# CURRICULUM AND DETAILED SYLLABI

# FOR

# B.E. EEE DEGREE PROGRAMME

## FOR THE STUDENTS ADMITTED IN THE

## ACADEMIC YEAR 2018-19 ONWARDS

**THIAGARAJAR COLLEGE OF ENGINEERING**
(A Government Aided Autonomous Institution affiliated to Anna University)
**MADURAI – 625 015, TAMILNADU**

Phone: 0452 – 2482240, 41
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## VISION

Transforming the individuals into globally competent electrical engineers to fulfill the technological needs of the society.

## MISSION

Establishing world class infrastructure in Electrical Engineering.

Enhancing the knowledge of the faculty in cutting edge technologies through continuous improvement programmes.

Providing well balanced curriculum in graduate, postgraduate and doctoral programmes.

Adopting innovative content delivery, assessment and continuous improvement methods to achieve desired outcomes.

Facilitating industry institution interaction in teaching & learning, consultancy and research activities to accomplish the technological needs of the society.

Encouraging the faculty and students to carry out innovative research work.

Practicing ethical standards by the faculty and students.

Motivating the students for active participation in co-curricular and extracurricular activities.

## Specialization in B.E. EEE Degree Programme

- Electrical Energy Systems
- Analog & Digital Electronic Systems
- Control & Automation
- Power Electronics & Drives

## Programme Educational Objectives (PEO's)

**PEO1:** Graduates of the programme will have successful career in chosen technical or professional fields.

**PEO2:** Graduates of the programme will have technical competency in solving challenging societal tasks in ethical and economical manner.

**PEO3:** Graduates of the programme will reveal lifelong learning and team work in their chosen profession.

## Programme Outcomes (POs) for B.E. Electrical and Electronics Engineering

After the successful completion of the B.E. Electrical and Electronics Engineering degree programme, the students should be able to:

**PO1 Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

**PO2 Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO3 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.

**PO4 Conduct investigations of complex problems**: The problems:

- that cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline.
- that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions.
- that require consideration of appropriate constraints/requirements not explicitly given in the problem statement. (like: cost, power requirement, durability, product life, etc.).
- which need to be defined (modeled) within appropriate mathematical framework.
- that often require use of modern computational concepts and tools.

**PO5 Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering 21 activities with an understanding of the limitations.

**PO6 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.

**PO7 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.

**PO8 Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

**PO9 Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO10 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.

**PO11 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.

**PO12 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.

**PEO-PO Mapping**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PEO1** | | | | | | | | | | | | |
| **PEO2** | | | | | | | | | | | | |
| **PEO3** | | | | | | | | | | | | |

<u>**Programme Specific Outcomes (PSO):**</u>

After the successful completion of the B.E. Electrical and Electronics Engineering degree programme, the students will be able to:

**PSO1: Design and analyze components/ systems that effectively generate, transmit, distribute and utilize electrical power.**

**PSO2: Design and analyze modern industrial electronic systems/components to perform analog and digital processing and control functions**

**PEO- Mission mapping**

| PEO | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 |
|---|---|---|---|---|---|---|---|---|
| PEO1 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 3 |
| PEO2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 3 |
| PEO3 | 1 | 2 | 3 | 2 | 3 | 2 | 1 | 3 |

1 – Low;   2 – Medium;   3 – Strong

**Credit Distribution**

| S.No | Category | Credits (Regular) | Credits (Lateral Entry) |
|---|---|---|---|
| A | **Foundation Courses** | **53-58** | **23-28** |
| | Humanities and Social Science (HSS) | **9 -11** | **6-8** |
| | Basic Science (BS) | **21** | **6** |
| | Engineering Science (ES) | **23 -26** | **11-14** |
| B | Professional Core Courses | **55** | **45** |
| C | **Elective Courses** | **24 - 48** | **24 - 48** |
| | Programme specific Elective | **12-24** | **12-24** |
| | Programme Elective for Expanded Scope | **6 – 12** | **6 – 12** |
| | General Elective | **3-6** | **3-6** |
| | Foundation Elective | **3-6** | **3-6** |
| D | Project work, seminar, internship in industry or at Higher Learning institutions | **15** | **15** |
| E | Mandatory Courses prescribed by AICTE/UGC **(Not to be included for CGPA)** | **-** | **-** |
| | Minimum Credits to be earned for the award of the Degree | **160 ( from A to D) and the successful completion of Mandatory Courses** | **120 ( from A to D) and the successful completion of Mandatory Courses** |

- General electives are courses offered by different departments that do not have any prerequisites and could be of interest to students of any branch
- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College

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**CHOICE BASED CREDIT SYSTEM**

Categorization of Courses

**Degree: B.E.** **Programme: EEE** **Batch: 2018-19 onwards**

## A. FOUNDATION COURSES: Total Credits to be earned: (53-58)

### a. Humanities and Social Science (09-11)

| S.No. | Course Code | Name of the Course | Number of Hours / Week | | | Credit | Prerequisites (Updated) |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | | |
| | | **THEORY** | | | | | |
| 1. | 18EG140 | English | 2 | - | - | 2 | Nil |
| 2. | 18EE540 | Accounting and Finance | 3 | - | - | 3 | Nil |
| 3. | 18EE490 | Project Management | 3 | - | - | 3 | Nil |
| | | **THEORY CUM PRACTICAL** | | | | | |
| 1. | 18EG460 | Professional Communication | - | 1 | 2 | 2 | Nil |
| | | **PRACTICALS** | | | | | |
| 1. | 18EG170 | English Laboratory | - | - | 2 | 1 | Nil |

### b. Basic Science (21)

| S.No. | Course Code | Name of the Course | Number of Hours / Week | | | Credit | Prerequisites (Updated) |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | | |
| | | **THEORY** | | | | | |
| 1. | 18MA110 | Engineering Calculus | 3 | 1 | - | 4 | Nil |
| 2. | 18PHB20 | Physics | 3 | - | - | 3 | Nil |
| 3. | 18CHB30 | Chemistry | 3 | - | - | 3 | Nil |
| 4. | 18MA210 | Matrices and Ordinary Differential Equations | 3 | - | - | 3 | Nil |
| 5. | 18EE310 | Numerical methods and Complex variables | 3 | - | - | 3 | Nil |
| 6. | 18EE410 | Probability and Random processes | 3 | - | - | 3 | Nil |
| | | **PRACTICALS** | | | | | |
| 1. | 18PH180 | Physics Laboratory | - | - | 2 | 1 | Nil |
| 2. | 18CH190 | Chemistry Laboratory | - | - | 2 | 1 | Nil |

### c. Engineering Science (23-26)

| S.No. | Course Code | Name of the Course | Number of Hours / Week | Credit | Prerequisites (Updated) |
|---|---|---|---|---|---|

| | | | L | T | P | | |
|---|---|---|---|---|---|---|---|
| | | **THEORY** | | | | | |
| 1. | 18ES150 | Engineering Exploration | 3 | - | - | 3 | Nil |
| 2. | 18EE220 | Materials Science for Electrical Engineering | 3 | - | - | 3 | Nil |
| 3. | 18ES390 | Design Thinking | 1 | - | 2 | 2 | Nil |
| 4. | 18ES590 | System Thinking | 1 | - | 2 | 2 | Nil |
| 5. | 18EE620 | Data Structures | 3 | - | - | 3 | 18EE360 |
| 6. | 18XXEX0 | Elective | | | | 3 | Nil |
| | | **THEORY CUM PRACTICAL** | | | | | |
| 1. | 18ME160 | Engineering Graphics | 3 | - | 2 | 4 | Nil |
| 2. | 18EE360 | C and C++ Programming | 2 | - | 2 | 3 | Nil |
| | | **PRACTICALS** | | | | | |
| 1. | 18EE280 | Electrical Workshop | - | - | 2 | 1 | Nil |
| 2. | 18ES290 | Lateral Thinking | - | - | 2 | 1 | Nil |

## B. PROFESSIONAL CORE COURSES    Credits to be earned: (55)

| CDIO Curricular component | Course Code | Name of the Course | Number of Hours / Week | | | Credit | Prerequisites (Updated) |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | | |
| | | **THEORY** | | | | | |
| 1.2.1 | 18EE230 | Electric Circuit Analysis | 3 | - | - | 3 | Nil |
| 1.2.2 | 18EE240 | Electromagnetic Fields | 2 | 1 | - | 3 | Nil |
| 1.2.3 | 18EE250 | Electronic devices and circuits | 3 | - | - | 3 | Nil |
| 1.2.4 | 18EE320 | DC Machines and Transformers | 3 | - | - | 3 | Nil |
| 1.2.5 | 18EE330 | Linear Integrated Circuits | 3 | - | - | 3 | Nil |
| 1.2.6 | 18EE340 | Digital Systems | 2 | 1 | - | 3 | Nil |
| 1.2.7 | 18EE350 | Signals and Systems | 3 | - | - | 3 | Nil |
| 1.2.8 | 18EE420 | AC Machines | 3 | - | - | 3 | Nil |
| 1.2.9 | 18EE430 | Measurements and Instrumentation | 3 | - | - | 3 | Nil |
| 1.2.10 | 18EE440 | Control Systems | 2 | 1 | - | 3 | Nil |
| 1.2.11 | 18EE510 | Generation, Transmission and Distribution | 2 | 1 | - | 3 | 18EE320<br>18EE420 |
| 1.2.12 | 18EE520 | Microcontrollers | 3 | - | - | 3 | 18EE340 |
| 1.2.13 | 18EE530 | Power Electronics | 3 | - | - | 3 | Nil |
| 1.2.14 | 18EE610 | Power System Analysis | 3 | - | - | 3 | 18EE420 |
| 1.2.15 | 18EE710 | Electric Power Utilization | 3 | - | - | 3 | 18EE320<br>18EE420 |
| | | | | | | | |
| | | **PRACTICALS** | | | | | |
| 1.2.3 | 18EE270 | Electronic Devices and Circuits Lab | - | - | 2 | 1 | Nil |
| 1.2.4 | 18EE370 | DC Machines and Transformers Lab | - | - | 2 | 1 | Nil |
| 1.2.5 & | 18EE380 | Integrated Circuits Lab | - | - | 2 | 1 | Nil |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.2.6 | | | | | | | |
| 1.2.9 | 18EE470 | Measurement & Instrumentation Lab | - | - | 2 | 1 | Nil |
| 1.2.8 | 18EE480 | AC Machines Lab | - | - | 2 | 1 | Nil |
| 1.2.12 | 18EE570 | Microcontrollers Lab | - | - | 2 | 1 | Nil |
| 1.2.10 | 18EE580 | Control & Automation Lab | - | - | 2 | 1 | Nil |
| 1.2.11 | 18EE670 | Energy Management System Laboratory | - | - | 2 | 1 | Nil |
| 1.2.13 & 14 | 18EE680 | Power Electronics and Drives Lab | - | - | 2 | 1 | Nil |
| 1.2.15 | 18EE770 | Electric Power Systems Laboratory | - | - | 2 | 1 | Nil |

**C. ELECTIVE COURSES: Credits to be earned: (24-48)**

a. Programme Specific Electives Credits to be earned:12-24

| S.No. | Course code | Name of the Course | Number of Hours / Week | | | Credit | Prerequisites (Updated) |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | | |
| | | **ELECTRICAL ENERGY SYSTEMS** | | | | | |
| | **THEORY** | | | | | | |
| 1 | 18EEPE0 | Power System Operation and Control | 3 | - | - | 3 | 18EE440 |
| 2 | 18EEPF0 | Electrical Machine Design | 2 | 1 | - | 3 | 18EE320<br>18EE420 |
| 3 | 18EEPG0 | Switchgear and Protection | 3 | - | - | 3 | Nil |
| 4 | 18EEPT0 | Wind and Solar Technology | 3 | - | - | 3 | Nil |
| 5 | 18EERC0 | Principles of Energy Conservation | 3 | - | - | 3 | Nil |
| 6 | 18EERD0 | Operation and Maintenance of Electrical equipment | 3 | - | - | 3 | 18EE320<br>18EE420<br>18EE510 |
| | | **ANALOG AND DIGITAL ELECTRONIC SYSTEMS** | | | | | |
| | **THEORY** | | | | | | |
| 7 | 18EEPH0 | VLSI Design | 3 | - | - | 3 | 18EE340 |
| 8 | 18EEPQ0 | Automotive Electronics | 3 | - | - | 3 | 18EE340<br>18EE430 |
| 9 | 18EERG0 | Industrial Electrical and Electronics | 3 | - | - | 3 | Nil |
| 10 | 18EERH0 | Testing & Certification of Automotive Electrical and Electronic Systems | 3 | - | - | 3 | 18EEPQ0 |
| 11 | 18EERL0 | Manufacturing of Automotive Electrical and Electronic Parts | 3 | - | - | 3 | Nil |
| | **THEORY CUM PRACTICAL** | | | | | | |
| 12 | 18EEPJ0 | FPGA based System Design | 2 | - | 2 | 3 | 18EE340 |
| 13 | 18EEPK0 | Digital Signal Processing | 2 | - | 2 | 3 | 18EE350 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14 | 18EEPN0 | Embedded Systems Design | 2 | - | 2 | 3 | 18EE520 |
| | | | | | | | |
| | | **CONTROL AND AUTOMATION** | | | | | |
| | **THEORY** | | | | | | |
| 15 | 18EEPA0 | Control System Design | 3 | - | - | 3 | 18EE350<br>18EE440 |
| 16 | 18EEPR0 | Automotive Fundamentals and Manufacturing | 3 | - | - | 3 | Nil |
| 17 | 18EERF0 | Industrial instrumentation | 3 | - | - | 3 | Nil |
| | **THEORY CUM PRACTICAL** | | | | | | |
| 18 | 18EEPS0 | Soft Computing | 2 | - | 2 | 3 | Nil |
| | | **POWER ELECTRONICS AND DRIVES** | | | | | |
| 19 | 18EEPU0 | Drives and Control | 3 | - | - | 3 | 18EE320<br>18EE420<br>18EE530 |
| 20 | 18EEPV0 | FACTS and Custom Power Devices | 3 | - | - | 3 | 18EE510<br>18EE530 |
| 21 | 18EEPY0 | Power Quality | 3 | - | - | 3 | 18EE510<br>18EE530 |
| 22 | 18EERA0 | Power Electronics for Renewable Energy Systems | 3 | - | - | 3 | 18EE530 |

b. Programme Specific Elective for Expanded Scope Credits to be earned: 06-12

| S.No. | Course Code | Name of the Course | Number of Hours / Week | | | Credit | |
|---|---|---|---|---|---|---|---|
| | | | L | T | P | | |
| **ELECTRICAL ENERGY SYSTEMS** | | | | | | | |
| | **THEORY** | | | | | | |
| 1 | 18EEPC0 | Design of Electrical Installations | 3 | - | - | 3 | 18EE320<br>18EE420 |
| 2 | 18EEPD0 | Smart Grid | 3 | - | - | 3 | Nil |
| 3 | 18EE1E0 | Thermal power plant instrumentation & control | 1 | - | - | 1 | Nil |
| | | **ANALOG AND DIGITAL ELECTRONIC SYSTEMS** | | | | | |
| | **THEORY** | | | | | | |
| 4 | 18EEPL0 | Biomedical Instrumentation | 3 | - | - | 3 | Nil |
| 5 | 18EEPM0 | Real Time Operating System | 3 | - | - | 3 | 18EE520 |
| | | **CONTROL AND AUTOMATION** | | | | | |
| | **THEORY** | | | | | | |
| 6 | 18EEPB0 | Operation Research | 3 | - | - | 3 | Nil |
| 7 | 18EEPP0 | Robotics | 3 | - | - | 3 | 18EE440 |
| 8 | 18EERJ0 | Quality Engineering | 3 | - | - | 3 | Nil |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 | 18EERK0 | Reliability Engineering | 3 | - | - | 3 | Nil |
| 10 | 18EE1D0 | Industrial control systems | 1 | - | - | 1 | Nil |
| | | **POWER ELECTRONICS AND DRIVES** | | | | | |
| | | **THEORY** | | | | | |
| 11 | 18EEPW0 | HVDC Transmission | 3 | - | - | 3 | 18EE510<br>18EE530 |
| 12 | 18EEPZ0 | Special Machines and Drives | 3 | - | - | 3 | 18EE320<br>18EE420 |
| 13 | 18EE1A0 | Design of Power Supplies | 1 | - | - | 1 | 18EE330 |
| 14 | 18EE1B0 | Lead Acid Battery Technology | 1 | - | - | 1 | Nil |
| 15 | 18EE1C0 | Introduction to power electronics system for XEVS | 1 | - | - | 1 | 18EE530 |
| | | **THEORY CUM PRACTICAL** | | | | | |
| 16 | 18EERB0 | Simulation of Power Electronic Systems | 2 | - | 2 | 3 | 18EE530 |

c. General Elective — Credits to be earned: 03-06

d. Electives from foundation courses- HSS, BS, ES — Credits to be earned: 03-06

## D. Project — Credits to be earned: 15

| S.No | Course code | Course Name | Credits |
|---|---|---|---|
| 1 | 18ES690 | Engineering Design Project | 3 |
| 2 | 18ES790 | Capstone Design Project | 3 |
| 3 | 18EE810 | Project | 9 |

## E. Mandatory Courses (Not included for CGPA)

Environment Science, Induction Programme, Indian Constitution, Essence of Indian Tradition knowledge( as per UGC guideline)

Minimum credits to be earned for the award of the degree =160 (From A to D) for Regular students and 120 (From A to D) for Lateral entry students.

