functions for adaptive networks – neuro fuzzy spectrum. | 08 |

**Recommended Books-**


1. E. Goldberg Davis, “Genetic Algorithms: Search Optimization and Machine Learning”, Addison Wesley, N.Y., 1989.
2. J.Ross Timothy, “Fuzzy Logic with Engineering Applications”, McGraw-Hill, International Editions, Electrical Engineering Series, Singapore, 1997.
3. J.S.R.Jang, C.T.Sun and E. Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI, 2004, Pearson Education 2004.
4. R.Eberhart, P.Simpson and R.Dobbins, “Computational Intelligence - PC Tools”, AP Professional, Boston, 1996.
5. S. Rajasekaran and G.A.V.Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithms”, PHI, 2003.
6. Soft Computing Techniques in Engineering, Health, Mathematical and Social Sciences. United States, CRC Press, 2021.

**Subject Code : PEEE 712B**

**Title of the course : Electrical and Hybrid Vehicles**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** understand the models to describe hybrid vehicles and their performance.
**CO 2:** understand the different possible ways of energy storage.
**CO 3:** understand the different strategies related to energy storage systems.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | |
|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 |
| **BLs** | BL2, BL4 | BL2 | BL2, BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | - | - | 2 | 2 | - | - | 1 | 2 | 1 | - | 2 | 2 |
| CO2 | 3 | 3 | 2 | 1 | 2 | - | 1 | - | 2 | 2 | - | 2 | 2 | 2 |
| CO3 | 3 | 3 | 2 | - | 2 | 2 | 1 | - | 2 | 2 | 3 | 2 | 3 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Introduction:** Conventional vehicles: basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.<br>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.<br>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. | 10 |
| | **Electric Trains:** 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.<br>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, configuration and control of permanent magnet motor drives, configuration and control of switch reluctance motor drives, drive system efficiency. | 14 |

| | | |
|---|---|---|
| **Unit-2S** | **Energy Storage:** 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, super capacitor based energy storage and its analysis, flywheel based energy storage and its analysis, hybridization of different energy storage devices.<br>sizing the drive system: matching the electric machine and the internal combustion engine (ICE), sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, communications, supporting subsystems | 12 |
| | **Energy Management Strategies:** 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, implementation issues of energy management strategies.<br>case studies: design of a hybrid electric vehicle (HEV), design of a battery electric vehicle (BEV).<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 12 |

**Recommended Books-**


1. C. Mi, M. A. Masrur and D. W. Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical perspectives”, John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.
3. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
4. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016.
5. Husain, Iqbal. Electric and Hybrid Vehicles: Design Fundamentals. United States, CRC Press, 2021.
6. Mi, Chris, and Masrur, M. Abul. Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives. United Kingdom, Wiley, 2017.

**Subject Code : PEEE-712C**

**Title of the course : Virtual Instrumentation**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** exercise basics of digital image generation, processing, sampling and quantization.
**CO 2:** know about image transforms techniques and image enhancement techniques.
**CO 3:** become conversant in 2-D system, spectral density function, estimation and information theory.
**CO 4:** analyse image restoration including models, filters and digital processing.
**CO 5:** develop process of image segmentation, image data compression and associated techniques.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL3 | BL2 | BL3 | BL4 | BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 2 | - | 2 | - | - | - | 1 | 2 | - | 2 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 1 | - | - | 2 | 3 | 2 | 2 | 3 | 3 |
| CO3 | 2 | - | 2 | 3 | 2 | - | 1 | - | 2 | 3 | 2 | 2 | 3 | 3 |
| CO4 | 2 | 2 | 2 | - | 3 | 2 | - | - | 2 | 2 | 3 | 3 | 3 | 3 |
| CO5 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | - | 2 | 3 | 3 | 3 | 3 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Introduction to Virtual Instrumentation:** Historical perspective, classification of different instruments / instrumentation system, definition and architecture of virtual instrumentation system, salient features and application area of virtual instrumentation. | 06 |
| | **Data Flow and Programming Techniques:** Graphical programming in data flow, comparison with conventional programming, popular data flow and VI software packages. Building a VI fron t panel and block diagram, sub VI. | 08 |
| | **ProgrammingTechniques:**Forandwhileloops,caseandsequencestructure,formula nodes, local and global variables, array and clusters, charts and graphs, string and file I/O, event driven programming. | 10 |
| Uuit-2 | **Data Acquisition Basics:** ADC, DAC, D/O, counters and timer, PC hardware structure, timing, interrupts, DMA, software and hardware installation, configuring data acquisition hardware using the drives in application software, use of DAQ library functions for different analog and digital input/output operations. | 06 |
| | **Common Instrument Interfaces:** RS 232, RS485, GBIP. Use of library functions to communicate with different instruments, Introduction to VISA. | 06 |
| | **Applications of VI** Measurement of max, min, peak-peak voltage, time period of a signal, power spectrum and logging Fourier transform, correlation methods, windowing and filtering. | 06 |
| | **Networking in Labview**: Lab view as a Network Client server, Publishing Vis on Web. | 06 |