**SCHEDULING OF COURSES (B.E.EEE. Programme) – 2018-19 admitted Batch**

| Semester | Theory | | | | | TCP | Practical | | | Mandatory Audit Courses | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| I | 18MA110 Engineering Calculus (4) | 18PHB20 Physics (3) | 18CHB30 Chemistry (3) | 18EG140 English (2) | 18ES150 Engineering Exploration (3) | 18ME160 Engineering Graphics (4) | 18EG170 English Laboratory (1) | 18PH180 Physics Laboratory (1) | 18CH190 Chemistry Laboratory (1) | - | 22 |
| II | 18MA210 Matrices and Ordinary Differential Equations (3) | 18EE220 Materials Science for Electrical Engineering (3) | 18EE230 (3) Electric Circuit Analysis | 18EE240 Electromagnetic Fields (3) | 18EE250 Electronic Devices and Circuits (3) | | 18EE270 (1) Electronic Devices and Circuits Lab | 18EE280 Electrical Workshop (1) | 18ES290 Lateral Thinking (1) | 18CHAA0 Environmental Science | 18 |
| III | 18EE310 Numerical methods and Complex variables (3) | 18EE320 (3) DC machines and Transformers | 18EE330 (3) Linear Integrated circuits | 18EE340 (3) Digital Systems | 18EE350(3) Signals and Systems | 18EE360 (3) C and C++ Programming | 18EE370 (1) DC Machines and Transformers Lab | 18EE380 (1) Integrated Circuits Lab | 18ES390 Design Thinking (2) | - | 22 |
| IV | 18EE410 Probability and Random processes (3) | 18EE420 (3) AC Machines | 18EE430 (3) Measurements and Instrumentation | 18EE440 (3) Control Systems | FE (3 credit Elective course) | 18EG460 Professional Communication (2) | 18EE470 Measurements and Instrumentation Lab (1) | 18EE480 (1) AC Machines Lab | 18EE490 Project Management (3) | 18CHAB0 Constitution of India | 22 |
| V | 18EE510 (3) Generation, Transmission and Distribution | 18EE520 (3) Micro Controllers | 18EE530 (3) Power Electronics | 18EE540 Accounting and Finance (3) | GE (3 credit Elective course) | PE (3 credit Elective course) | 18EE570 (1) Micro Controllers Lab | 18EE580 (1) Control & Automation Lab- | 18ES590 System Thinking (2) | 18CHAC0 Essence of Indian Knowledge | 22 |
| VI | 18EE610 (3) Power System Analysis | 18EE620 (3) Data Structures | PE (3 credit Elective course) | PE/ FE (3 credit Elective course) | Engineering Sciences Elective (3) | | 18EE670 (1) Energy Management System Laboratory | 18EE680 (1) Power Electronics & Drives Lab | 18ES690 Engineering Design Project (3) | - | 20 |
| VII | 18EE710 (3) Electric Power Utilization | PE (3 credit Elective course) | PE (3 credit Elective course) | PE/ GE (3 credit Elective course) | PE (3 credit Elective course) | - | 18EE770 (1) Electric Power Systems Laboratory | - | 18ES790 Capstone Design Project (3) | - | 19 |
| VIII | PE (3 credit Elective course) | PE/ FE (3 credit Elective course) | - | - | - | - | - | - | 18EE810 Project (9) | - | 15 |

**Total Credits:** **160**

| Colour code | Category |
|---|---|
| | **Foundation Courses** |
| | Humanities and Social Science (HSS) |
| | Basic Science (BS) |
| | Engineering Science (ES) |
| | **Professional Core Courses** |
| | Electrical Energy System Courses |
| | Analog & Digital Electronic System Courses |
| | Control & Automation Courses |
| | Power Electronics & Drives Courses |
| | **Elective Courses** |
| | Programme specific Elective / Programme Elective for Expanded Scope (PE) |
| | General Elective (GE) |
| | Foundation Elective (FE) |
| | **Project work** |
| | **Mandatory Courses** |

**CURRICULUM AND DETAILED SYLLABI**

**FOR**

**B.E. / B.Tech. DEGREE PROGRAMME**

**FIRST SEMESTER**

**FOR THE STUDENTS ADMITTED IN THE**

**ACADEMIC YEAR 2018-19 ONWARDS**


## THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided ISO 9001:2008 certified Autonomous Institution affiliated to Anna University)

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**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**
**B.E. / B.Tech. Degree Programmes**

**COURSES OF STUDY**
(For the candidates admitted from 2018-19 onwards)

**FIRST SEMESTER**

| Course Code | Name of the Course | Category | No. of Hours / Week | | | credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| 18MA110 | Engineering Calculus | BS | 3 | 1 | - | 4 |
| 18PHA20/ 18PHB20/ 18PHC20 | Physics | BS | 3 | - | - | 3 |
| 18CHA30/ 18CHB30/ 18CHC30 | Chemistry | BS | 3 | - | - | 3 |
| 18EG140 | English | HSS | 2 | - | - | 2 |
| 18ES150 | Engineering Exploration | ES | 3 | - | - | 3 |
| **THEORY CUM PRACTICAL** | | | | | | |
| 18ME160 | Engineering Graphics | ES | 3 | - | 2 | 4 |
| **PRACTICAL** | | | | | | |
| 18EG170 | English Laboratory | HSS | - | - | 2 | 1 |
| 18PH180 | Physics Laboratory | BS | - | - | 2 | 1 |
| 18CH190 | Chemistry Laboratory | BS | - | - | 2 | 1 |
| | | | | | | |
| **Total** | | | **17** | **1** | **8** | **22** |

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science

L : Lecture
T : Tutorial
P : Practical

**Note**:
1 Hour Lecture is equivalent to 1 credit
1 Hour Tutorial is equivalent to 1 credit
2 Hours Practical is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**
**B.E. / B.Tech. Degree Programme**

**SCHEME OF EXAMINATIONS**
(For the candidates admitted from 2018-19 onwards)

**FIRST SEMESTER**

| S.No. | Course Code | Name of the Course | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam ** | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | 18MA110 | Engineering Calculus | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | 18PHA20/ 18PHB20/ 18PHC20 | Physics | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | 18CHA30/ 18CHB30/ 18CHC30 | Chemistry | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | 18EG140 | English | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | 18ES150 | Engineering Exploration | 3 | 50 | 50 | 100 | 25 | 50 |
| **THEORY CUM PRACTICAL** | | | | | | | | |
| 6 | 18ME160 | Engineering Graphics | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 7 | 18EG170 | English Laboratory | 3 | 50 | 50 | 100 | 25 | 50 |
| 8 | 18PH180 | Physics Laboratory | | | | | | |
| 9 | 18CH190 | Chemistry Laboratory | 3 | 50 | 50 | 100 | 25 | 50 |

* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

| 18MA110 | ENGINEERING CALCULUS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 3 | 1 | 0 | 4 |

## Preamble

This course aims to convey to the student a sense of the utility of calculus and develop technical competence. This course is designed to implement the calculus through geometrically, numerically, algebraically and verbally. Students will apply the main tools for analyzing and describing the behavior of functions of single and multi variables: limits, derivatives, integrals of single and multi variables to solve complex engineering problems using analytical methods and MATLAB.

## Prerequisite

NIL

## Course Outcomes

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Understand the concept of functions, limits and continuity | Understand |
| CO2 | Compute derivatives and apply in solving engineering problems | Apply |
| CO3 | Employ partial derivatives to find maxima minima of functions of multi variables | Apply |
| CO4 | Demonstrate and apply the techniques of integration | Apply |
| CO5 | Apply integrals of multivariable to find areas enclosed between two curves and volume enclosed between surfaces | Apply |

## Mapping with Programme Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | S | M | | | | | | | | |
| CO2 | S | S | M | M | | | | | | | | |
| CO3 | S | S | S | M | | | | | | | | |
| CO4 | S | S | S | M | | | | | | | | |
| CO5 | S | S | S | M | | | | | | | | |
| S- Strong; M-Medium; L-Low | | | | | | | | | | | | |

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | 0 |
| Understand | 30 | 30 | 30 | 30 |
| Apply | 60 | 60 | 60 | 70 |
| Analyse | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

## Course Level Assessment Questions

**Course Outcome 1(CO1)**

1. Define function and limit.
2. Estimate the value of $\lim\limits_{x\to 0}\dfrac{\sin x}{\sin \pi x}$.
3. If $f(x)$ is continuous on $(-\infty,\infty)$, what can you say about its graph?

**Course Outcome 2(CO2)**

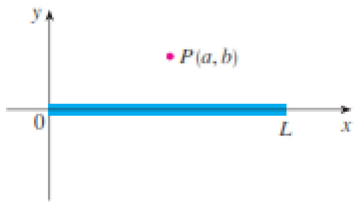
1. What is wrong with this equation $\frac{x^2+x-6}{x-2}=x+3$ and investigate why the equation $\lim\limits_{x\to 2}\dfrac{x^2+x-6}{x-2}=\lim\limits_{x\to 2}(x+3)$ is correct.
2. Between $0^oC$ and $30^0C$ , the volume V ( in cubic centimeters) of 1 kg of water at a temperature T is given approximately by the formula V = 999.87 - 0.06426T + $0.0085043T^2$ - $0.0000679T^3$ , Compute the temperature at which water has its maximum density.
3. The voltage, *v*, across a capacitor of capacitance*,* in series with a resistor of resistance, *v*, is given by $(t+1)e^{-1000\,t}$ where *C =1μF, E > 0,* is a constant. Determine *i* where $i = C\frac{dv}{dt}$.

**Course Outcome 3(CO3)**

1. Define partial derivative of a function of two variables.
2. Suppose that the temperature at a point $(x, y, z)$ in space is given by $T(x, y, z)=\dfrac{80}{1+x^2+2y^2+3z^2}$ , where $T$ is measured in degrees Celsius and $(x, y, z)$ in meters. In which direction does the temperature increase fastest at the point $(1,1,-2)$ ? Identify the maximum rate of increase.
3. Compute the dimensions of the rectangular box with largest volume if the total surface area is given as 64 $cm^2$ .
4. Show that the Cobb-Douglas production function $P = bL^{\alpha}K^{\beta}$ satisfies the equation $L\dfrac{\partial P}{\partial L}+K\dfrac{\partial P}{\partial K}=\alpha\dfrac{P}{L}$ .

**Course Outcome 4(CO4)**

1. State fundamental theorem of calculus.
2. Find the volume of the solid obtained by rotating the region bounded by $y = x^3$ , $y = 8$ and $x = 0$ about the $y$ axis.
3. A charged rod of length L produces an electric field at point P(a,b) given by $E(P)=\displaystyle\int_{-a}^{L-a}\frac{\lambda b}{4\pi\varepsilon_0(x^2+b^2)^{3/2}}\,dx$ where $\lambda$ is the charge density per unit length on the rod and $\varepsilon_0$ is the free space permittivity (see the below figure). Evaluate the integral to determine an expression for the electric field E(P).



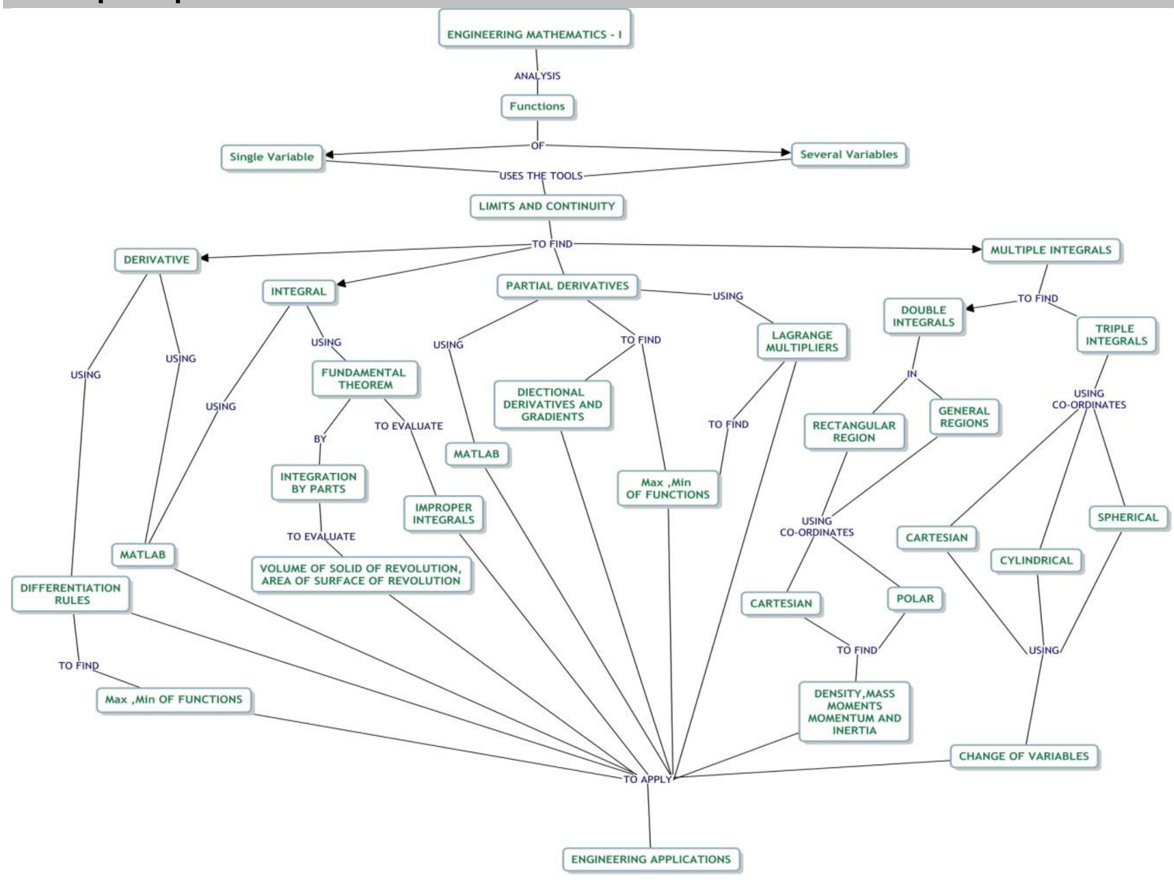

4. A cantilever beam of length *L*, fixed at one end and deflected by a distance *D* at the free end has strain energy *V* given by $V = \frac{EI}{2}\int_0^L \left(\frac{d^2y}{dx^2}\right)^2 dx$ where *EI* is the flexural rigidity. The deflection *y* at a distance *x* from the fixed end is given by $y = D\left[1-\cos\left(\frac{\pi x}{2L}\right)\right]$

   Find $V$ .

**Course Outcome 5(CO5)**

1. Recall any three properties of double integrals
2. Calculate the static moments of homogeneous lamina with respect to the coordinate axes. The lamina is bounded by lines $\frac{x^2}{9}+\frac{y^2}{4}=1$ , $2x+3y-6=0$ .
3. Calculate the coordinates of the center of mass of homogeneous solid bounded by surfaces x=0, y = 0, z = 0, x +y = 1, $x^2 + y^2 = 1$.

## Concept Map



## Syllabus

**DIFFERENTIAL CALCULUS** **(12 hours)**

Representation of functions - New functions from old functions - Limit of a function - Continuity - Limits at infinity - Derivative as a function - Differentiation rules(formula and problems only) –The mean value theorem - Maxima and Minima of functions of one variable - Application problems in engineering – Application problems using MATLAB.

**FUNCTIONS OF SEVERAL VARIABLES** **(12 hours)**

Partial derivatives – Chain rule - Vector functions and their Derivatives - Directional derivatives and gradient vector - Maxima and minima of functions of two variables - Lagrange Multipliers - Application problems in engineering - Application problems using MATLAB.

**INTEGRAL CALCULUS** **(12 hours)**

Area under curves - The definite integrals – Fundamental theorem of calculus - Integration by parts - Volume of solid of revolution - Area of surface of revolution - Improper integrals - Application problems in engineering - Application problems using MATLAB

**MULTIPLE INTEGRAL** **(12 hours)**

Iterated integrals - Double integrals over general regions - Double integrals in polar coordinates - Applications of double integrals (density, mass, moments & moments of inertia problems only) - Triple integrals - Triple integrals in cylindrical coordinates - Triple integrals in spherical coordinates - Change of variables in multiple integrals - Application problems in engineering

## Text Book

1) James Stewart, "Calculus Early Transcendentals", 7e, Cengage Learning, New Delhi, 2017. **DIFFERENTIAL CALCULUS:**[Sections: 1.1, 1.3, 2.2,2.5,2.6,2.8, 3.1-3.6,4.1,4.2]
**FUNCTIONS OF SEVERAL VARIABLES:** Sections: 14.3, 14.5,13.1,13.2,14.6-14.8]
**INTEGRAL CALCULUS:** [Sections: 5.1-5.4,7.1, 6.2, 8.2 and 7.8]
**MULTIPLE INTEGRAL:** [Sections: 15.2-15.5, 15.7-15.10]

2) Lecture Notes on Engineering Mathematics-I Application Problems and Solution Manual, Department of Mathematics, Thiagarajar College of Engineering, Madurai.

## Reference Books

1) Kuldeep Singh, "Engineering Mathematics Through Appplications",2e, Palgrave Macmillan, 2011.
2) Erwin Kreszig, "Advanced Engineering Mathematics",10th edition, Wiley, 2017.
3) George B. Thomas, " Thomas Calculus: early transcendentals ", Pearson, New Delhi, 2013.
4) R.K.Jain, S.R.K.Iyengar, ”Advanced Engineering Mathematics”5e, Narosa Publishing House, 2016.

## Course Contents and Lecture Schedule

| S.No | Topic | No. of Hours |
|---|---|---|
| **1** | **DIFFERENTIAL CALCULUS** | |
| 1.1 | Representation of functions, New functions from old functions | 1 |
| 1.2 | Limits of a function | 1 |
| 1.3 | Continuity, Limits at infinity | 1 |

| S.No | Topic | No. of Hours |
|---|---|---|
| 1.4 | Tutorial | 1 |
| 1.5 | Derivatives as a function, Differentiation rules | 2 |
| 1.6 | The mean value theorem | 1 |
| 1.7 | Maxima and minima of function of one variable | 1 |
| 1.8 | Tutorial | 1 |
| 1.9 | Application problems in engineering | 2 |
| 1.10 | Application problems using MATLAB(Tutorial) | 1 |
| **2** | **FUNCTIONS OF SEVERAL VARIABLES** | |
| 2.1 | Partial derivatives, Chain rule | 2 |
| 2.2 | Vector functions and their derivatives | 1 |
| 2.3 | Tutorial | 1 |
| 2.4 | Directional derivatives, Gradient vector | 1 |
| 2.5 | Maxima and minima of functions of two variables | 2 |
| 2.6 | Lagrange Multipliers | 1 |
| 2.7 | Tutorial | 1 |
| 2.8 | Application problems in engineering | 2 |
| 2.9 | Application problems using MATLAB(Tutorial) | 1 |
| 3 | **INTEGRAL CALCULUS** | |
| 3.1 | Area under curves, The definite integrals, fundamental theorem of calculus | 2 |
| 3.2 | Integration by parts | 1 |
| 3.3 | Tutorial | 1 |
| 3.4 | volume of solid of revolution, area of surface of revolution | 2 |
| 3.5 | Improper integrals | 2 |
| 3.6 | Tutorial | 1 |
| 3.7 | Application problems in engineering | 2 |
| 3.8 | Application problems using MATLAB(Tutorial) | 1 |
| **4** | **MULTIPLE INTEGRAL** | |
| 4.1 | Iterated integrals | 1 |
| 4.2 | Double integrals over general regions | 1 |
| 4.3 | Double integrals in polar coordinates | 1 |
| 4.4 | Tutorial | 1 |
| 4.5 | Applications of double integrals | 1 |
| 4.6 | Triple integrals | 2 |
| 4.7 | Tutorial | 1 |
| 4.8 | Triple integrals in cylindrical coordinates | 1 |
| 4.9 | Triple integrals in spherical coordinates | 1 |
| 4.10 | Change of variables in multiple integrals | 1 |
| 4.11 | Tutorial | 1 |
| | **Total** | 48 |

## Course Designers

1. Dr.V.Gnanaraj - vgmat@tce.edu
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| 18PHA20 | PHYSICS (Common to Civil, Mechanical and Mechatronics) |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 3 | 0 | 0 | 3 |

**Preamble**

The course work aims in imparting fundamental knowledge of oscillations, waves and optics, and mechanics which are essential in understanding and designing mechanical systems and measuring devices.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Solve for the solutions and describe the behavior of a damped harmonic oscillator and waves | Apply |
| CO2 | Explain the fundamentals of optical phenomena and its application. | Understand |
| CO3 | Use the vector analytical techniques for analysis of forces and moments in mechanical systems | Apply |
| CO4 | Demonstrate ability to utilize principles of vector mechanics to analyze weather systems | Understand |
| CO5 | Explain the fundamental concepts of kinetics and kinematic of rigid bodies for analysis of practical problems. | Understand |
| CO6 | Use the principles of angular velocity to study three dimensional motion of rigid bodies | Apply |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | | | | | L | L | | |
| CO2 | M | L | L | - | | | | | L | L | | |
| CO3 | S | M | L | L | | | | | L | L | | |
| CO4 | M | L | L | - | | | | | L | L | | |
| CO5 | M | L | L | - | | | | | L | L | | |
| CO6 | S | M | L | L | | | | | L | L | | |
| S- Strong; M-Medium; L-Low | | | | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | 0 |
| Understand | 30 | 30 | 30 | 50 |
| Apply | 50 | 50 | 50 | 50 |
| Analyse | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. A $5.00 \times 10^5$ kg subway train is brought to a stop from a speed of 0.500 m/s in 0.400 m by a large spring bumper at the end of its track. What is the force constant k of the spring?
2. Show that the wave velocity of deep water waves is twice the group velocity.
3. Derive the law of reflection based on Fermats principle.

**Course Outcome 2 (CO2)**:

1. Consider a lower energy level situated 200 $cm^{-1}$ from the ground state. There are no other energy levels nearby. Determine the fraction of the population found in this level compared to the ground state population at a temperature of 300 K. Boltzmann's constant is equal to $1.38 \times 10^{-23} JK^{-1}$.The conversion from $cm^{-1}$ to joules is given by: $E(J) = 100hC\ E(cm^{-1})$, where h is Planck's constant ($6.62 \times 10^{-34}$ Js) and c is the speed of light in a vacuum ($3 \times 10^8 ms^{-1}$)
2. Explain the principle, construction and working of Mach-Zehnder interferometer.
3. What is a four level solid state laser? Discuss the principle and operation of Nd:YAG Laser.

**Course Outcome 3 (CO3)**:

1. A 10, 000 lb aircraft is descending on a cylindrical helix. The rate of descent is $\dot{z} = -10$ft/s, the speed is v = 211 ft/s, and $\dot{\theta} = 3^o \approx 0.05$rad/s. This is standard for gas turbine powered aircraft. Find out the force on the aircraft and the radius of curvature of the path
2. Derive Newton's second law of motion in spherical and cylindrical coordinate systems.
3. A particle attached to a string of length 2 m is given an initial velocity of 6 m/s. The string is attached to a peg and, as the particle rotates about the peg, the string winds around the peg. By conservation of angular momentum, find the length of string wound around the peg when the velocity of the particle is 20 m/s?

**Course Outcome 4 (CO4)**:

1. Consider a situation where a cricket player (fielder) slides to a stop on level ground. Using energy considerations (in non conservative forces),calculate the distance the 60 kg cricket player slides, given that his initial speed is 7 m/s and the force of friction against him is a constant 430 N.
2. Compute the centripetal force per unit mass on a spacecraft in an 820 km circular Polar orbit as it flies over the equator and the South pole.
3. Solve Newton's equations of motion in polar coordinates

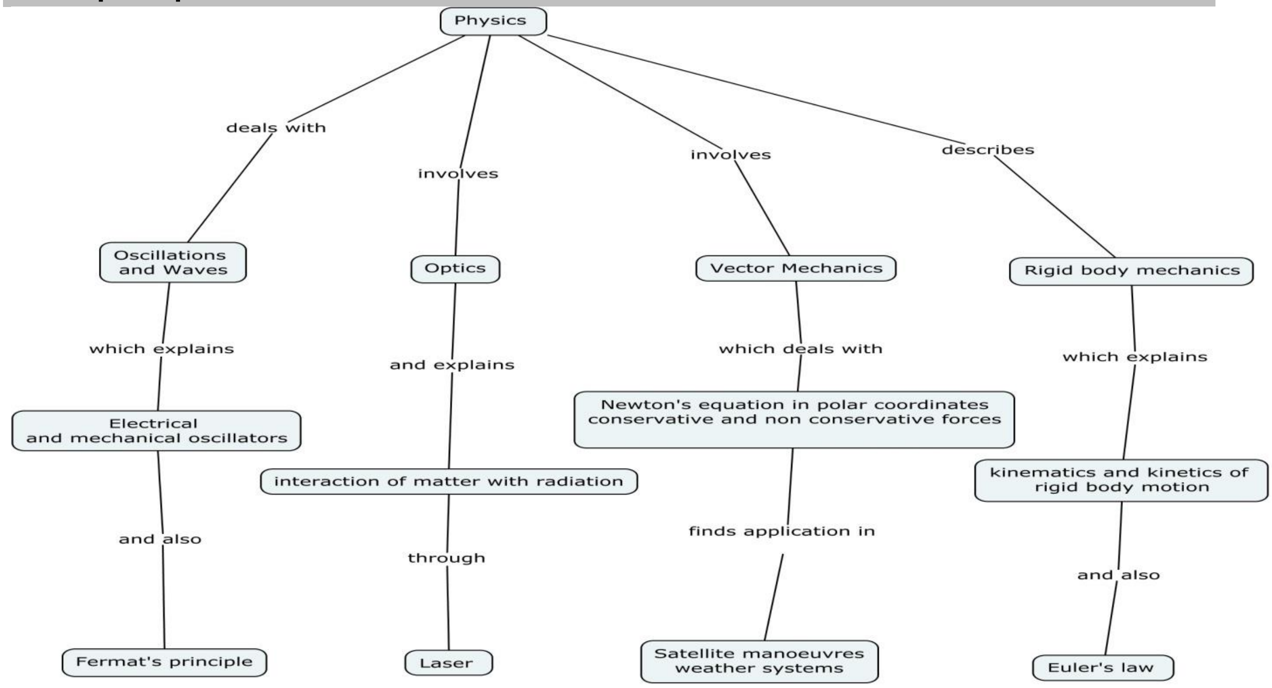
**Course Outcome 5 (CO5)**:

1. A motor shaft attains a velocity of 1500 rpm in 3 seconds starting from rest. Assuming constant angular acceleration, find out the number of full revolution of the shaft during this period.
2. Derive Euler's equations of motion of a rigid body.
3. A cylinder of diameter 500 mm rolls down an inclined plane with uniform acceleration (of the center-of-mass) $a = 0.1\ m/s^2$. At an instant $t_0$, the mass-center has speed $v_0 = 0.5$ m/s. (i) Find the angular speed $\omega$ and the angular acceleration $\dot{\omega}$ at $t_0$. (ii) How many revolutions does the cylinder make in the next 2 seconds?

**Course Outcome 6 (CO6)**:

1. A solid right circular cone of base radius *r* and height *h* rolls on a flat surface without slipping. The centre of the circular base moves in a circular path around the z- axis (vertical axis passing through the tip of the cone) with a constant speed *v*. Determine the angular velocity and angular acceleration of the solid cone.
2. Derive an expression for angular velocity and its rate of change for three dimensional motion of a rigid body.
4. Discuss the conical motion of a rod with center of mass fixed.

## Concept Map




## Syllabus

### Oscillations and Waves

Simple harmonic motion - Mechanical and Electrical simple harmonic oscillators - energy decay in a damped harmonic oscillator - Non-dispersive transverse and longitudinal waves in one dimension - Waves with dispersion - water waves- Acoustic waves- superposition of waves - wave groups and group velocity – Rayleigh criteria for limit of resolution and its applications to imaging.

### Optics

Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer - Fraunhofer diffraction from a single slit and a circular aperture - Einstein's theory of matter radiation interaction and A and B coefficients –$CO_2$ – Nd-YAG lasers - applications of lasers.

### Vector Mechanics of Particles

Transformation of scalars and vectors under Rotation transformation - Forces in Nature - Newton's laws and its completeness in describing particle motion - Solving Newton's equations of motion in polar coordinates -Conservative and non-conservative forces - curl of a force field -Conservation of Angular Momentum - Energy equation and energy diagrams – circular and elliptical orbits.- Applications to Satellite manoeuvres

### Rigid Body Mechanics

Motion of a rigid body in the plane - Rotation in the plane - Kinematics in a coordinate system rotating and translating in the plane - Angular momentum about a point of a rigid body in planar motion - Euler's laws of motion - their independence from Newton's laws - Two-dimensional motion in terms of angular velocity vector, and its rate of change – Difference between 2D & 3D motion.

**Text Book**

1. Ian G.Main, Vibrations and waves in Physics -3rd edition, Cambridge University, Press, 1994.
2. M.K.Verma, Introduction to Mechanics, CRC Press, 2009.
3. JL Meriam and L.G. Kraige, Engineering Mechanics – Dynamics - 7th edition, Wiley,2015.
4. D. Kleppner and R. Kolenkow, An Introduction to Mechanics – 1st edition, McGraw Hill, 2009.

**Reference Books**

1. M.K.Harbola, Engineering Mechanics-2nd edition, Cengage Learning, 2012.
2. JL Synge & BA Griffiths, Principles of Mechanics, McGraw-Hill Book company Inc, 1949.
3. WT Thomson, Theory of Vibrations with Applications,-3rd edition, CBS Publishers, 2002.

**Course Contents and Lecture Schedule**

| S No. | Topic | No. of Hours |
|---|---|---|
| **1.** | **Oscillations & Waves** | |
| 1.1 | Simple harmonic motion – Mechanical and Electrical simple harmonic oscillators. | 2 |
| 1.2 | Energy decay in a damped harmonic oscillator – Non-dispersive transverse and longitudinal waves in one dimension. | 2 |
| 1.3 | Waves with dispersion – water waves- Acoustic waves – superposition of waves – wave groups and group velocity. | 1 |
| 1.4 | Rayleigh criteria for limit of resolution and its applications to imaging | 1 |
| **2** | **Optics** | |
| 2.1 | Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer. | 2 |
| 2.2 | Fraunhofer diffraction from a single slit and a circular aperture . | 1 |
| 2.3 | Einstein's theory of matter radiation interaction and A and B coefficients . | 1 |
| 2.4 | $CO_2$ Laser. | 1 |
| 2.5 | Nd-YAG lasers Applications of lasers. | 1 |
| **3.** | **Vector Mechanics of Particles** | |
| 3.1 | Transformation of scalars and vectors under rotation transformation | 2 |
| 3.2 | Forces in Nature, Newton's laws and its completeness in describing particle motion | 2 |
| 3.3 | Solving Newton's equations of motion in polar coordinates | 2 |
| 3.4 | Conservative and non-conservative forces, curl of a force field, Conservation of angular momentum | 2 |
| 3.5 | Energy equation and energy diagrams, circular and elliptical orbits | 2 |
| 3.6 | Applications to Satellite manoeuvres | 2 |
| **4.** | **Rigid Body Mechanics** | |
| 4.1 | Motion of a rigid body in the plane, Rotation in the plane | 2 |

| S No. | Topic | No. of Hours |
|---|---|---|
| 4.2 | Kinematics in a coordinate system rotating and translating in the plane | 2 |
| 4.3 | Angular momentum about a point of a rigid body in planar motion | 2 |
| 4.4 | Euler's laws of motion, their independence from Newton's laws | 2 |
| 4.5 | Two-dimensional motion in terms of angular velocity vector, and its rate of change. | 2 |
| 4.6 | Distinction between 2D & 3D motion | 2 |
| | **Total** | **36** |

**Course Designers**


1. Dr. M.Mahendran mmphy@tce.edu
2. Dr. N. Sankara Subramanian nssphy@tce.edu
3. Dr. R. Kodipandyan rkp@tce.edu
4. Dr. A. Karuppasamy akphy@tce.edu

| 18PHB20 | PHYSICS<br>(Common to EEE and ECE) |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 3 | 0 | 0 | 3 |

## Preamble

The course work aims in imparting fundamental knowledge of oscillations and waves and electromagnetic theory which are essential in understanding and explaining engineering devices.

## Prerequisite

Basic course (No prerequisite)

## Course Outcomes

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Solve for the solutions and describe the behavior of a damped harmonic oscillator and waves | Apply |
| CO2 | Explain the fundamentals of optical phenomena and its application. | Understand |
| CO3 | Understand the fundamentals of electrostatics and Calculation of electric field and electrostatic potential for a charge distribution | Apply |
| CO4 | Explain bound charges due to electric polarization and estimation of vector potential through concepts of magneto statics. | Understand |
| CO5 | Describe and make calculations of plane electromagnetic waves in homogeneous media and derive Poynting theorem | Understand |
| CO6 | Learn the propagation of EM waves and its applications by solving physical problems and Energy and Momentum carried by electromagnetic waves through linear media. | Apply |

## Mapping with Programme Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | | | | | L | L | | |
| CO2 | M | L | L | - | | | | | L | L | | |
| CO3 | S | M | L | L | | | | | L | L | | |
| CO4 | M | L | L | - | | | | | L | L | | |
| CO5 | M | L | L | - | | | | | L | L | | |
| CO6 | S | M | L | L | | | | | L | L | | |
| S- Strong; M-Medium; L-Low | | | | | | | | | | | | |

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | 20 |
| Understand | 30 | 30 | 30 | 30 |
| Apply | 50 | 50 | 50 | 50 |
| Analyse | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. Assuming a car is 900 kg and has a suspension system that has a force constant $6.5 \times 10^4$ N/m. The car hits a bump and bounces with an amplitude of 0.100 m. What is its maximum vertical velocity if no damping occurs?
2. Establish the connection between quality factor, width of response and energy dissipation.
3. State the Rayleigh's criteria for limit of resolution.

**Course Outcome 2 (CO2)**:

1. Differentiate between laser light and ordinary light.
2. Predict the working of the CO2 laser without Helium gas in the mixture.
3. Explain the construction and working of Nd-YAG Laser

**Course Outcome 3 (CO3)**:

1. Discuss the Continuous charge distribution and the electric field produced by it.
2. Derive Laplace's and Poisson's equation
3. Deduce Gauss' law.

**Course Outcome 4 (CO4):**

1. Summarize physical interpretation of bound charges
2. Define vector potential and give its significance.
3. Explain the magnetic field of a steady current and hence obtain Bio-Savart law .

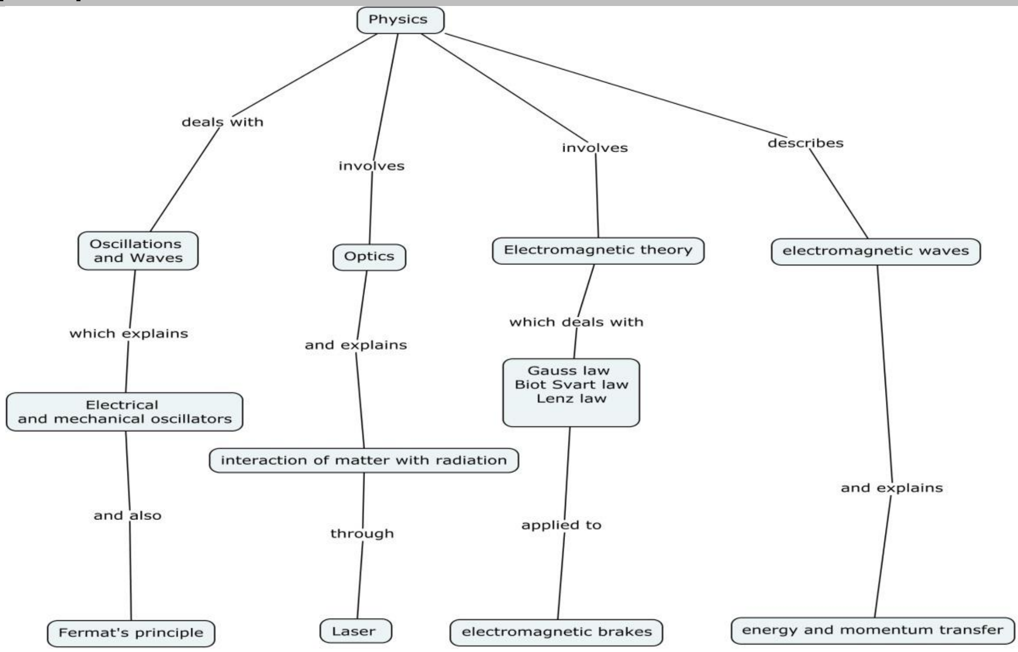
**Course Outcome 5 (CO5):**

1. Derive and interpret Continuity equation for current densities.
2. Write and explain the importance of Poynting vector
3. Deduce Faraday's law of electromagnetic from the Maxwell's equation

**Course Outcome 6 (CO6):**

1. Discuss the propagation of EM waves through vacuum.
2. Define and obtain expressions for transmission and reflection coefficients
3. Find the reflection and transmission coefficients of an electric field wave travelling in wave and incident normally on a boundary between air and a dielctric having Permeability $\mu_0$ and permittivity 4.74.