**Recommended Books:**


1. Sanjay Gupta, “Virtual Instrumentation Using Labview”, 2ndEdition, McGraw Hill Education,2017.
2. J Travis and J Kring, “LabVIEW for Everyone”, 3rd Edition, Prentice Hall India,2006.
3. R Jennings and F D A Queva, “Lab view Graphical Programming”, 5th edition, McGraw-Hill Education,2019.
4. P A Blume, **“**LabVIEW Style Book”, Prentice Hall India,2017.
5. J Jarome, “Virtual Instrumentation using Labview, Prentice Hall India,2010.
6. R Bitter, T Mohiuddin and M Nawrocki, Labview Advanced Programming Techniques2nd edition, CRC Press,2017.

**Subject Code : PEEE-712D**

**Title of the course : POWER SYSTERM COMPENSATION**

| L | T | P | Credits | Hrs |
|---|---|---|---|---|
| **3** | **0** | **0** | **3** | **3** |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1**: learn the role of reactive power compensation to enhance the stability and capability of existing network.

**CO 2**: knowledge of Modern power controllers to enhance the stability and capability of existing network

**CO 3**: apply various controlling mechanisms on FACTS devices

**CO4:** assess the results obtained by solving above problems.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL1 | BL2, BL4 | BL3 | BL5 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Programme Outcomes (POs)/Program specific outcomes (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 1 | 1 | 2 | 1 | - | - | 1 | 1 | - | 1 | 3 | 2 |
| CO2 | 3 | - | 2 | - | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 | 3 | 1 |
| CO3 | 3 | 3 | - | 1 | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | 2 |
| CO4 | 3 | 3 | 1 | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 | 1 | 2 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **Introduction:** Reactive Power Requirement and necessity of Compensation, Objectives in Load Compensation, Dynamic Power Compensation, Passive Compensation: SVC, TCR | 12 |
| | **Classification of FACTS device**: Shunt Compensators: STATCOM - Characteristics and Device selection (GTO/SCR/IGBTs), STATCOM Control Strategies and applications,<br>**Series Compensation:** SSSC - Compensator characteristics and control Strategies, SSC applications | 12 |
| **Unit-2** | **TCSC:** Compensator characteristics and control Strategies, TCSC applications<br>**Series-shunt Compensation:** UPFC Principle of operation, configuration and control, Simulation of UPFC, Steady State Model of UPFC. | 12 |
| | **Sub synchronous resonance**: Definitions and its mitigation with FACTS devices, Power system Control using FACTS devices | 12 |

**Recommended Books-**


1. T J E Miller, Reactive Power Control In Power Systems', John Wiley, 1982
2. Prabha Kundur, Power System Stability and Control
3. N G Hingorani And L Gyugyi, Understanding Facts', IEEE Press, 2000
4. Y.H. Song And A.T. Johns,, Flexible Ac Transmission Systems (Facts)', IEEE Press, 1999
5. Yong-Hua Song And Xi-Fan Wang, Operation Of Market Oriented Power Systems Springer-Verlag Londan, Springer-Verlag Londan
6. Sarma, Mulukutla S., and Vedam, R. Sastry. Power Quality: VAR Compensation in Power Systems. United States, CRC Press, 2017.