## Concept Map




## Syllabus

**Oscillations and Waves** **( 6 hours)**

Simple harmonic motion - Mechanical and Electrical simple harmonic oscillators - energy decay in a damped harmonic oscillator - Non-dispersive transverse and longitudinal waves in one dimension - Waves with dispersion - water waves –Acoustic waves - superposition of waves - wave groups and group velocity – Rayleigh criteria for limit of resolution and its applications to imaging

**Optics** **(6 hours)**

Fermat’s principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer - Fraunhofer diffraction from a single slit and a circular aperture - Einstein’s theory of matter radiation interaction and A and B coefficients –$CO_2$ – Nd-YAG lasers - applications of lasers.

**Electromagnetic Theory** **(12 Hours)**

Electrostatics: Introduction, Calculation of electric field and electrostatic potential for a charge distribution - Gauss' law, Divergence and curl of electrostatic field, Application: Faraday’s cage and coffee-ring effect(qualitative only). Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; Solving simple electrostatics problems in presence of dielectrics.

Magnetostatics: Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes’ theorem. Lenz’s law; Electromagnetic breaking (qualitative only)

**Electromagnetic waves** **(12 hours)**

Continuity equation for current densities- Modifying equation for the curl of magnetic field – Energy in an electromagnetic field - Flow of energy and Poynting vector - Maxwell’s equations- The wave equation- Plane electromagnetic waves in Vacuum– their transverse nature and Polarization ; relation between electric and magnetic fields of an electromagnetic wave -

Energy and Momentum carried by electromagnetic waves, Propagation through linear media- Normal incidence - problems.

**Text Books**


1. Ian G.Main, Vibrations and waves in Physics -3rd edition, Cambridge University Press,1994.
2. David J. Griffiths, Introduction to Electrodynamics, Prentice Hall, Second Indian edition,1981.
3. Paul Lorrain , Dale R. Corson , Francois Lorrain, Electromagnetic Fields and Waves, 3rd Edition, W.H. Freeman, 1990.
4. A.A. Rangwala,A.S. Mahajan, Electricity and Magnetism – 1st edition , McGraw Hill Education, 2004.


**Reference**


1. Halliday Resnick Krane, Physics Volume 2, Fifth edition, Wiley Publications, 2002.
2. W. Saslow, Electricity, Magnetism and light, Academic press 2005.
3. WT Thomson, Theory of Vibrations with Applications,-3rd edition, CBS Publishers, 2002.


**Course Contents and Lecture Schedule**

| S No. | Topic | No. of Hours |
|---|---|---|
| 1. | **Oscillations & Waves** | |
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| 1.2 | Energy decay in a damped harmonic oscillator – Non-dispersive transverse and longitudinal waves in one dimension. | 2 |
| 1.3 | Waves with dispersion – water waves – Acoustic waves – superposition of waves – wave groups and group velocity. | 1 |
| 1.4 | Rayleigh criteria for limit of resolution and its applications to imaging. | 1 |
| 2 | **Optics** | |
| 2.1 | Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer. | 2 |
| 2.2 | Fraunhofer diffraction from a single slit and a circular aperture . | 1 |
| 2.3 | Einstein's theory of matter radiation interaction and A and B coefficients | 1 |
| 2.4 | $CO_2$ Laser | 1 |
| 2.5 | Nd-YAG lasers Applications of lasers. | 1 |
| 3 | **Electromagnetic Theory** | |
| 3.1 | Electrostatics: Introduction, Calculation of electric field and electrostatic potential for a charge distribution - Gauss' law – work done- Electric potential problems. Divergence and curl of electrostatic field | 4 |
| 3.2 | Applications: Faraday's cage and coffee-ring effect. Electrostatic field and potential of a dipole. | 2 |
| 3.3 | Bound charges due to electric polarization; Electric displacement; Solving simple electrostatics problems in presence of dielectrics. | 2 |
| 3.4 | Magnetostatics: Bio-Savart law, Divergence and curl of static magnetic field | 2 |

| S No. | Topic | No. of Hours |
|---|---|---|
| 3.5 | vector potential and calculating it for a given magnetic field using Stokes' theorem. Lenz's law; Electromagnetic breaking (qualitative only) | 2 |
| 4 | **Electromagnetic waves** | |
| 4.1 | Continuity equation for current densities- Modifying equation for the curl of magnetic field – | 2 |
| 4.2 | Energy in an electromagnetic field - Flow of energy and Poynting vector - Maxwell's equations- The wave equation- | 3 |
| 4.3 | Plane electromagnetic waves in Vacuum– their transverse nature and Polarization | 2 |
| 4.4 | Relation between electric and magnetic fields of an electromagnetic wave | 2 |
| 4.5 | Energy and Momentum carried by electromagnetic waves, Propagation through linear media- Reflection and Transmission coefficients, problems. | 3 |
| | **Total** | **36** |

**Course Designers**

1. Dr.S.Rajathi srphy@tce.edu
2. Dr. V.Gayathri vgphy@tce.edu
3. Dr.M.Senthamizh selvi mssphy@tce.edu
4. Dr. A.L.Subramaniyan alsphy@tce.edu

| 18PHC20 | PHYSICS<br>(Common to CSE and IT) |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 3 | 0 | 0 | 3 |

## Preamble

The course work aims in imparting fundamental knowledge of oscillations and waves and optics and quantum mechanics which are essential in understanding and explaining engineering devices.

## Prerequisite

Basic course (No prerequisite)

## Course Outcomes

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Solve for the solutions and describe the behavior of a damped harmonic oscillator and waves | Apply |
| CO2 | Explain the fundamentals of optical phenomena and its application. | Understand |
| CO3 | Explain the basic principles of Quantum mechanic | Understand |
| CO4 | Use the principles of quantum mechanics to calculate observables on known wave functions | Apply |
| CO5 | Solve Schrodinger equation for simple potentials ,scattering and related phenomena | Understand |
| CO6 | identify and relate the Eigen value problems for energy, momentum, angular momentum and explain the idea of spin | Apply |

## Mapping with Programme Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | | | | | L | L | | |
| CO2 | M | L | L | - | | | | | L | L | | |
| CO3 | M | L | L | - | | | | | L | L | | |
| CO4 | S | M | L | L | | | | | L | L | | |
| CO5 | M | L | L | - | | | | | L | L | | |
| CO6 | S | M | L | L | | | | | L | L | | |

S- Strong; M-Medium; L-Low

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | 20 |
| Understand | 30 | 30 | 30 | 30 |
| Apply | 50 | 50 | 50 | 50 |
| Analyze | 0 | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 |

## Course Level Assessment Questions

**Course Outcome 1 (CO1)**

1. Assuming a car is 900 kg and has a suspension system that has a force constant $6.5x10^4$ N/m. The car hits a bump and bounces with an amplitude of 0.100 m. What is its maximum vertical velocity if no damping occurs?
2. Establish the connection between quality factor, width of response and energy dissipation.
3. State the Rayleigh's criteria for limit of resolution.

**Course Outcome 2 (CO2)**

1. Find the ratio of population of two energy states in a Laser the transition between which is responsible for the emission of photons of wavelength6893A at a temperature of 300K.Comment on the type of emission based on the ration of population.
2. Analyze the role of mixture of gases for a $CO_2$ laser and predict the working of the laser without Helium gas in the mixture.
3. Differentiate between $CO_2$ laser and Nd-YAG Laser with respect to their construction and energy level diagram.

**Course Outcome 3 (CO3)**

1. List the properties of wave function.
2. Set up the time independent Schrodinger wave equation and explain the Eigen functions and Eigen values.
3. Describe an experiment to verify the uncertainty principle.

**Course Outcome 4 (CO4)**

1. Calculate the expectation value of the position of a particle trapped in a box of length 10A° wide.
2 Compute the smallest possible uncertainty in position of an electron moving with a Velocity of $3x10^7$ m.
3 An electron is constrained to a one dimensional box of side 1nm.Calculate the first four Eigen values in electron volt.

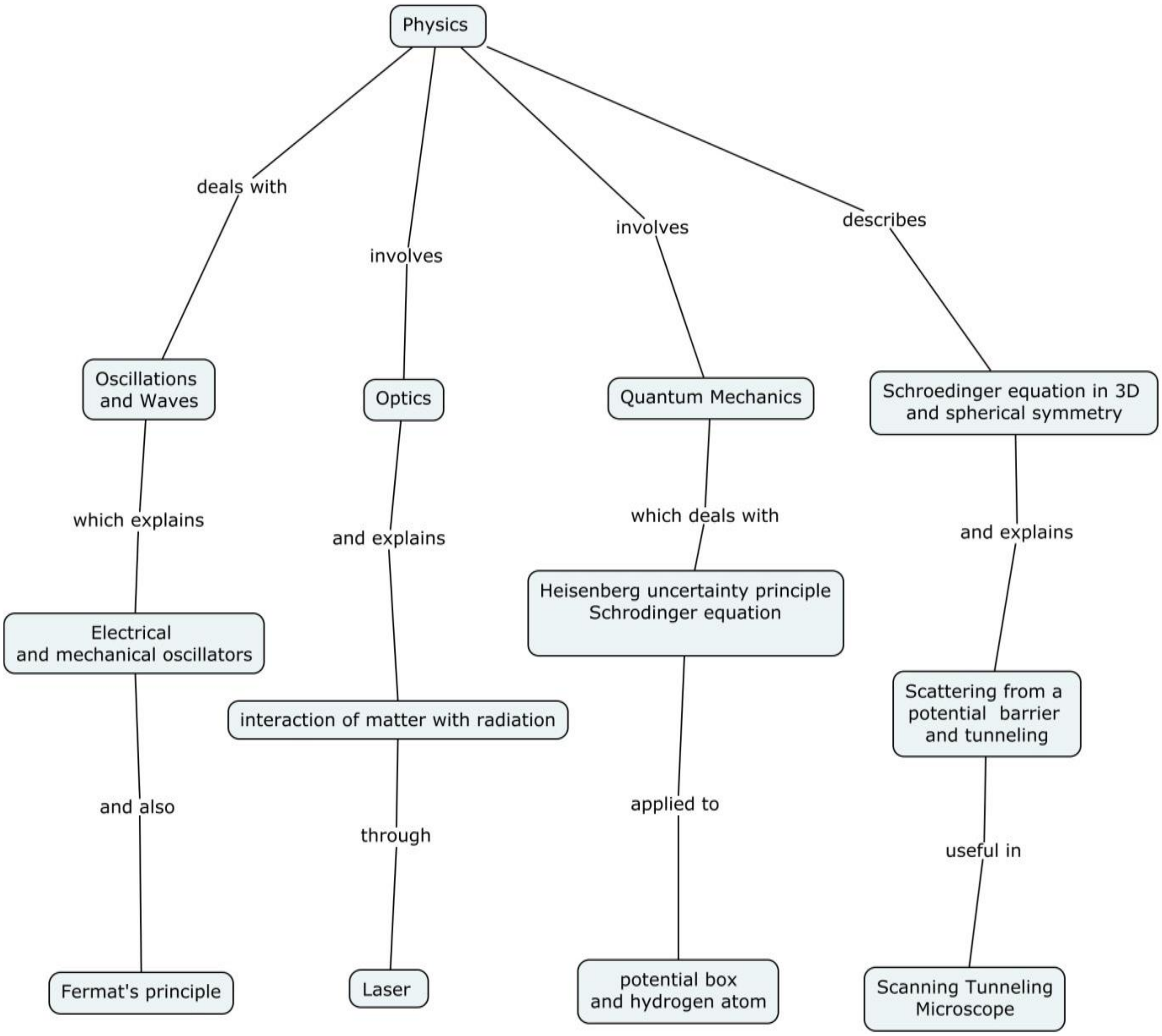
**Course Outcome 5 (CO5)**

1. Assuming the time independent Schrödinger wave equation, discuss the solution for a particle in a three dimensional potential well of infinite height.
2. Discuss the barrier tunneling phenomenon for a rectangular finite potential barrier of height $V_{o.}$
3. State the principle of STM and describe its working.

**Course Outcome 6 (CO6)**

1. Identify the degeneracies in hydrogen atom energy level based on the principle of quantum numbers.
2. Illustrate the vector model of orbital angular momentum
3. Given ψ($x$) = $A$sin($kx$). Find the Eigen values of the operator $O = \partial^2/\partial x^2$. Identify whether $\partial/\partial x$ is an Eigen operator

## Concept Map




## Syllabus

**Oscillations and Waves:** Simple harmonic motion - Mechanical and Electrical simple harmonic oscillators - energy decay in a damped harmonic oscillator - Non-dispersive transverse and longitudinal waves in one dimension - Waves with dispersion - water waves – Acoustic waves - superposition of waves - wave groups and group velocity – Rayleigh criteria for limit of resolution and its applications to imaging.

**Optics :** Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer - Fraunhofer diffraction from a single slit and a circular aperture - Einstein's theory of matter radiation interaction and A and B coefficients –$CO_2$ – Nd-YAG lasers - applications of lasers.

**Introduction to Quantum mechanics**

Wave nature of Particles, Time-dependent and time independent Schrodinger equation for wave function, Born interpretation, probability current, Expectation values, Free-particle wave function and wave-packets, Uncertainty principle – Derivation & Experiment. Solution of stationary-state Schrodinger equation for one dimensional problems– particle in a box, Square-well potential, linear harmonic oscillator.

**Applying the Schrodinger equation**

Numerical solution of stationary-state - Schrodinger equation for three dimensional problems for different potentials and related examples - Angular momentum operator - Hydrogen atom ground-state, orbitals - interaction with magnetic field, spin. Scattering from a potential barrier and tunneling; related examples like alpha-decay, field ionization Schrodinger equation for spherically symmetric potentials and scanning tunneling microscope.

**Text Books**


1. Ian G. Main, Vibrations and waves in Physics -3rd edition, Cambridge University press, ,1994.
2. David .J. Griifiths, Introduction to quantum mechanics -2nd edition, Cambridge University press, 2017.
3. P M Mathews, K.Venkatesan, Quantum mechanics, 2 nd edition, Tata McGraw-Hill Education, 2010.


**Reference**


1. http.//nptel.ac.in/courses/115106066/Quantum mechanics Prof. S. Lakshmi Bala, IIT Madras.
2. http://nptel.ac.in/courses/115101010/ Quantum mechanics Prof. S. H.Patil, IIT Bombay.
3. http://nptel.ac.in/courses/115104096/ Introduction to quantum mechanics, Prof Manoj K.Harbola, IIT Kanpur


**Course Contents and Lecture Schedule**

| S No. | Topic | No. of Hours |
|---|---|---|
| 1. | **Oscillations & Waves** | |
| 1.1 | Simple harmonic motion – Mechanical and Electrical simple harmonic oscillators. | 2 |
| 1.2 | Energy decay in a damped harmonic oscillator – Non-dispersive transverse and longitudinal waves in one dimension. | 2 |
| 1.3 | Waves with dispersion – water waves – Acoustic Waves – superposition of waves – wave groups and group velocity. | 1 |
| 1.4 | Rayleigh criteria for limit of resolution and its applications to imaging. | 1 |
| 2 | **Optics** | |
| 2.1 | Fermat's principle of stationary time - reflectance and transmittance - evanescent wave. Mach-Zehnder interferometer. | 2 |
| 2.2 | Farunhofer diffraction from a single slit and a circular aperture. | 1 |
| 2.3 | Einstein's theory of matter radiation interaction and A and B coefficients. | 1 |
| 2.4 | $CO_2$ Laser. | 1 |
| 2.5 | Nd-YAG lasers -Applications of lasers. | 1 |
| 3 | **Introduction to Quantum mechanics** | |
| 3.1 | Wave nature of Particles, Time-dependent and time independent Schrodinger equation for wave function. | 3 |
| 3.2 | Born interpretation, probability current, Expectation values. | 3 |
| 3.3 | Free-particle wave function and wave-packets, Uncertainty principle – Derivation & Experiment. | 3 |

| S No. | Topic | No. of Hours |
|---|---|---|
| 3.4 | Schrodinger equation for one dimensional problems– particle in a box, square-well potential, linear harmonic oscillator. | 3 |
| 4 | **Applying the Schrodinger equation** | |
| 4.1 | Numerical solution of stationary-state | 1 |
| 4.2 | Schrodinger equation for one dimensional problem for different potentials and related examples. | 3 |
| 4.3 | Angular momentum operator, Hydrogen atom ground-state, orbitals, interaction with magnetic field , spin | 3 |
| 4.4 | Scattering from a potential barrier and tunneling; related examples like alpha-decay, field ionization | 3 |
| 4.5 | Schrodinger equation for spherically symmetric potentials | 1 |
| 4.6 | Scanning tunneling microscope. | 1 |
| | **Total** | **36** |

**Course Designers**


1. Dr. M.Mahendran mmphy@tce.edu
2. Mr. V.Veeraganesh vvgphy@tce.edu
3. Dr. A.L.Subramaniyan alsphy@tce.edu
4. Dr.T.Manichandran stmanichandran@tce.edu

| 18CHA30 | CHEMISTRY (COMMON TO CIVIL, MECHANICAL AND MECHATRONICS) |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 3 | 0 | 0 | 3 |

**Preamble**

The objective of this course is to bestow a better understanding of basic concepts of chemistry and its applications on Civil, Mechanical and Mechatronics domain. It also imparts knowledge on properties of water and its treatment methods, spectroscopic techniques for material characterization, corrosion and protection of metals. This course also highlights preparation, properties and applications of polymer and composite materials. It also gives basic idea about adhesives and lubricants and their mechanisms.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Identify the properties of water and its treatment methods | Understand |
| CO2 | Summarize the Principles and Instrumentations of Spectroscopic techniques | Understand |
| CO3 | Select the appropriate spectroscopic techniques for characterization of materials | Apply |
| CO4 | Adapt the customized corrosion control methods | Apply |
| CO5 | Dramatize the preparation, properties and applications of Engineering materials | Understand |
| CO6 | Describe the mechanism of adhesion and lubrication | Understand |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | M | - | - | - | - | - | - | - | - | - | M | - |
| 2. | M | L | L | - | - | - | - | - | - | - | - | - |
| CO3. | S | S | M | M | - | - | - | - | - | - | - | - |
| CO4. | S | S | M | M | - | - | L | - | - | - | L | - |
| CO5. | M | M | M | - | - | - | L | - | - | - | - | - |
| CO6. | M | - | L | - | - | - | - | - | - | - | - | - |
| S- Strong; M-Medium; L-Low | | | | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | 20 |
| Understand | 40 | 40 | 40 | 40 |
| Apply | 40 | 40 | 40 | 40 |
| Analyze | - | - | - | - |
| Evaluate | - | - | - | - |
| Create | - | - | - | - |

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

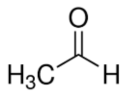
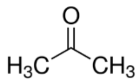
1. Distinguish between scale and sludge.
2. 100 ml of given water sample consumed 48 ml of EDTA during titration using EBT indicator. 35 ml of same EDTA consumed by 100 ml of standard hard water containing 1 mg of pure $CaCO_3$ per ml. Calculate the permanent, temporary and total hardness of given water sample in $CaCO_3$ equivalents.
3. Outline the steps involved in the waste water treatment process.