**Subject Code : PEEE-721A**

**Title of the course : Power Quality and FACTs**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO1:** understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.
**CO2**: understand the working principles of FACTS devices and their operating characteristics.
**CO3**: understand the basic concepts of power quality.
**CO4**: understand the working principles of devices to improve power quality.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL2 | BL2, BL4 | BL2 | BL2 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 2 | 2 | 3 | 2 | - | - | 2 | 3 | 2 | 2 | 3 | 2 |
| CO2 | 3 | - | 2 | 2 | 3 | 1 | - | - | 1 | 3 | 2 | 2 | 3 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | - | - | 1 | 3 | 2 | 1 | 3 | 1 |
| CO4 | 3 | 2 | - | 2 | 3 | 2 | - | - | 2 | 3 | 3 | 1 | 3 | 2 |

| Unit | Main Topics &Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Transmission Lines and Series/Shunt Reactive Power Compensation:** Basics of AC transmission. analysis of uncompensated AC transmission lines. passive reactive power compensation. shunt and series compensation at the mid-point of an AC line. comparison of series and shunt compensation. | 06 |
| | **Thyristor-Based Flexible AC Transmission Controllers (FACTS):** Description and characteristics of Thyristor-based FACTS devices: Static VAR compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor controlled braking resistor and single pole single throw (SPST) switch. configurations/modes of operation, harmonics and control of svc and TCSC. fault current limiter. | 08 |
| | **Voltage Source Converter Based (FACTS) Controllers:** Voltage source converters (VSC): six pulse VSC, multi-pulse and multi- level converters, pulse-width modulation for VSCs. selective harmonic elimination, sinusoidal PWM and space vector modulation, STATCOM: principle of operation, reactive power control: Type I and Type II controllers, Static synchronous series compensator (SSSC) and unified power flow controller (UPFC): principle of operation and control. working principle of interphase power flow controller. other devices: GTO controlled series compensator. fault current limiter. | 10 |

| | | |
|---|---|---|
| **Unit-2** | **Application of FACTS:** Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single-machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM. | 10 |
| | **Dynamic Voltage Restorer and Unified Power Quality Conditioner:** Reactive power compensation, harmonics and unbalance mitigation in distribution systems using DSTATCOM and shunt active filters. synchronous reference frame extraction of reference currents. current control techniques in for DSTATCOM. voltage sag/swell mitigation: dynamic voltage restorer – working principle and control strategies. series active filtering. unified power quality conditioner (UPQC): working principle. capabilities and control strategies. | 14 |

**Recommended Books-**


1. N.G. Hingorani and L. Gyugyi, “Understanding FACTS: Concepts and Technology of FACTS Systems”, Wiley-IEEE Press, 1999.
2. K.R.Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Ltd. 2007.
3. T.J.E.Miller, “Reactive Power Control in Electric Systems”, John Wiley and Sons, New York, 1983.
4. R.C.Dugan, “Electrical Power Systems Quality”, McGraw Hill Education, 2012.
5. G. T. Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1991
6. Sankaran, C.. Power Quality. Ukraine, CRC Press, 2017.
7. Padiyar, K. R.. Facts Controllers in Power Transmission and Distribution. United Kingdom, Anshan, 2009.

**Subject Code : PEEE 721B**

**Title of the course : Utilization of Electrical Energy**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** acquire the knowledge of different type of electrical heating and welding methods.
**CO 2:** understand the construction and working principle of control devices, need.
**CO 3:** fulfill the objective of utilization application of electrical energy in electrochemical process.
**CO 4:** know about various electrical circuits used in refrigeration, air conditioning and water Coolers.
**CO 5:** analyze the various methods of illumination and electric traction system.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL2 | BL3 | BL1 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 2 | - | 2 | 1 | 1 | - | 3 | 2 | 2 | - | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 2 | 1 | - | 3 | - | 2 | 2 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 2 | - | 2 | - | - | 3 | - | - | 1 | 3 | 3 |
| CO4 | 2 | 2 | 3 | 2 | 2 | 2 | - | - | 3 | 2 | 2 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | - | 3 | 2 | 2 | - | 3 | 3 |

| Unit | Main Topics &Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | Electric Heating: Introduction, advantages of electrical heating, heating methods like resistance heating – direct resistance heating, indirect resistance heating, electric ovens, different types of heating materials, temperature control of resistance furnaces, design of heating element, domestic water heaters and other heating appliances. induction heating – principle, core type and coreless induction furnaces. electric arc heating – direct and indirect arc heating, arc furnaces. dielectric heating –principle and applications in various industrial fields. | **12** |
| | Electric Welding: Welding methods–electric arc wielding and resistance wielding. modern wielding techniques like ultrasonic wielding and laser welding, welding transformer. | **10** |
| **Unit-2** | Electrochemical Process: Need of electro-deposition. applications of faraday's laws in electro-deposition. factors governing electro-deposition. objectives of electroplating. equipment's and accessories for electroplating plant, electroplating on non-conducting material, principle of anodizing and its applications. | **08** |

| | | |
|---|---|---|
| | Illumination: Definitions of flux, solid angle, luminous intensity, illumination, luminous efficiency, depreciation factor, coefficient of utilization, space to height ratio, reflection factor; laws of illumination, calculation of number of light points for interior illuminations; calculation of illumination at different points, simple design problems and illumination schemes, indoor and outdoor illumination level. different sources of light: differences in incandescent and discharge lamps – their construction and characteristics.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | **12** |