**Course Outcome 2 (CO2):**

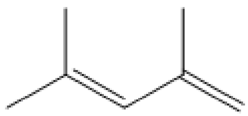
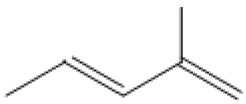
1. State Beer-Lambert law.
2. Write the selection rule in absorption spectroscopy.
3. Explain the procedure involved in finding the metals present in an alloy sample using ICP-OES.

**Course Outcome 3 (CO3):**

1. Compare the stretching frequencies of carbonyl functional groups in the following compounds

i)  (ii) 

2. Following Woodward-Fiesher- scott rules, it has been observed that the following compounds have absorption maximum at (i) 225 nm, (ii) 220 (iii) 230. Explain which is which.

a).  b).  c). 

3. Describe the function of different magnets available to generate magnetic field in MRI scanner.

**Course Outcome 4 (CO4)**

4. Illustrate the different forms of corrosion with appropriate mechanism
5. Dramatize suitable methods to prevent corrosion of iron bar used in construction.
6. Discuss in detail about the constituents and functions of paint.

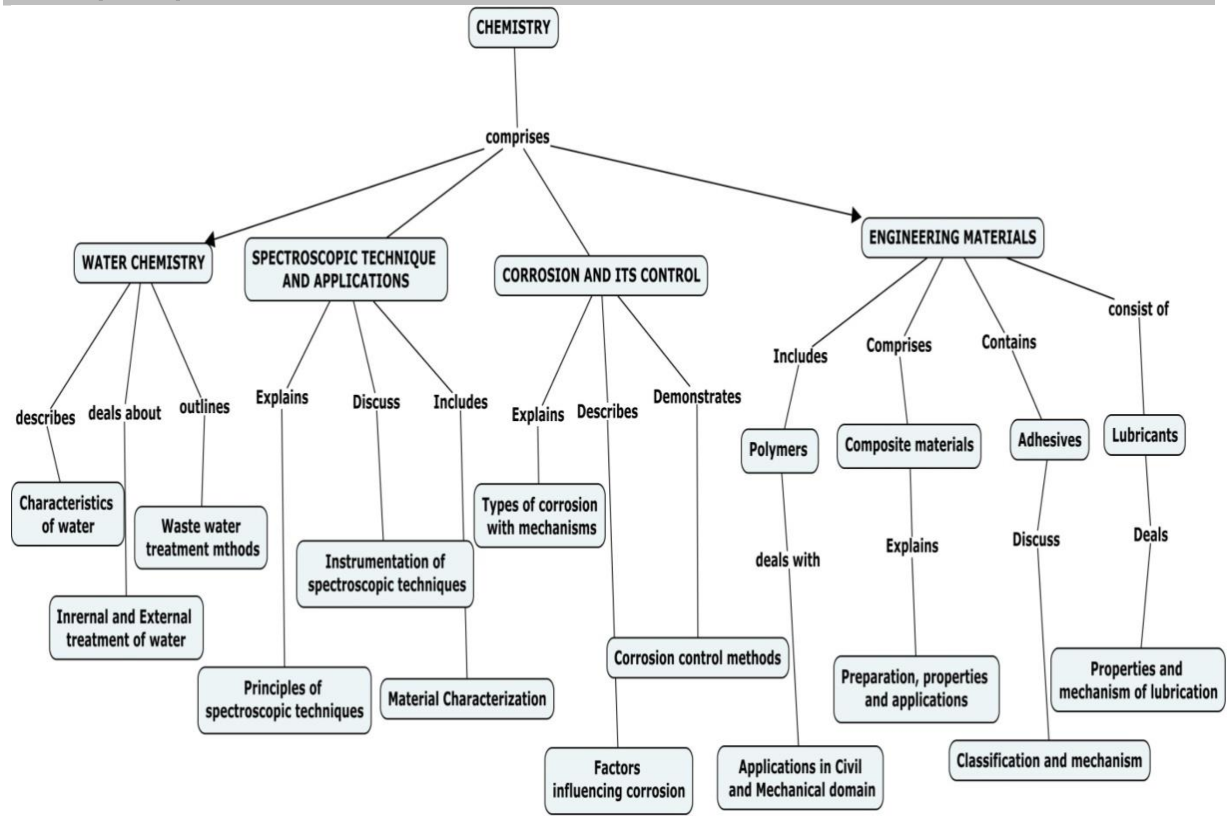
**Course Outcome 5 (CO5)**

1. Explain the application of composite materials in automobile engineering.
2. Demonstrate the applications of polymer in the enhancement of concrete properties.
3. Summarize the properties and application of reinforced composite materials.

**Course Outcome 6 (CO6)**

1. List the types of lubricant materials.
2. Identify the factors which influence the action of adhesive.
3. Discuss the mechanism of lubrication.

## Concept Map




## Syllabus

**Water Chemistry :** Water- sources-Hardness of water-types-Estimation of hardness of water by EDTA method. Disadvantages of hardwater -Boiler troubles- scale & sludge. Internal treatment methods. External treatment methods- zeolite, ion exchange. Desalination process- reverse osmosis, electrodialysis, multi stage flash distillation. Waste water treatment processes.

**Spectroscopic technique and applications**-Principles of spectroscopy and selection rules-Electronic spectroscopy, Fluorescence- applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules- Applications. Nuclear magnetic resonance and magnetic resonance imaging. Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy- Principle, instrumentation and applications.

**Corrosion and its prevention-**Corrosion- causes- factors- types- chemical, electrochemical corrosion (galvanic, differential aeration), Corrosion of steel in various environments. Rate of corrosion. Corrosion control - material selection and design aspects - electrochemical protection – sacrificial anode method and impressed current cathodic method. Coatings – Metallic – Chromate conversion coating, electroplating – precious metal coating. Paints- constituents and function.

**Engineering materials –** Polymers - Introduction-classification-properties –applications in construction and manufacturing processes. Composite Materials: Introduction-Classification – Preparation, properties and applications. Fiber-Reinforced Composites-preparation, properties and applications..Adhesives- Introduction-classification-fundamental aspects – mechanism of adhesion- factors influencing adhesive action. Lubricants-introduction-classification-properties-functions-mechanism of lubrication.

**Text Book**

1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 16th edition, 2015.
2. C. N. Banwelland E.M. McCash, "Fundamentals of Molecular Spectroscopy", Tata McGraw-Hill (India), 5th Edition, 2013.

**Reference Books**

1. S.S. Dara and S.S.Umare, "A Textbook of Engineering Chemistry", S.Chand & Company, 12th Edition, Reprint, 2013.
2. Shashi Chawla, " A text book of Engineering Chemistry", Dhanpat Rai & Co.(pvt) ltd, 3rd edition, reprint 2011.

**Course Contents and Lecture Schedule**

| S. No. | Topic | No. of hours |
|---|---|---|
| 1.0 | **Water Chemistry** | |
| 1.1 | Introduction -Water- sources-Hardness of water-types | 1 |
| 1.2 | Estimation of hardness of water by EDTA method | 2 |
| 1.3 | Disadvantages of hard water -Boiler troubles- scale & sludge. | 1 |
| 1.4 | Internal treatment methods | 1 |
| 1.5 | External treatment methods- zeolite, ion exchange | 1 |
| 1.6 | Desalination process- reverse osmosis, electrodialysis, multi stage flash distillation | 1 |
| 1.7 | Waste water treatment processes | 2 |
| 2.0 | **Spectroscopic technique and applications** | |
| 2.1 | Introduction | 1 |
| 2.2 | Principles of spectroscopy and selection rules | 1 |
| 2.3 | Electronic spectroscopy, Fluorescence- applications in medicine. | 1 |
| 2.4 | Vibrational and rotational spectroscopy of diatomic molecules- Applications | 2 |
| 2.5 | Nuclear magnetic resonance and magnetic resonance imaging | 2 |
| 2.6 | Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy- Principle, instrumentation and applications. | 2 |
| 3.0 | **Corrosion and its prevention** | |
| 3.1 | Corrosion- causes- factors- | 1 |
| 3.2 | types- chemical, electrochemical corrosion (galvanic, differential aeration), Corrosion of steel in various environments (Marine) | 2 |
| 3.3 | Rate of corrosion | 1 |
| 3.4 | Corrosion control - material selection and design aspects | 1 |
| 3.5 | electrochemical protection – sacrificial anode method and impressed current cathodic method | 1 |
| 3.6 | Coatings – Metallic - Chromate conversion coating, electroplating – precious metal coating. | 2 |
| 3.7 | Paints- constituents and function. | 1 |
| 4.0 | **Engineering materials** | |

| S. No. | Topic | No. of hours |
|---|---|---|
| 4.1 | Polymers - Introduction-classification-properties | 1 |
| 4.2 | Applications in construction and mechanical domains | 1 |
| 4.3 | Composite Materials: Introduction-Classification – Preparation, properties and applications of Polymer Matrix Composites, | 1 |
| 4.4 | Metal Matrix Composites, Ceramic Matrix Composites Carbon-Carbon Composites | 2 |
| 4.5 | Fiber-Reinforced Composites- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and boron carbide fibers and nature-made composites, and applications. | 2 |
| 4.6 | Adhesives- Introduction-classification-fundamental aspects – mechanism of adhesion- factors influencing adhesive action | 1 |
| 4.7 | Lubricants-introduction-classification-properties-functions-mechanism of lubrication. | 1 |
| | **Total** | **36** |

**Course Designers:**


| | | |
|---|---|---|
| 1. | Dr. M.Kottaisamy | hodchem@tce.edu |
| 2 | Dr.(Mrs).K.Radha | krchem@tce.edu |
| 2. | Dr.S.Rajkumar | rajkumarsubramanium@tce.edu |
| 3. | Dr.M.Velayudham | mvchem@tce.edu |

| 18CHB30 | CHEMISTRY<br>(Common to EEE and ECE) |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 3 | 0 | 0 | 3 |

**Preamble**

This course work aims in imparting fundamental knowledge of materials and their applications in electrical, electronics and communication engineering. This course provides exposure to the students regarding the characterization of materials by spectroscopic methods. This course also deals with the selection of materials based on their properties for application in energy storage, energy conversion and electronic devices. It also extends the importance of water and gives better understanding of Water treatment processes.

**Prerequisite**

NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1. | Identify the properties of water and its treatment methods | Understand |
| CO2. | Summarize the Principles and Instrumentations of Spectroscopic Techniques | Understand |
| CO3. | Select the appropriate spectroscopic techniques for characteristics of materials | Apply |
| CO4. | Outline the importance of industrial electrochemical processes and protective coating | Understand |
| CO5. | Indicate the materials best suited for the construction of energy storage devices for different applications | Apply |
| CO6. | Identify the implications of material properties in the performance of electronic devices. | Apply |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | M | L | - | - | - | - | - | - | - | - | L |
| CO2 | M | M | L | - | - | - | - | - | - | - | - | - |
| CO3 | S | S | L | - | - | - | - | - | - | - | - | - |
| CO4 | M | M | M | M | - | - | L | - | - | - | - | L |
| CO5. | S | S | M | M | - | - | M | - | - | - | - | L |
| CO6 | S | S | M | M | - | - | M | - | - | - | - | L |
| S- Strong; M-Medium; L-Low | | | | | | | | | | | | |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | 20 |
| Understand | 30 | 30 | 30 | 30 |
| Apply | 50 | 50 | 50 | 50 |
| Analyze | _ | _ | _ | _ |
| Evaluate | _ | _ | _ | _ |
| Create | _ | _ | _ | _ |

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

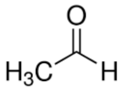
1. Distinguish between scale and sludge.
2. 100 ml of given water sample consumed 48 ml of EDTA during titration using EBT indicator. 35 ml of same EDTA consumed by 100 ml of standard hard water containing 1 mg of pure $CaCO_3$ per ml. Calculate the permanent, temporary and total hardness of given water samples in $CaCO_3$ equivalents.
3. Outline the steps involved in the waste water treatment process.

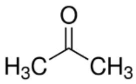
**Course Outcome 2 (CO2):**

4. State Beer-Lambert law.
5. Write the selection rule in absorption spectroscopy.
6. Explain the procedure involved in finding the metals present in an alloy sample using ICP-OES.

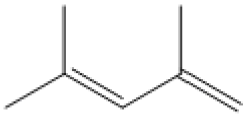
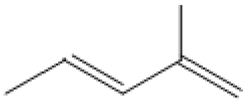
**Course Outcome 3 (CO3):**

1. Compare the stretching frequencies of carbonyl functional groups in the following compounds

i) 

(ii) 


2. Following Woodward-Fiesher- scott rules, it has been observed that the following compounds have absorption maximum at (i) 225 nm, (ii) 220 (iii) 230. Explain which is which.

a).  b).  c). 

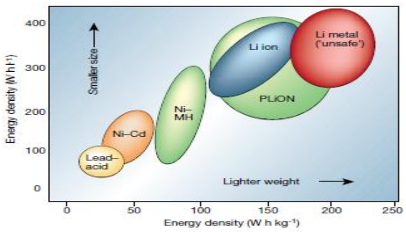
3. Describe the function of different magnets available to generate magnetic field in MRI scanner.

**Course Outcome 4 (CO4)**

1. Explain the drawbacks of gold electroplating.
2. Name the different types of electrolyte used in platinum electroplating.
3. Write the equations for hydrogen generation by electrolysis process under acidic and alkaline conditions.

**Course Outcome 5 (CO5)**

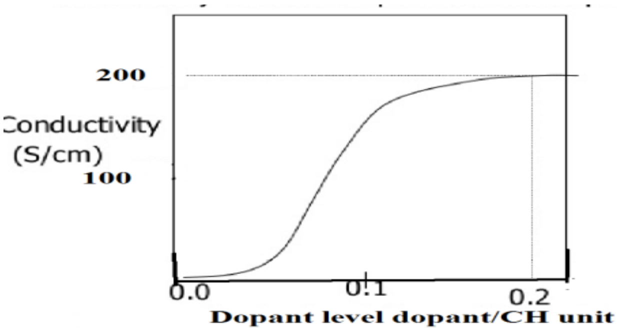
1. Illustrate the working principle, charging and discharging reactions in Lead acid battery.
2. With the help of comparative chart of different battery types, justify the reason for considering Lithium ion batteries as future power source.




3. Illustrate $H_2$-$O_2$ fuel cell construction and explain associated electrochemical reactions.

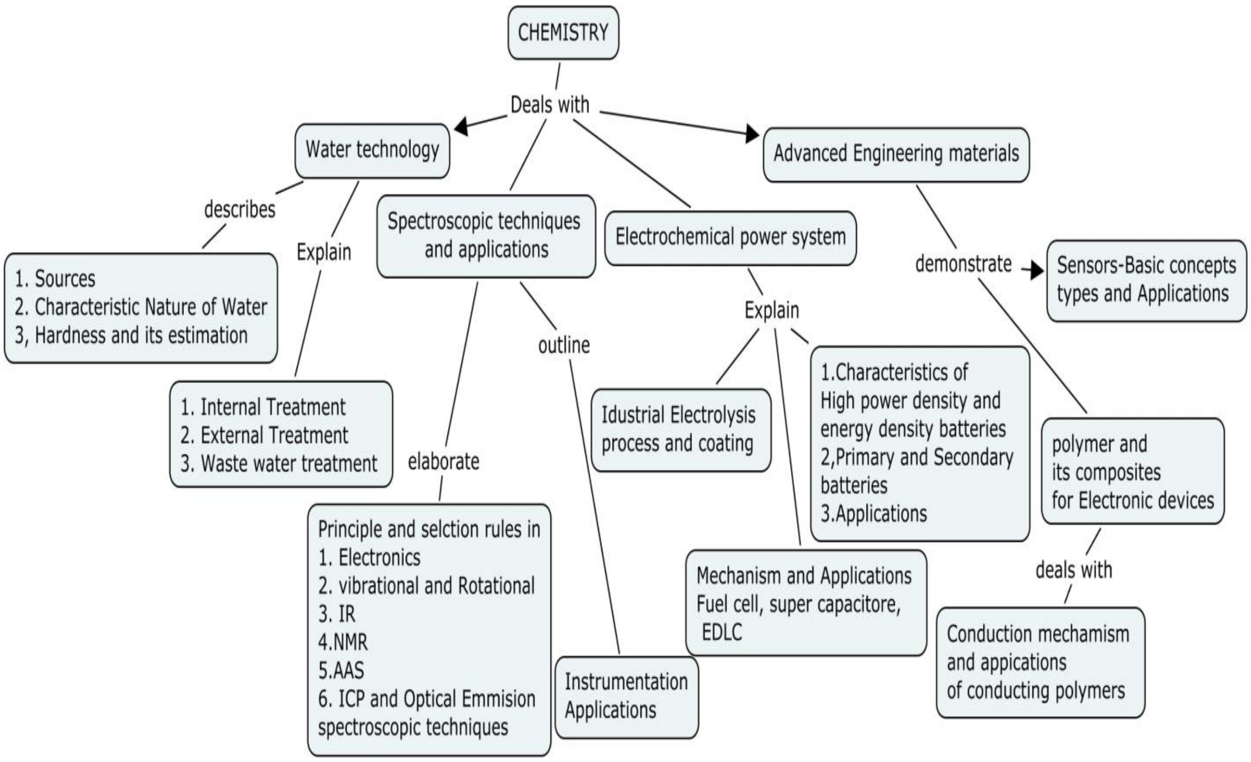
**Course Outcome 6 (CO6)**

1. Explain the conduction mechanism of polyaniline as a host for enzyme in biosensor.
2. In the following profile, identify the reason why the conductivity of polymer has been increased with dopant level.




3. Identify the suitable bio sensing materials for the detection of glucose in human blood serum.

## Concept Map




## Syllabus

**Water Chemistry:** Water- sources-Hardness of water-types-Estimation of hardness of water by EDTA method. Disadvantages of hardwater -Boiler troubles- scale & sludge.Internal treatment methods. External treatment methods- zeolite, ion exchange. Desalination process-reverse osmosis, electrodialysis, multi stage flash distillation. Waste water treatment processes.

**Spectroscopic technique and applications** -Principles of spectroscopy and selection rules-Electronic spectroscopy, Fluorescence- applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules- Applications. Nuclear magnetic resonance and magnetic resonance imaging. Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy- Principle, instrumentation and applications.

**Electrochemical power system-**Electrochemistry–Basics - Industrial electrolytic process – Water electrolysis – Hydrogen generator- Electroplating - Decorative and functional coating-Value added coatings and Electroless process of making printed circuit board- Materials for Energy storage: Batteries **-** High energy density and Power density batteries -Operational characteristics – Primary and Secondary batteries– Fuel cells – Basic concept and types -Advantages and Disadvantages of fuel cell-Hydrogen Economy-Hydrogen storage- Super capacitors.

**Advanced Engineering materials:** Polymers and its composites for Electronic devices - Dielectric, mechanical and electrical properties-chemical methods for tailoring the properties-Conducting polymers – principle and preparation method-conduction mechanism–application of polymer and its composites in communication and flexible electronic devices - Frequency selective surfaces-Sensing properties of materials-concept-Applications

**Text Book**

1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 16th edition, 2015.
2. C. N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, TataMcGraw-Hill (India), 5th Edition, 2013.

**Reference Books**

1. A.J. Bard and L.R. Faulkner, Electrochemical Methods, Fundamentals and Application. Wiley,2001
2. 2.Y.R.Sharma, Elementary Organic Spectroscopy, S. Chand, 2007.
3. 3.ShashiChawla, A text book of Engineering Chemistry, Dhanpat Rai& Co.(pvt) Ltd, 3rd Edition, reprint 2013

**Course Contents and Lecture Schedule**

| S.No | Topic | No. of Hours |
|---|---|---|
| **1.0** | **Water Chemistry** | |
| 1.1 | Introduction -Water- sources-Hardness of water-types | 1 |
| 1.2 | Estimation of hardness of water by EDTA method | 2 |
| 1.3 | Disadvantages of hard water -Boiler troubles- scale & sludge. | 1 |
| 1.4 | Internal treatment methods | 1 |
| 1.5 | External treatment methods- zeolite, ion exchange | 1 |
| 1.6 | Desalination process- reverse osmosis, electrodialysis, multi stage flash distillation | 1 |
| 1.7 | Waste water treatment processes | 2 |
| **2.0** | **Spectroscopic technique and applications** | |
| 2.1 | Introduction | 1 |
| 2.2 | Principles of spectroscopy and selection rules | 1 |
| 2.3 | Electronic spectroscopy, Fluorescence- applications in medicine. | 1 |
| 2.4 | Vibrational and rotational spectroscopy of diatomic molecules-Applications | 2 |
| 2.5 | Nuclear magnetic resonance and magnetic resonance imaging | 2 |

| S.No | Topic | No. of Hours |
|---|---|---|
| 2.6 | Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy- Principle, instrumentation and applications. | 2 |
| **3.0** | **Electrochemical power system** | |
| 3.1 | Industrial electrolytic process – Water electrolysis – Hydrogen generator- Decorative and functional coating-Electroplating Protective coating (Zn and Ni); | **2** |
| 3.2 | Value added coatings (Au, Pt).and Electroless process of making printed circuit board | **1** |
| 3.3 | High energy density and Power density batteries-Operational characteristics – Primary ($Zn/MnO_2$ or $Zn/Ag_2O$) and Secondary batteries (Pb- acid and Lithium ion/polymer batteries) | **2** |
| 3.4 | Fuel cells – Basic concept and types Proton exchange membrane FC- Methanol FC-solid oxide FC- (principle only) | **2** |
| 3.5 | Advantages and Disadvantages of fuel cell-Hydrogen Economy-Hydrogen storage- Super capacitors – EDLC and Hybrid type (principle only) | **2** |
| **4.0** | **Advanced Engineering materials** | |
| 4.1 | Dielectric, mechanical and electrical properties-chemical methods for tailoring the properties-Doping-Functionalization-core/shell nanostructure | **2** |
| 4.2 | Conducting polymers – principle and preparation method-conduction mechanism-(conjugated polymers- conjugated doped polymers) | **2** |
| 4.3 | application of polymer and its composites in sensors, light emitting diodes. telecommunications, power transmissions | **2** |
| 4.4 | antistatic coatings, conducting adhesives, artificial nerves - EMI shielding, Frequency selective surfaces | **1** |
| 4.5 | Sensing properties of materials-concept-Applications- Electronic sensors in Environmental monitoring process | **2** |
| | **Total** | **36** |

**Course Designers:**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| 18CHC30 | CHEMISTRY<br>(Common to CSE and IT) |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 3 | 0 | 0 | 3 |

## Preamble

The objective of this course is to bestow the better understanding of basic concepts of chemistry and its applications in Computer Science and Engineering and Information Technology. This course provides exposure on corrosion and its protection in computer components. It also imparts knowledge on properties and application of nano-materials in data storage devices. Besides, it highlights properties of water and its treatment methods, spectroscopic techniques for material characterization, properties and applications of polymers.

## Prerequisite

NIL

## Course Outcomes

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO 1. | Identify the properties of water and its treatment methods | Understand |
| CO 2. | Summarize the principles and instrumentations of spectroscopic techniques | Understand |
| CO 3. | Select the appropriate spectroscopic techniques for characteristics of materials | Apply |
| CO 4. | Adapt the suitable corrosion control methods | Apply |
| CO 5. | Describe the preparation, properties and applications of polymers and nanomaterials. | Understand |
| CO 6. | Discuss the significance of nanomaterials in computer peripherals and data storage devices | Understand |

## Mapping with Programme Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | - | - | - | - | - | - | - | - | - | L | - |
| CO2 | M | L | L | - | - | - | - | - | - | - | - | - |
| CO3. | S | S | M | M | - | - | - | - | - | - | - | - |
| CO4. | S | S | M | M | - | - | L | - | - | - | L | - |
| CO5. | M | M | M | M | - | - | L | - | - | - | - | - |
| CO6. | M | M | M | M | L | - | M | - | - | - | - | - |
| S- Strong; M-Medium; L-Low | | | | | | | | | | | | |

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | 20 |
| Understand | 40 | 40 | 40 | 40 |
| Apply | 40 | 40 | 40 | 40 |
| Analyze | - | - | - | - |
| Evaluate | - | - | - | - |
| Create | - | - | - | - |

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

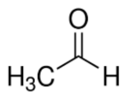
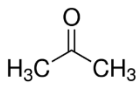
1. Distinguish between scale and sludge.
2. 100 ml of given water sample consumed 48 ml of EDTA during titration using EBT indicator. 35 ml of same EDTA consumed by 100 ml of standard hard water containing 1 mg of pure $CaCO_3$ per ml. Calculate the permanent, temporary and total hardness of given water samples in $CaCO_3$ equivalents.
3. Outline the steps involved in the waste water treatment process.

**Course Outcome 2 (CO2):**

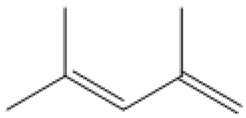
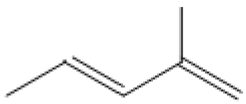
1. State Beer-Lambert law.
2. Write the selection rule in absorption spectroscopy.
3. Explain the procedure involved in finding the metals present in an alloy sample using ICP-OES.

**Course Outcome 3 (CO3):**

1. Compare the stretching frequencies of carbonyl functional groups in the following compounds

   i)  (ii) 

2. Following Woodward-Fiesher- scott rules, it has been observed that the following compounds have absorption maximum at (i) 225 nm, (ii) 220 (iii) 230. Explain which is which.

   a).  b).  c). 

3. Describe the function of different magnets available to generate magnetic field in MRI scanner.

**Course Outcome 4 (CO4):**

1. Linear polarisation of steel specimen (0.1 x 0.1 $cm^2$) kept in 4% aqueous NaCl solution is studied. It gives corrosion current $I_{corr}$ = 50 μA/$cm^2$.Equivalent weight and density of steel are 55.85 g/mol and 8.05 g/ $cm^3$ respectively. Calculate the rate of corrosion of steel in mm/year.
2. Demonstrate causes and control measures of corrosion in computer peripherals and electronic devices.
3. Explain the factors influencing rate of corrosion.

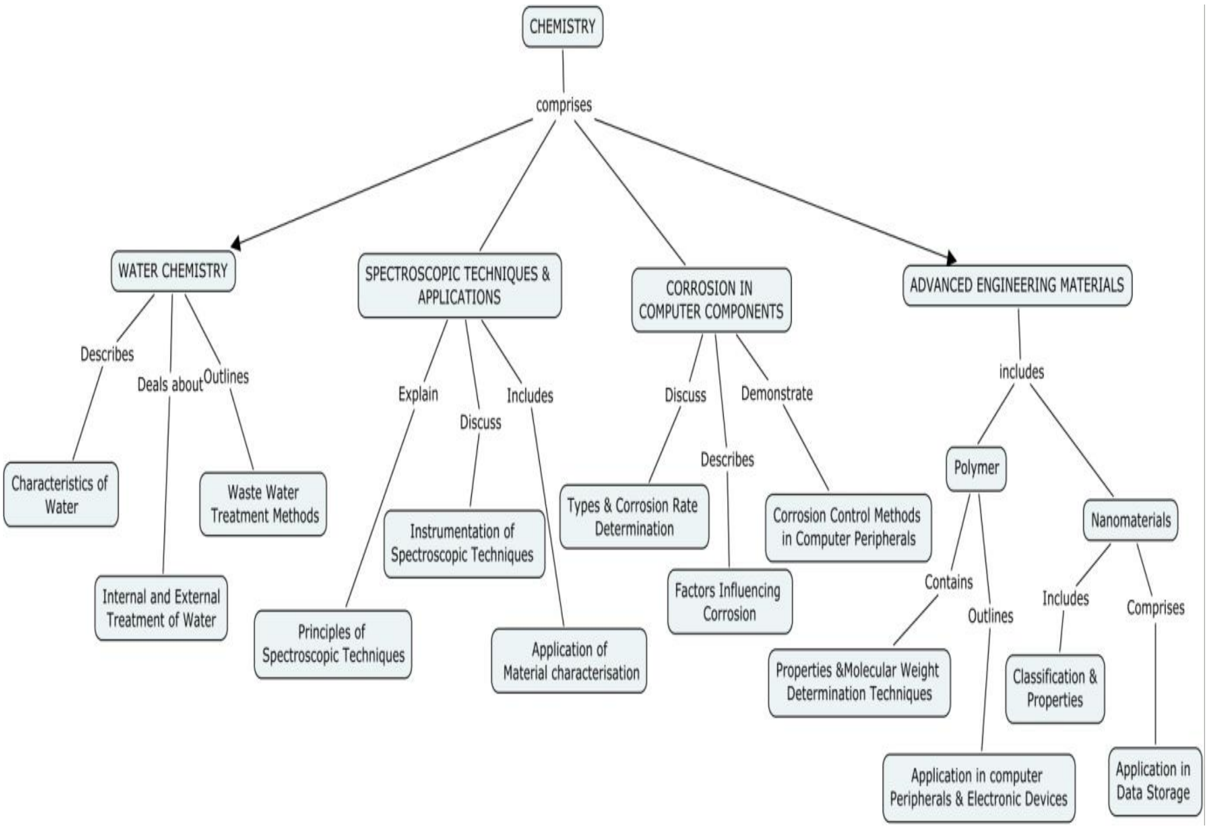
**Course Outcome 5 (CO5):**

1. Demonstrate the mechanism of conducting polymer of poly acetylene.
2. Explain the application of polymer material application in display devices.
3. Compare OLED vs LCD in display properties.

**Course Outcome 6 (CO6):**

1. Recall the classification of nanomaterials
2. Explain size dependent properties on nanomaterials
3. Describe the role of nanomaterials in data storage devices.

## Concept Map




## Syllabus

**Water Chemistry:**

Water- sources-Hardness of water-types-Estimation of hardness of water by EDTA method. Disadvantages of hardwater -Boiler troubles- scale & sludge. Internal treatment methods. External treatment methods- zeolite, ion exchange. Desalination process- reverses osmosis, electrodialysis, multi stage flash distillation. Waste water treatment processes.

**Spectroscopic technique and applications:**

Principles of spectroscopy and selection rules- Electronic spectroscopy, Fluorescence-applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules-Applications. Nuclear magnetic resonance and magnetic resonance imaging. Atomic Absorption Spectroscopy and Inductively Coupled Plasma-Optical Emission Spectroscopy-Principle, instrumentation and applications.

**Corrosion in computer components:**

Introduction -types of corrosion-electrochemical analysis-Polarization and Impedance - Rate of corrosion determination- influencing factors in corrosion-corrosion degradation in computer peripherals, electronic devices -control measures-self protecting corrosion products –Pilling Bed worth rule- precious metal coating and impact-salt spray- electroless plating-Printed Circuit Board (PCB) manufacturing.

**Advanced Engineering Materials:**

**Polymers** – introduction – structure- property relationship of polymer -conducting polymers – properties and applications in biosensors, organic light emitting diodes.Polymers in telecommunications, power transmission and liquid crystalline display devices, flexible electronic devices. Polymer composite–classification and applications in computer components. **Nanomaterials**: Difference between nano and bulk materials- classifications-size dependent properties. Data storage materials – properties and applications.

**Text Book**


1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 16th edition, 2015.
2. C. N. Banwelland E.M. McCash, “Fundamentals of Molecular Spectroscopy”, Tata McGraw-Hill (India), 5th Edition, 2013.


**Reference Books**


1. Shashi Chawla, “ A text book of Engineering Chemistry”, Dhanpat Rai & Co.(pvt) ltd 3rd edition, reprint 2011.
2. Mars Fontana, “Corrosion Engineering, Mc Graw Hill Education 3rd edition reprint, 2017.R.V.Gadag, A. Nityananda Shetty “Engineering Chemistry” I.K. international Publishing Pvt Ltd. 3rd edition 2014.


**Course Contents and Lecture Schedule**

| S. No. | Topic | No. of hour |
|---|---|---|
| 1.0 | **Water Technology** | |
| 1.1 | Introduction -Water- sources-Hardness of water-types | 1 |
| 1.2 | Estimation of hardness of water by EDTA method | 2 |
| 1.3 | Disadvantages of hardwater -Boiler troubles- scale & sludge. | 1 |
| 1.4 | Internal treatment methods | 1 |
| 1.5 | External treatment methods- zeolite, ion exchange | 1 |
| 1.6 | Desalination process- reverse osmosis, electrodialysis, multi stage flash distillation | 1 |
| 1.7 | Waste water treatment processes | 2 |
| 2.0 | **Spectroscopic techniques and applications** | |
| 2.1 | Introduction | 1 |
| 2.2 | Principles of spectroscopy and selection rules | 1 |
| 2.3 | Electronic spectroscopy, Fluorescence- applications in medicine. | 1 |
| 2.4 | Vibrational and rotational spectroscopy of diatomic molecules- Applications | 2 |
| 2.5 | Nuclear magnetic resonance and magnetic resonance imaging | 2 |
| 2.6 | Atomic Absorption Spectroscopy and Inductively Coupled Plasma- Optical Emission Spectroscopy- Principle, instrumentation and applications. | 2 |
| 3.0 | **Corrosion in computer components** | |
| 3.1 | Types of corrosion, Electrochemical analysis – polarisation and impedance | 2 |
| 3.2 | Rate of corrosion determination | 1 |
| 3.3 | Factors influencing corrosion-local heat generation | 2 |
| 3.4 | Corrosion in computer peripherals and electronic devices | 1 |
| 3.5 | Corrosion control methods and precious metal coating | 2 |
| 3.6 | Printed Circuit Board Manufacturing | 1 |

| S. No. | Topic | No. of hour |
|---|---|---|
| 4.0 | **Advanced Engineering Materials** | |
| 4.1 | Polymers - Structure property relationship of polymer | 2 |
| 4.2 | Conducting polymers – synthesis, properties and applications in biosensors and OLED | 3 |
| 4.3 | Polymer composites – classification and applications in computer components. | 1 |
| 4.4 | Nanomaterials – classification and size dependent properties | 1 |
| 4.5 | Properties of Data storage nanomaterials | 2 |
| | **Total** | **36** |

**Course Designers:**


1. Dr. M. Kottaisamy hodchem@tce.edu
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| 18EG140 | ENGLISH | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | HSS | 2 | 0 | 0 | 2 |

## Preamble

The course aims at developing communication skills in English essential for understanding and expressing the ideas in different academic, social, and professional contexts. The students acquire the skills of listening, speaking, reading, and writing competencies in English language, making them employable in the globalised scenario.