**Recommended Books-**


1. Manak Bhavan, IEC standards for Lamps, Lighting Fixtures and Lighting, 2nd Edition, New Delhi, 2000.
2. C. L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, Eastern Wiley Ltd, 1989.
3. E. O. Taylor and V.V.L. Rao, Utilization of Electrical Energy, Orient Longman,1971.
4. J.B Gupta, Utilization of Electric Power and Electric Traction Kataria & Sons, 2009.
5. G. C. Garg, Utilization of Electric Power & Electric Traction, Khanna Publishers, New Delhi,2003.
6. Chaudhari, M. A.. UTILIZATION OF ELECTRICAL ENERGY (22626). India, Nirali Prakashan, 2020.
7. Berg, Ernst Julius. Electrical Energy: Its Generation, Transmission, and Utilization. United Kingdom, Forgotten Books, 2019.

**Subject Code : PEEE-721C**

**Title of the course : Robotics**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** learn the fundamentals of Robotics, various actuators and transmission systems.
**CO 2:** study various sensors for motion, detection and machine vision techniques.
**CO 3:** become conversant in various end effectors, gripping mechanism and arm Kinematics in robots.
**CO 4:** manipulate Robot arm dynamics & trajectory using Lagranges Euler, Newton Euler formulations.
**CO 5:** analyse case studies including hill climbing techniques and robot selection.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL1, BL2 | BL2 | BL6 | BL4 |

| CO/PO Mapping: (Strong(S) / Medium(M) / Weak(W) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 2 | - | 2 | 1 | 1 | - | 3 | 2 | 2 | - | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 3 | 2 | - | - | 3 | 2 | 2 | 2 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | - | 3 | - | - | - | 3 | 3 |
| CO4 | 2 | 2 | 3 | 2 | - | 2 | - | - | 3 | 2 | 2 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | - | 3 | 2 | 2 | - | 3 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Fundamentals of Robot Technology:** Robots in science fiction, automation and robotics, Asimov's laws of Robotics Definition of robot, anatomy of a robot, classification (type of control, capability, configuration and mobility), use of robots, robot motions and degrees of freedom, joint notation scheme, work volume, speed of motion, load carrying capacity, speed of response and stability, precision of movement | 04 |
| | **Actuators & Power Transmission System:** Pneumatic, hydraulic, electric, dc servomotor, stepper motor, ac servomotors.<br>**Power Transmission Systems:** Gears, power screws, pulleys, chains and harmonic drives, horse power, electric motor efficiency. | 08 |
| | **Transducer and Sensors:** Position sensors, potentiometers, resolvers, encoders, velocity sensors, tactile sensors, touch sensors (capacitance, resistance, resistive material, etc.), force sensors (force sensing resistor, capacitance, force sensing wrist, joint sensing, and tactile array sensors), proximity sensors, optical proximity sensors/range sensors (two emitter proximity sensor, ranging light based sensor, LIDAR, etc.), acoustic sensors, magnetic sensors. | 06 |
| | **Machine Vision:** Introduction, sensing and digitalizing function in machine vision, imaging devices, lighting techniques, ADC, image processing and analysis, Image data reduction, segmentation feature extraction, object recognition, training the vision system, robotic applications. | 06 |

| | | |
|---|---|---|
| **Unit-2** | **Robot end Effectors: T**ype of end effectors, mechanical grippers, basic definitions and operations, type of gripper mechanism, other types of grippers (vacuum cups, magnetic grippers, adhesive grippers, and hooks and scoops), tools, the robot to end effector, interface, check list of factors in the selection and design of grippers. | 06 |
| | **Robot Arm Kinematics:** Construction of manipulator, the direct kinematics problem, the inverse kinematics problem, inverse transform techniques for Euler Angles solution, geometrical approach. | 06 |
| | **Robot Arm Dynamics & Planning of Manipulator Trajectories:** Lagrange Euler formulation, kinetic energy of a robot manipulator, potential energy of robot manipulator, motion equations of a manipulator, Newton Euler formulation, rotating coordinate system, moving coordinate system. Joint interpolated trajectory, planning of Cartesian path trajectories, four types of robot controls. | 08 |
| | **Case Studies:** Hill climbing techniques, multiple robots, machine interface, robot cell design, selection of robot.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 04 |