## Prerequisite

NIL

## Course Outcomes

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Recall the basics of language in terms of vocabulary, grammar, pronunciation, syntax and semantics. | Remember |
| CO2 | Understand the grammatical nuances and use them accordingly in respective contexts. | Understand |
| CO3 | Read and comprehend the content in English in general and technical contexts as well. | Understand |
| CO4 | Write with coherence and cohesion effectively. | Apply |
| CO5 | Apply the language in established structure with precision in social and professional contexts. | Apply |

## Mapping with Programme Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1. | | | | | | | | | | S | | S |
| CO2. | | | | | | | | | | S | | M |
| CO3. | | | | | | | | | | S | | S |
| CO4. | | | | | | | | | | S | | S |
| CO5. | | | | | | | | | | S | | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | | Terminal Examination |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| Remember | - | - | - | - |
| Understand | 15 | 15 | 30 | 30 |
| Apply | 35 | 35 | 70 | 70 |
| Analyse | - | - | - | - |
| Evaluate | - | - | - | - |
| Create | - | - | - | - |

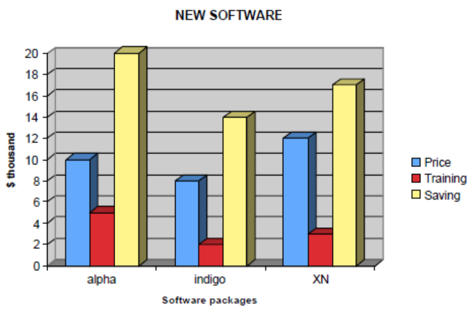
## Course Level Assessment Questions

**Course Outcomes 1, 2 and 3**

1. Rewrite as directed.
    a) Write a basic definition of a " mobile".
    b)Combine the following sentences to bring out the "Purpose and Function".
    The coal gas is compressed. Condensation in the gas mains can be avoided.
    c) Expand the following nominal compounds: i) car race ii) race car
    d) Combine the following sentences using a relative clause.
    Smart meters are small computers. They provide real-time information on how much electricity is being used by each customer.
    e) Combine the following sentences to bring out the "Cause and Effect"
    Sand is mixed with the cement. It prevents the excessive shrinkage during drying.
    f) Give the words for the following transcriptions
    **i)** /tekˈnɒl.ə.dʒi/ **ii)** /prəˌnʌn*t*.siˈeɪ.ʃən/
    g) Write down the phonetic symbols of the letters underlined. i).**Th**ick ii) Plea**s**ure
    h) Syllabify the word and underline the stressed syllable: Communication
    i) Frame question tags for the following sentence: Don't open your books
    j) Fill in the blank with the correct form of the verb given in brackets.
    Tamil Nadu's share of students in the IITs and NITs ________ (register) a considerable drop in the recent years.
2. Read the following passage and answer the following (different types of) questions**.**
    - Descriptive questions for eliciting short answers
    - True or false
    - Sentence Completion
    - Synonyms/meaning of the words in the text

**Course Outcomes 4 & 5**

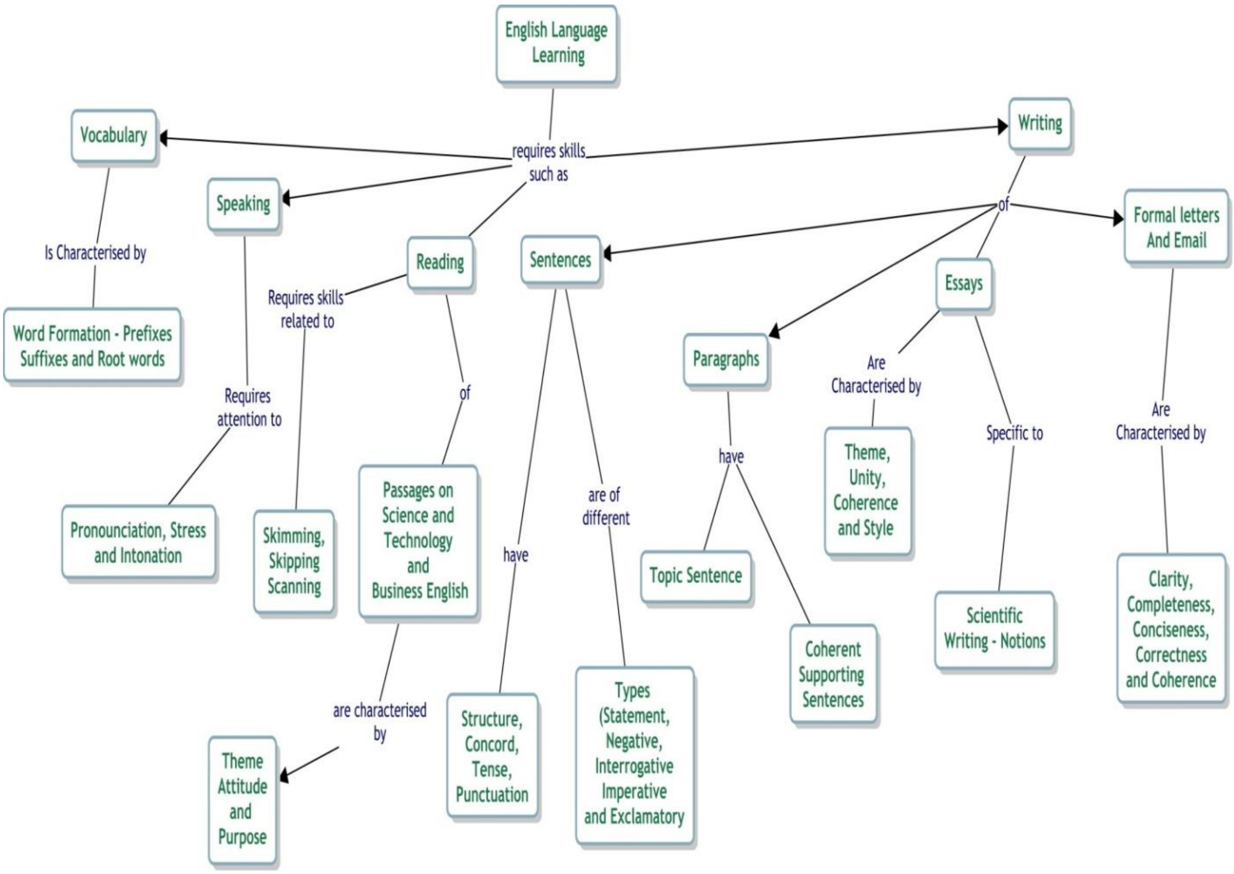
1. Write a paragraph in about 100-150 words on E-learning
2. Write a paragraph in about 100-150 words on Plastics
3. Write an e-mail to a company requesting permission to attend in-plant training for a fortnight.
4. Draft a letter to a company requesting you to undergo in-plant training there, inventing necessary details, in proper format.
5. Prepare a set of 10 instructions on how to draw money from an ATM.
6. Prepare a set of 12 recommendations to keep our environment clean.
7. Make notes of the passage given in appropriate format with a title andsummarize in about 100 words.
8. Interpret the following graphic data in about 150 words




9. Write an essay in about 250 words on 'The Impact of Technology on Nature'

10. Write an essay in about 250 words on ‘Green Engineering’ )

**Concept Map:**




**Syllabus:**

MODULE- I

Basics of language – Phonetics - Phonemes, Syllables and Stress, Vocabulary – Word Analysis, Prefix, Suffix, Roots, Parts of Speech, Sentence Patterns.

MODULE- II

Basics of grammar – Tenses, Subject-Verb Agreement, Impersonal Passive Voice, Relative Clauses; Notions for Technical English – Noun Compounds, Classifications and Definitions, Cause and Effect, Purpose and Function, Numerical Adjectives, Reading Comprehension – Skimming, Scanning, Skipping ( as tested in BEC Vantage Level)

MODULE-III

Writing with coherence and cohesion, Summarizing, Note-Making, Interpretation of Graphics, Writing Instructions and Recommendations, Paragraph and Essay Writing.

MODULE-IV

Writing with correct spelling, punctuation and grammar, Blog writing, E-mail Writing (BEC Vantage Writing-Unit I) – Formal Letters by students for Bonafide Certificate/Permission.

**Suggested Reading:**

Books:

1. Murphy, Raymond, English Grammar in Use with Answers; Reference and Practice for Intermediate Students, Cambridge: CUP, 2004
2. Jones, Daniel. An English Pronouncing Dictionary, Cambridge: CUP, 2006

3. Brook-Hart,Guy. Cambridge English- Business Benchmark-Upper Intermediate, CUP,2014.
4. Dhanavel, S.P. English and Communication Skills for Students of Science & Engineering, Orient BlackSwan, Chennai: 2016.
5. Swan, Michael. Practical English Usage.4th Edn. OUP. 2016.

Websites:

1. http://www.englishclub.com
2. http://owl.english.purdue.edu
3. https://www.oxfordonlineenglish.com
4. www.bbclearningenglish.com

**Course Contents and Lecture Schedule**

| S.No | Topic | No. of Hours |
|---|---|---|
| 1. | Introduction | 1 |
| 2. | Sentence Patterns | 1 |
| 3. | Tenses | 2 |
| 4. | Subject-Verb Agreement | 1 |
| 5. | Phonetics – Consonants, Vowels, Dipthongs | 1 |
| 6. | Phonetics – Syllable and Stress | 1 |
| 7. | Word Formation – Prefixes, Suffixes and Root Words | 1 |
| 8. | Reading Comprehension - I (Skipping, Skimming, and Scanning) | 1 |
| 9. | Note-Making and Summarizing | 1 |
| 10. | Writing Instructions and Recommendations | 1 |
| 11. | Tutorials | 1 |
| 12. | Defining and Non-Defining Relative Clauses | 1 |
| 13. | Impersonal Passive Voice | 2 |
| 14. | Notions of Technical English – Noun Compounds, Definitions, Cause & Effect, Purpose and Function, Numerical Adjectives | 1 |
| 15. | Paragraph / Essay Writing- Topic and Supporting Sentences, Coherence | 2 |
| 16. | E-Mail Writing – (BEC Vantage Writing Task I ) | 1 |
| 17. | Formal Letters by students for Bonafide Certificate/Permission | 1 |
| 18. | Interpretation of Graphics | 1 |
| 19. | Reading Comprehension – II (As tested in BEC Writing Task III) | 2 |
| 20. | Tutorials | 1 |
| **Total** | | **24** |

**Course Designers:**

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2 Dr.A.Tamilselvi tamilselvi@tce.edu
3 Mr. R. Vinoth vino@tce.edu
4 Dr. R. K. Jaishree Karthiga jai@tce.edu

| 18ES150 | ENGINEERING EXPLORATION |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| ES | 1 | 2 | - | 3 |

## Preamble

The course Engineering Exploration provides an introduction to the engineering field. It is designed to help the student to learn about engineering and how it affects our everyday lives. On the successful completion of the course, students will be to explain how engineering is different from science and technology and how science, mathematics and technology are an integral part of engineering design.

## Prerequisite

NIL

## Course Outcomes

On the successful completion of the course, students will be able to

| | |
|---|---|
| CO1. Explain technological & engineering development, change and impacts of engineering | Understand |
| CO2. Draw a product in enough detail that others can accurately build it and write specification sheet for a given product | Apply |
| CO3. Complete initial steps (Define a problem, list criteria and constraints, brainstorm potential solutions and document the ideas) in engineering design process | Apply |
| CO4. Draw sketches to a design problem and provide a trade-off matrix | Apply |
| CO5. Communicate possible solutions through drawings and prepare project report | Apply |
| CO6. Use reverse engineering to suggest improvements in a tool design | Apply |
| CO7. Apply the concept of engineering fundamentals in Civil, Mechanical, Electrical and Computer Engineering | Apply |

## Mapping with Programme Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C01 | M | L | - | - | - | - | - | - | - | - | - | - |
| C02 | S | M | L | - | - | - | - | - | - | - | - | - |
| C03 | S | M | L | - | - | - | - | - | - | - | - | - |
| C04 | S | M | L | - | - | - | - | - | - | - | - | - |
| C05 | S | M | L | - | - | - | - | - | - | - | - | - |
| C06 | S | M | L | - | - | - | - | - | - | - | - | - |
| C07 | S | M | L | - | - | - | - | - | - | - | - | - |

S- Strong; M-Medium; L-Low

## Assessment Pattern

| S.No | Bloom's category | Continuous Assessment Tests | | | End Semester Examinations |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | |
| 1 | Remember | 20 | 20 | 20 | 20 |
| 2 | Understand | 20 | 20 | 20 | 20 |
| 3 | Apply | 60 | 60 | 60 | 60 |
| 4 | Analyze | 0 | 0 | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Evaluate | 0 | 0 | 0 | 0 |
| 6 | Create | 0 | 0 | 0 | 0 |

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. What is the role of Engineer?
2. How do you believe the growth of engineering has impacted the product that we have today?
3. Select an engineering product, list the specifications and constraints that must be considered when designing the product. Make a list of tradeoff.

**Course Outcome 2 (CO2):**

1. List the steps of a design problem.
2. Identify the problem you see in the product you used in your daily life.
3. Determine the design constraint and criteria for a problem.
4. Create an isometric drawing of a design.

**Course Outcome 3 (CO3):**

1. List the five factors when considering development problem.
2. Imagine you have noticed the car you are riding is making a squeaking noise from the engine compartment. Define the problem with your vehicle. Classify the potential problem.
3. Imagine you are hired by your local city to develop a new public transportation.
    a. Define the problem.
    b. List the criteria and constraint.
    c. List the potential solution.

**Course Outcome 4 (CO4):**

1. Imagine you are an engineer who is designing a portable sitting device; you need to design a chair that will be portable that will fit in the trunk of the car which hold 100 kg individual and will be easily produced. Create sketches using a four step process to this design problem.
2. Imagine you are an engineer who develops method to automatically sort books at college library. Develop possible sketches and list potential solution and give the tradeoff matrix.
3. How can your research improve the design?

**Course Outcome 5 (CO5):**

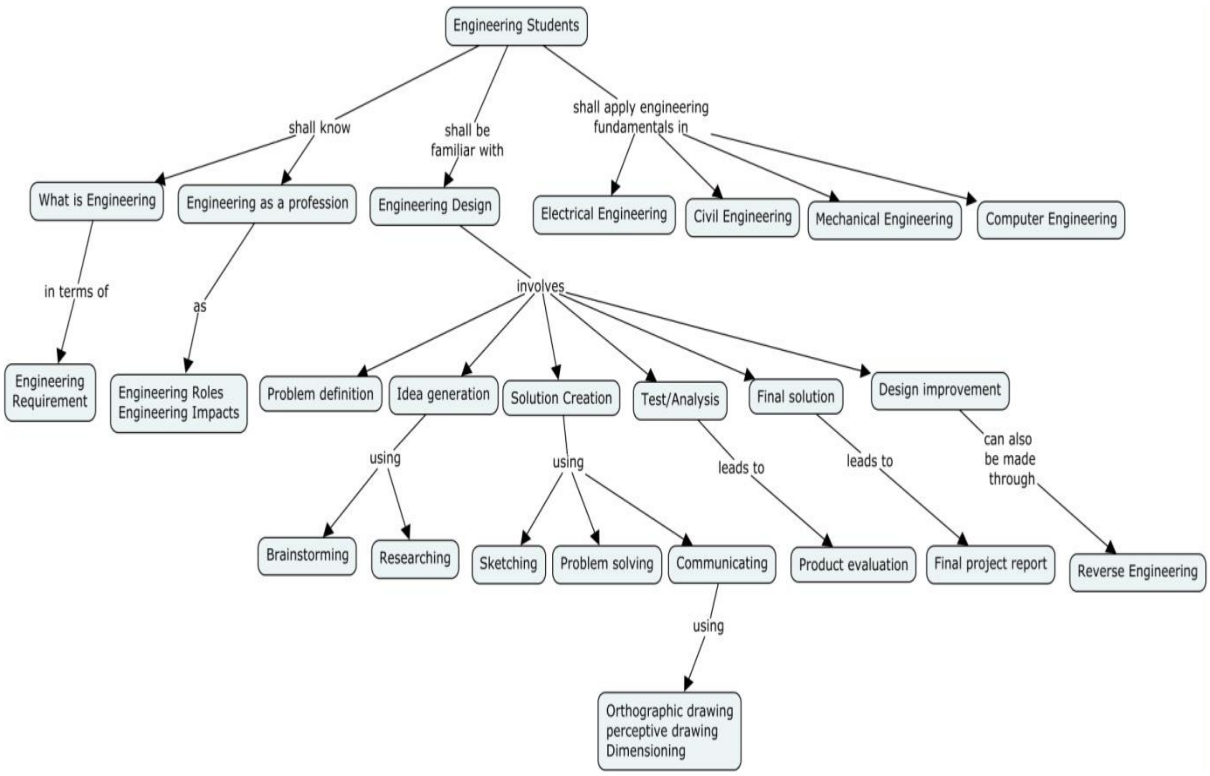
1. What details are able to show with the perspective drawing?
2. What is the difference between mockup and prototype?
3. List five different question engineers must ask about function of the design.

**Course Outcome 6 (CO6):**

1. Select a product to analyze with respect to function, fit, aesthetics, safety and environment impact. Write a summary on evaluation of the product. If you would like make changes to the design list the changes.
2. What design components should be reconsidered in reverse engineering processes? Why?
3. What are the benefits of reverse engineering?

**Course Outcome 7 (CO7):**
1. Explain ohms law and list the related formulas.
2. What role do you think the range selection plays in the accuracy of the measurements?
3. Why it is important for a civil engineer to study structural forces?
4. Describe the differences between fluids used in hydraulics and pneumatics.