**Recommended Books-**


1. Kaplan and Irvin, “Nuclear Physics”, Narosa,1987.
2. G. F. Knoll, “Radiation, Detection & Measurement”, John Wiley & Sons,1998.
3. P. W. Nicholson, “Nuclear Electronics”, John Wiley,1998.
4. Satoru Goto, “Robot Arms”, InTech,2011.
5. ROBOTICS: MECHANICS AND CONTROL. N.p., PHI Learning Pvt. Ltd., 2019.
6. Robotics: Legal, Ethical and Socioeconomic Impacts. Croatia, IntechOpen, 2017.

**Subject Code : PEEE-721D**

**Title of the course : Power System Restructuring**

| L | T | P | Credits | Hrs |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**

After successful completion of course, the students should be able to

**CO 1**: acquaint students with the new deregulation techniques of power system, planning, control, load forecasting, metering, and risk assessment

**CO2:** describe important concepts related with deregulation like market power, congestion management, demand side management etc.

**CO3:** model and apply cost analysis with deregulation of power sector.

**CO4:** assess the results obtained by solving above problems.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL2 | BL2 | BL3 | BL4 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Programme Outcomes (POs)/Program specific outcomes (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 1 | - | 2 | 1 | - | 1 | 1 | 1 | 1 | 1 | 3 | 2 |
| CO2 | 3 | 1 | 2 | 1 | 2 | 1 | - | 1 | 1 | - | 1 | 1 | 3 | 1 |
| CO3 | 3 | 3 | - | 1 | 2 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | 2 |
| CO4 | 3 | 3 | 1 | 1 | 2 | 1 | - | - | 1 | 1 | - | 1 | 2 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Introduction:** Competitive market for generation, Advantages of competitive generation, role of the existing power industry, electricity demand operation and reliability, renewable generation technologies, energy policy and cost, distributed generation, market regulation, connection and use of system charges, traditional central utility model, independent system operator (ISO), retail electric providers. | 10 |
| | **Wholesale electricity markets**: Definitions, characteristics, bidding, market clearing and pricing, ISO models, market power evaluation, demand side management, distribution planning. | 06 |
| | **Role of the transmission provider**: New Market Organization, multilateral transaction model, power exchange and ISO - functions and responsibilities, classification of ISO types, trading arrangements, power pool, pool and bilateral contracts, multilateral trades. | 08 |
| Unit-2 | **Transmission pricing in open access system**: rolled in pricing methods, marginal pricing methods, embedded cost recovery, open transmission system operation, and congestion management in open access transmission systems in normal operation | 12 |
| | Predicting electricity costs, electricity cost derivation, electricity pricing of inter provincial power market, transmission pricing.<br>**Experiences in restructuring:** Europe, USA, Canada, and Asian countries | 12 |

**Recommended Books-**

1. Power Systems, Third Edition. United Kingdom, Taylor & Francis, 2012.
2. Hadjsaïd, Nouredine, and Sabonnadière, Jean-Claude. Power Systems and Restructuring. United Kingdom, Wiley. 2020
3. Kirschen, Daniel S., and Goran Strbac. Fundamentals of power system economics. John Wiley & Sons, 2018.
4. Fred C. S., Michael C. C., Richard D. T. and Roger E. B., "Spot Pricing of Electricity", Kluwer Academic Publishers. 1988
5. Marija I., Francisco G. and Lester F., "Power Systems Restructuring: Engineering and Economics", Kluwer Academic Publishers.

**Subject Code : PEIE-722A**

**Title of the course : Advanced Microprocessors and Microcontrollers**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1**: study 8086 microprocessor along with its the internal architecture.
**CO 2**: develop knowledge of programming of 8086 microprocessor using assembly language.
**CO 3**: analyze 8051 microcontroller design, memory mapping and serial data transmission.
**CO 4**: be conversant in application of 8051 microcontroller and its architecture and design.
**CO 5**: interfacing of 8086 with Peripheral devices.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL1 | BL2 | BL4 | BL3, BL6 | BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 1 | - | 3 | 2 | - | - | 1 | - | 3 | 2 | 3 | 1 |
| CO2 | 3 | - | 3 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 2 | 2 | - | - | 2 | 2 | 3 | 2 | 3 | 2 |
| CO4 | 3 | 2 | 3 | 2 | 2 | - | 1 | - | 2 | 2 | - | 2 | 3 | 2 |
| CO5 | 3 | 2 | 3 | 2 | 3 | 3 | 1 | - | 2 | 3 | 2 | 3 | 3 | 2 |

| Unit | Main Topics and Course Outline | Hours(s) |
|---|---|---|
| Unit-1 | **Introduction to 16-Bit Microprocessor:** 8086 internal architecture, instruction format, addressing modes, program development steps, and 8086 instruction set, assembler directives, assembly language, program development tools,8086 system connections, timing, troubleshooting: pin-diagram, Max/Min. modes, timing diagrams. | **08** |
| | **Programming of 8086:** Simple sequence programs, jumps, flags, conditional Jumps and sub- programs. | **08** |
| | **Interfacing of 8086:** Memory interfacing, programmable parallel ports & handshake, 8254 software- programmable timer/counter, 8259 a priorities interrupt controller, interfacing a microprocessor to keyboards and alphanumeric displays, D/A converter operation, interfacing and applications, A/D converter specifications | **08** |
| Unit-2 | **Introduction:** Microprocessor, micro-controllers and their comparison. the 8051 architecture: introduction, 8051 micro-controller hardware, input/ output, pins, ports and circuits, external memory, counters and timers, serial data input/ output, interrupts | **08** |
| | 8051 Assembly Language Programming: Instruction format and addressing techniques, instruction set programming | **08** |

| | | |
|---|---|---|
| | **8051 Microcontroller Design:** Micro-controller specification, external memory and memory space decoding, reset and clock circuits, expanding Input/output (I/O), memory mapped I/O, memory address decoding, memory access times, testing the design, timing subroutines, lookup tables for the 8051, serial data transmission.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | **08** |

**Recommended Books-**


1. Ayala, J. Kenneth, The 8051 Micro Controller- Architecture, Programming and Application, .Penram International Publication .
2. Bhanot, Surekha, Oxford Higher Education, 2008.
3. Dunning Gary, Introduction to PLCs. Tata McGraw Hill, 2005.
4. M. A. Mazidi, Mazidi J. G. The 8051 Micro-controller & Embedded System. Pearson Education, 2008.
5. John B. Peatman, Design with Micro Controller. Tata McGraw Hill, 1988.
6. Microprocessors & Microcontrollers. India, UNICORN Publishing Group, 2020.
7. Advanced Processors. India, UNICORN Publishing Group, 2020.

**Subject Code : PEEE 722**B

**Title of the course : High Voltage Engineering**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| **3** | **0** | **0** | **3** | **3** |

**Course Outcomes:**

After successful completion of course, the students should be able to
**CO 1:** develop the concept of high voltage transmission.
**CO 2:** acquire the knowledge of conducting and insulating materials requirements in voltage transmission system.
**CO 3:** gain the knowledge of high voltage generation.
**CO 4:** idea of testing of high voltage equipment's.

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | |
|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 |
| **BLs** | BL2 | BL1, BL2 | BL1 | BL5, BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | - | 2 | 3 | 2 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 3 | 2 | 2 | - | - | 1 | - | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | - | 2 | 2 | 2 | 1 | - | 3 | 2 | - | 2 | 3 | 2 |
| CO4 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | - | 3 | 2 | 2 | 2 | 2 | 2 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| **Unit-1** | **E.H.V. Transmission and Corona Loss;** Need for EHV transmission. use of bundled conductors, corona characteristics of smooth bundled conductors with different configurations, corona loss. factors affecting the corona loss, radio interference due to corona. shunt and series compensation in EHV lines. tuned power lines. insulation co-ordination. | **06** |
| | **HVDC Transmission:** Advantages, disadvantages and economics of HVDC Transmission system. Types of D.C. links, converter station equipment, their characteristics. | **06** |
| | **Lightning and Switching Over-voltages:** Charge formation in clouds, stepped leader, dart leader, lightning surges. switching over voltages, protection against over-voltages, surge diverters, surge modifiers. | **06** |
| | **Conduction and breakdown in Gases, Liquids & Solid Dielectrics:**<br>Solids - Intrinsic, electromechanical and thermal breakdown composite dielectrics, solid dielectrics used in practice.<br>Liquids: - Conduction and breakdown in pure and commercial liquids, suspended particle theory, cavitation and bubble theory, stressed oil volume theory, liquids used in practice. | **06** |

| | | |
|---|---|---|
| | Gases: - Ionization process, Townsend's current growth equations, 1st and 2nd ionization coefficients. Townsend's criterion for breakdown. Streamer theory of breakdown, Pashen's law of Gases, Gases used in practice. | |
| **Unit-2** | **Generation of High Voltages:** D.C., A.C. (Power frequency and High frequency) impulse voltage and impulse current generation tripping and contact of impulse generator. | **08** |
| | **Test procedures in H.V. Engg. Lab.:** Testing of cables, insulators, bushings, circuit breakers and transformers. | **08** |
| | Measurements of High Voltages and Currents : Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements. | **08** |

**Recommended Books-**


1. Rakesh Das Bagamudre, E.H.V. A.C. Transmission Engg.New Age International Publishers.
2. Kimbark, HVDC Transmission, Wiley-Blackwell; Volume 1,1971.
3. Kamaraju and Naidu H.V. Engineering, McGraw Hill Education; 5th Edition,2013.
4. R.S. Jha ,H.V. Engineering, Dhanpat Rai & Sons,1977.
5. Kuffel & Abdullah,H.V. Engineering, Pergamon Press; 1st Edition edition ,1970.
6. C. L. Wadhwa, H. V. Engineering, NEW AGE; 3rd Edition,2012.
7. Küchler, Andreas. High Voltage Engineering: Fundamentals Technology Applications. Germany, Springer Berlin Heidelberg, 2017.
8. High Voltage Engineering and Applications. Switzerland, MDPI AG, 2020.

**Subject Code : PEIE-722C**

**Title of the course : Modelling and Simulation**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** become conversant in systems modelling and their computer simulation.
**CO 2:** know about simulation of continuous and discrete system with various distribution methods.
**CO 3:** analyse simulation experiments, learn to verify results and terminate running simulation.
**CO 4:** develop knowledge of simulation languages, their features and various operations.
**CO 5:** model stochastic network using simulation and its merits.

| Mapping COs/Bloom's Taxonomy Level (BLs) | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL2 | BL2 | BL4 | BL1, BL2 | BL5, BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | - | 2 | - | 2 | 2 | - | - | 1 | - | 2 | 2 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 2 | 2 | 2 | - | - | 1 | 2 | 2 | - | 3 | 3 |
| CO3 | 3 | 3 | 2 | 2 | 1 | 2 | - | - | 2 | 1 | - | 2 | 3 | 3 |
| CO4 | 2 | 2 | - | 1 | 3 | 2 | 1 | - | 1 | 1 | 2 | 2 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 3 | 2 | 1 | 1 | - | 1 | - | 1 | 1 | 3 | 3 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Introduction;** Introduction , systems and models, computer simulation and its applications. | 04 |
| | **System Simulation:** Continuous system simulation, modelling continuous systems, simulation of continuous systems, discrete system simulation, methodology, event scheduling and process interaction approaches, random number generation, testing of randomness, generation of stochastic variates, random samples from continuous distributions, uniform distribution, exponential distribution, erlang distribution, gamma distribution, normal distribution, beta distribution, random samples from discrete distributions: Bernoulli, discrete uniform, Binomial, geometric and Poisson. | 10 |
| | **Evaluation and Validation:** Evaluation of simulation experiments, verification and validation of simulation experiments , statistical reliability in evaluating simulation experiments, confidence intervals for terminating simulation runs. | 10 |
| Unit-2 | **Simulation Languages:** Simulation languages, programming considerations, general features of GPSS, SIM SCRIPT and SIMULA, simulation of queueing systems, parameters of queue, formulation of queueing problems, generation of arrival pattern, generation of service patterns, simulation of single server queues ,simulation of multi-server queues, simulation of random queues. | 12 |

| | | |
|---|---|---|
| | **Simulation of Various Networks:** Simulation of stochastic network, simulation of PERT network, definition of network diagrams, forward pass computation, simulation of forward pass, backward pass computations, simulation of backward pass, determination of float and slack times determination of critical path, simulation of complete network, merits of simulation of stochastic networks.<br>Projects related to this course should be given to students(in groups) in order to promote team work and ethical values. | 12 |

**Recommended Books**


1. N. Deo., "System Simulation Digital Computer", Prentice Hall of India,1983.
2. G. Gordan, "System Simulation", Prentice Hall of India.,1989.
3. Law A.M., Ketton W.D., "Simulation Modelling and Analysis", McGraw Hill,2000.
4. S. S. Rao, Engineering Optimization, 4th Edition, New Age International (P) Ltd.,2009.
5. W B J Zimmerman Process Modeling and Simulation with Finite Element Methods Univ. of Sheffield UK 2004.
6. Pantelides, Costas. Process Modelling and Simulation. N.p., Mdpi AG, 2019.
7. Mujica Mota, Miguel, et al. Robust Modelling and Simulation: Integration of SIMIO with Coloured Petri Nets. Germany, Springer International Publishing, 2017.

**Subject Code : PEEE-722D**

**Title of the course : POWER SYSTEM OPTIMIZATION**

| L | T | P | Credits | Weekly Load |
|---|---|---|---|---|
| 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
After successful completion of course, the students should be able to
**CO 1:** formulate and solve nonlinear programming problems
**CO 2:** solve one dimensional and multidimensional search methods.
**CO 3:** apply search methods to solve constrained and unconstrained optimization Problems.
**CO 4**: apply nature inspired algorithm for engineering problems
**CO 5:** apply optimization to power system generation scheduling

| **Mapping COs/Bloom's Taxonomy Level (BLs)** | | | | | |
|---|---|---|---|---|---|
| **COs** | CO1 | CO2 | CO3 | CO4 | CO5 |
| **BLs** | BL3 | BL3, BL4 | BL6 | BL6 | BL3, BL6 |

| CO/PO Mapping: (Strong(3) / Medium(2) / Weak(1) indicates strength of correlation): | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COs | Program Outcomes (POs)/Program Special Outcome (PSO's) | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | - | 1 | - | 3 | - | - | 2 | 2 | - | 3 | 1 | 1 |
| CO2 | 3 | 2 | 2 | 1 | - | 3 | - | - | 3 | 3 | 3 | 2 | 2 | 2 |
| CO3 | 3 | 2 | - | - | 2 | 2 | 1 | - | 3 | 3 | 3 | 2 | 3 | 2 |
| CO4 | 3 | 2 | 2 | - | 2 | 3 | 1 | - | 3 | 3 | 2 | - | 3 | 1 |
| CO5 | 3 | 3 | 3 | 1 | 2 | 2 | - | 1 | 3 | 3 | 3 | 2 | 3 | 1 |

| Unit | Main Topics and Course Outlines | Hour(s) |
|---|---|---|
| Unit-1 | **Non-linear Programming:**<br>Unconstrained problems of Maxima and Minima, Constrained problems of Maxima and Minima: Equality and inequality constraints, Variable Elimination Method LaGrange Method, Kuhn Tucker conditions. Penalty function approach Quadratic programming: Wolfe's Modified simplex method. | 8 |
| | **Optimization Techniques**<br>**One- dimensional search methods:** Sequential search, Bracketing method, Interval Halving Method, Fibonacci search, Simplex search method, Bisection method, Secant Method, Newton Raphson Method<br>**Multi-dimensional search methods:**<br>Univariate search, gradient methods- steepest descent / ascent methods, conjugate gradient method: Davidson-Fletcher-Powell, Newton Raphson Method | 12 |
| Unit-2 | **Nature-inspired Optimization Techniques:**<br>Evolution in Nature-Fundamentals of Evolutionary Algorithms-Working Principles of Genetic Algorithm, Genetic Operators: Selection, Crossover and Mutation, Issues in GA implementation, anatomy of a particle equations based on velocity and positions -PSO topologies - control parameters. Differential Evolution methods | 8 |
| | Economic load dispatch of thermal units, Optimal hydrothermal scheduling, multi-objective generation scheduling, Particle swarm optimization and differential evolutional for Generation scheduling, Dynamic Programming, Unit commitment, | 12 |

**Recommended Books-**


1. D.P. Kothari and J.S. Dhillon, Power System Optimization, 3rd Ed. Prentice Hall of India
2. S.S. Rao, "Engineering Optimization: Theory and Practice", 4rd Ed, New Age International.
3. Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples", PHI
4. Xin-She Yang, "Recent Advances in Swarm Intelligence and Evolutionary Computation", Springer International Publishing, Switzerland.
5. Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", John Wiley & Sons.
6. Rajasekaran S, Pai, G.A. Vijaya Lakshmi., "Neural networks, Fuzzy logic and Genetic Algorihms: Synthesis and Applications", 2nd Ed.Prentice Hall of India.


Departmental BOS Committee Members:

| | | | |
|---|---|---|---|
| **1** | **Dr. Rishabh Verma** | **2. Dr. Mohan Kashyap** | **3. Dr. Manpreet Singh Manna** |
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