## Concept Map




## Syllabus

**What is Engineering:** Engineering Requirement, Knowledge within Engineering disciplines, Engineering advancements **Engineering Design:** Problem definition, idea generation through brainstorming and researching, solution creation through evaluating and communicating, text/analysis, final solution and design improvement. **Defining problems and Brainstorming:** Researching design, sketching problem solving **Communicating solution**: Dimensioning orthographic drawing, perspective drawing **Modeling and Testing final output:** Product evaluation, reverse engineering, final project report. **Civil Engineering:** Structural forces structural analysis, bridge design components, structural design **Mechanical Engineering:** Types of motion, mechanical power system, mechanical power formula, mechanical design. **Electrical Engineering:** Reading analog multimeter, measuring current, voltage and resistance, electricity from chemicals, solar cells, magnets, Ohms law and watts law, circuit identification and circuit calculation, resistor color code, continuity **Computer Engineering:** Logic gates, algorithms, computer architecture, binary code

## Reference Books

1. Ryan A.Brown, Joshua W.Brown and Michael Berkihiser: "Engineering Fundamentals: Design, Principles, and Careers", Goodheart-Willcox Publisher, Second Edition, 2014.
2. Saeed Moaveni ,"Engineering Fundamentals: An Introduction to Engineering", Cengage learning, Fourth Edition, 2011.

## Course Contents and Lecture Schedule

| No. | Topic | No. of Lectures |
|---|---|---|
| 1. | **What is Engineering** | |
| 1.1 | Engineering Requirement | 1 |
| 1.2 | Knowledge within Engineering disciplines, | 1 |
| 1.3 | Engineering advancements | 1 |
| 2 | **Engineering Design** | |
| 2.1 | Problem definition, | 1 |
| 2.2 | idea generation through brainstorming and researching | 1 |
| 2.3 | solution creation through evaluating and communicating, | 1 |
| 2.4 | text/analysis | 1 |
| 2.5 | final solution and design improvement | 1 |
| 3 | **Defining problems and Brainstorming:** | |
| 3.1 | Researching design | 1 |
| 3.2 | sketching problem solving | 2 |
| 4 | **Communicating solution** | |
| 4.1 | Dimensioning orthographic drawing | 1 |
| 4.2 | perspective drawing | 1 |
| 5 | **Modeling and Testing final output** | |
| 5.1 | Product evaluation | 1 |
| 5.2 | reverse engineering | 1 |
| 5.3 | final project report | 1 |
| 6 | **Civil Engineering** | |
| 6.1 | Structural forces structural analysis | 2 |
| 6.2 | bridge design components | 2 |
| 6.3 | structural design | 1 |
| 7 | **Mechanical Engineering** | |
| 7.1 | Types of motion | 2 |
| 7.2 | mechanical power system | 1 |
| 7.3 | mechanical power formula | 1 |
| 7.4 | mechanical design | 1 |
| 8 | **Electrical Engineering:** | |
| 8.1 | Reading analog multimeter, measuring current, voltage and resistance | 1 |
| 8.2 | electricity from chemicals, solar cells, magnets, | 1 |
| 8.3 | Ohms law and watts law, circuit identification and circuit calculation | 1 |
| 8.4 | resistor color code, continuity | 2 |

| No. | Topic | No. of Lectures |
|---|---|---|
| **9** | **Computer Engineering** | |
| 9.1 | Logic gates, algorithms, | 1 |
| 9.2 | computer architecture, | 2 |
| 9.3 | binary code | 2 |
| | Total | 36 |

**Course Designers:**

1. Dr.S.J. Thiruvengadam sjtece@tce.edu
2. Dr. S.Baskar sbeee@tce.edu

| 18ME160 | ENGINEERING GRAPHICS | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | ES | 3 | 0 | 2 | 4 |

**Preamble**

Engineering Graphics is referred as language of engineers. An engineer needs to understand the physical geometry of any object through its orthographic or pictorial projections. The knowledge on engineering graphics is essential in proposing new product designs through drawings and in reading or understanding existing drawings. This course covers orthographic and pictorial projections, sectional views, development of surfaces and use of computer aided drafting tools.

**Prerequisite**

NIL

**Course Outcomes**

On successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Draw conic Sections such as ellipse, parabola, hyperbola and rectangular hyperbola. | Apply |
| CO2 | Draw the orthographic projections (Elevation and Plan) of straight lines inclined to both reference planes. | Apply |
| CO3 | Draw the orthographic projections (Elevation, Plan and End view) of plane surfaces inclined to both reference planes | Apply |
| CO4 | Draw the orthographic projections (Elevation and Plan) of regular solids (Prisms, Pyramids, Cylinder and Cone) with axis inclined to any one reference plane. | Apply |
| CO5 | Draw the orthographic projections (Elevation and Plan) of sectioned solids (Prisms, Pyramids, Cylinder and Cone) with axis perpendicular to horizontal plane and true shape of the sections. | Apply |
| CO6 | Draw the development of surfaces (base and lateral) of sectioned regular solids (Prisms, Pyramids, Cylinder and Cone). | Apply |
| CO7 | Draw the isometric projections of regular solids and combined solids (Prisms, Pyramids, Cylinder, Cone and sphere) and of solid parts from the orthographic views. | Apply |
| CO8 | Develop computer-aided 3D models for the given part drawing (2D/3D ) and draw orthographic views for the 3D model with appropriate dimensioning using CAD package. (Continuous Assessment only) | Apply |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1. | S | M | S | M | M | _ | _ | _ | M | M | _ | _ |
| CO2. | S | M | S | M | M | _ | _ | _ | M | M | _ | _ |
| CO3. | S | M | S | M | M | _ | _ | _ | M | M | _ | _ |
| CO4. | S | M | S | M | M | _ | _ | _ | M | M | _ | _ |
| CO5. | S | M | S | M | M | _ | _ | _ | M | M | _ | _ |
| CO6. | S | M | S | M | M | _ | _ | _ | M | M | _ | _ |
| CO7. | S | M | S | M | M | _ | _ | _ | M | M | _ | _ |
| CO8. | S | M | S | M | S | _ | _ | _ | M | M | _ | _ |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Test | Terminal Examination |
|---|---|---|
| Remember | 0 | 0 |
| Understand | 0 | 0 |
| Apply | 100 | 100 |
| Analyse | 0 | 0 |
| Evaluate | 0 | 0 |
| Create | 0 | 0 |

**Course Level Assessment Questions**

**Course Outcome 1 (CO1)**

1. Draw an ellipse if the distance of focus from the directrix is 70 mm and the eccentricity is ¾.
2. Draw a parabola if the distance of focus from the directrix is 60 mm.

**Course Outcome 2 (CO2)**

2. One end "A" of a straight line AB 85 mm long is 10 mm above HP and 15 mm in front of VP. The line is inclined to HP at 40° and inclined to VP at 30°. Draw the projections.
3. A line CD has its end "C" 20 mm above HP and 25 mm in front of VP. The other end "D" is 45 mm above HP and 40 mm in front of VP. The distance between the end projectors is 60 mm. Draw its projections and find its true length.

**Course Outcome 3 (CO3)**

1. A semi circular plate of 80 mm diameter has its straight edge on V.P and inclined at 30° to H.P. The surface of the plate is inclined at 45° to V.P. Draw the projections of the plate.
2. A thin rectangular plate of 60 x 40 mm size has its shorter edge on H.P and inclined 30° to V.P. Draw the projections of the plate when its top view is a square of 40 mm side.

**Course Outcome 4 (CO4)**

1. A hexagonal prism of side of base 35 mm and axis length 80 mm rests on HP on one of its rectangular faces such that its axis is inclined to VP by 45°. Draw its elevation and plan.
2. A square pyramid of base side 40 mm and axis 75 mm long is resting on one of its base edges in such a way that one of its triangular faces is perpendicular to both HP and VP. Draw its front view and top view.

**Course Outcome 5 (CO5)**

1. A cone of base 75 mm diameter and axis 80 mm long is resting on its base on H.P. It is cut by a section plane perpendicular to VP, inclined at 45° to H.P and cutting the axis at a point 35 mm from the apex. Draw the front view, sectional top view and true shape of the section.
2. A hexagonal pyramid, base 30 mm side and axis 65 mm long is resting on its base on HP with two edges of the base parallel to V.P. It is cut by a section plane perpendicular to V.P and inclined 45° to H.P, intersecting the axis at a point 25 mm above the base. Draw the front view, sectional top view and true shape of the section.

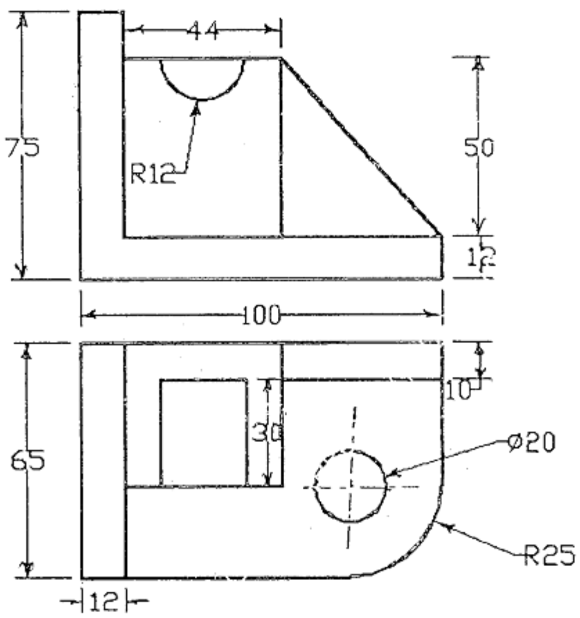
**Course Outcome 6 (CO6)**

1. A cone of base diameter 60 mm and axis 70 mm long is resting on its base on H.P. A section plane perpendicular to H.P and V.P cuts the cone at a distance of 10 mm from the axis. Draw the development of the cut solid.

2. A pentagonal prism of base side 30 mm and axis height 75 mm is resting on its base on HP such that rectangular face is parallel to V.P. It is cut by a cutting plane perpendicular to V.P and 30° inclined to H.P. It meets the axis 15 mm below the top base. Draw the development of the cut prism.

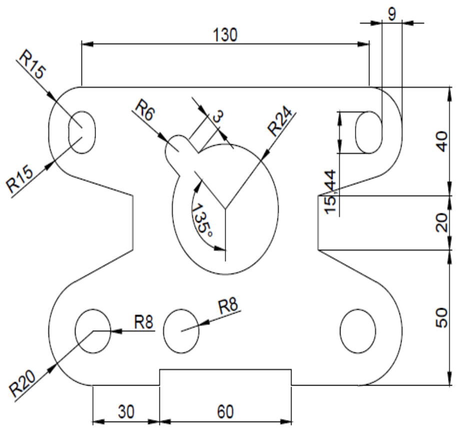
**Course Outcome 7 (CO7)**

1. Draw the isometric projection of hexagonal prism of base side 40 mm and height 60 mm with a right circular cone of base diameter 50 mm and altitude 50 mm resting on its top such that the axes of both solids are collinear and vertical.
2. Draw the isometric view of the part with the following orthographic views.

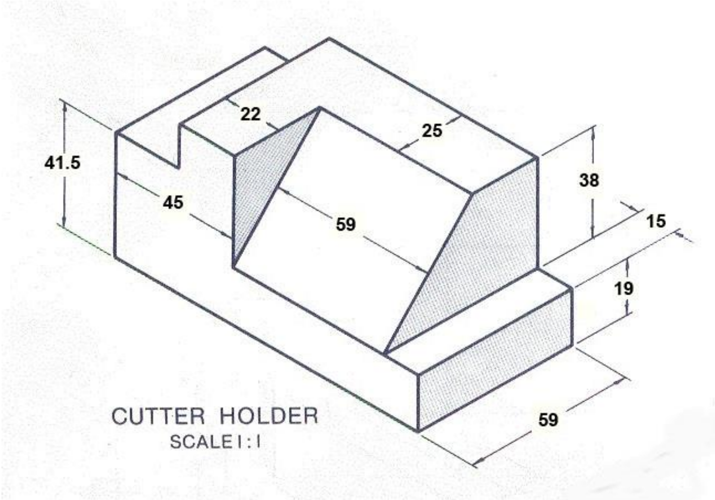



**Course Outcome 8 (CO8)**

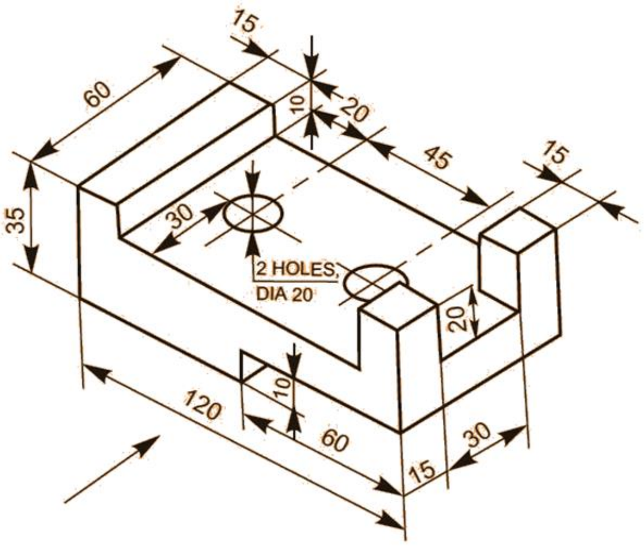
1. Develop a 2D model using CAD package for the given figure.



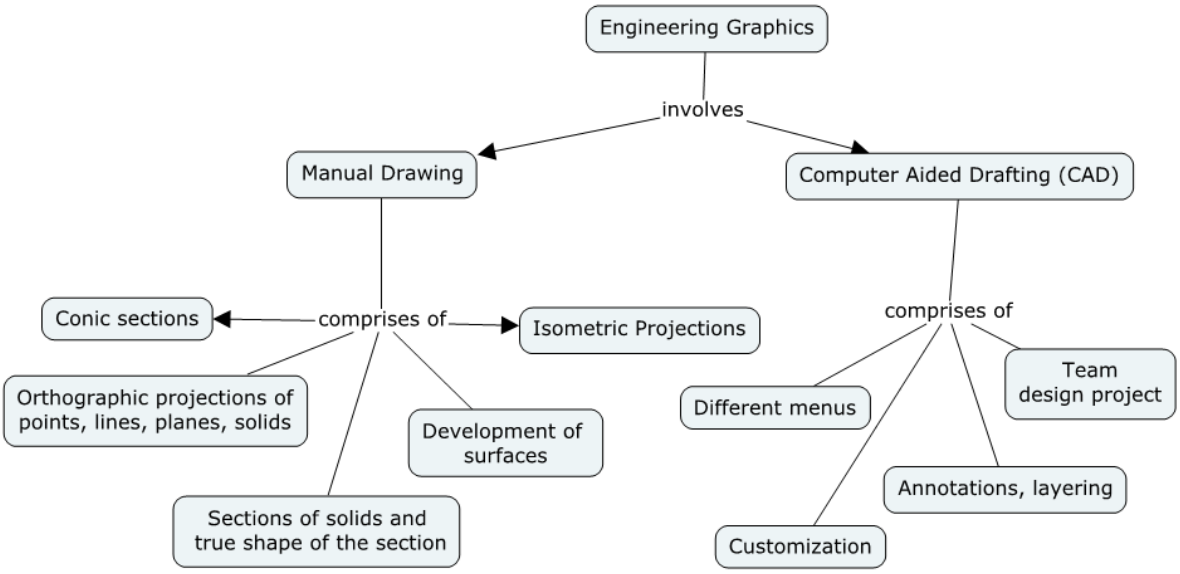

2. Develop a 3D model using CAD package for the given part drawing.




2. Draw the orthographic views for the given 3D model with appropriate dimensioning using CAD package.



## Concept Map




## Syllabus

**Introduction**- Significance of engineering graphics, Use of drawing instruments –Standards, Lettering, numbering and dimensioning, Principles of orthographic projections, First angle projection, Scales.

**Conic Sections** - Construction of ellipse, parabola, hyperbola (Eccentricity Method only) and rectangular hyperbola.

**Projection (Elevation and Plan) of points** located in all quadrants.

**Projection (Elevation and Plan) of straight lines** inclined to both reference planes - Determination of true lengths and true inclinations by rotating line method.

**Projection (Elevation, Plan and End view) of planes** inclined to both reference planes by rotating object method.

**Projection (Elevation and Plan) of regular solids** (Prisms, Pyramids, Cylinder and cone) by rotating object method when the axis is inclined to one of the reference planes.

**Projection (Elevation and Plan) of sectioned solids** (Prisms, Pyramids, Cylinder and cone) and true shape of the sections, when the axis of the solid is perpendicular to horizontal plane.

**Development of surfaces** (base and lateral) **of sectioned regular solids** (Prisms, Pyramids, Cylinder and Cone).

**Isometric projection** – Principle, isometric scale, Isometric views and Isometric projections of single solid and combined solids (Prisms, Pyramids, Cylinder, Cone and sphere) when the axis is vertical. **Conversion of orthographic projections** (Elevation, Plan and End view) of solid parts / engineering components into isometric view.

**Computer Aided Drafting** (For Continuous Assessment only)**:**

Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus

(Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits. Drawing geometric entities such as lines, arcs and circles in isometric views. Development of 3D wire-frame and shaded models. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems – Dimensioning in iso-metric and orthographic views.

**Text Book**


1. Bhatt N.D., Panchal V.M. and Ingle P.R., (2014) “Engineering Drawing”, Charotar Publishing House.


**Reference Books**


1. Natarajan K.V., “A text book of Engineering Graphics”, Dhanalakshmi Publishers, Chennai, 2009.
2. Basant Agarwal and Agarwal C.M., “Engineering Drawing”, Tata McGraw Hill Publishing Company Limited, New Delhi, 2008
3. Venugopal K. and Prabhu Raja V., “Engineering Graphics”, New Age International (P) Limited, 2008.
4. Gopalakrishna K.R., “Engineering Drawing” (Vol. I&II combined), Subhas Stores, Bangalore, 2007.
5. Shah M.B, and Rana B.C (2008) “Engineering Drawing and Computer Graphics”, Pearson Education.
6. (Corresponding set of) CAD Software Theory and User Manuals.


**Course Contents and Lecture Schedule**

| Sl.No | Topic | Lecture Hours | Practice Hours |
|---|---|---|---|
| **1** | **Introduction**- Significance of engineering graphics, Use of drawing instruments –Standards, Lettering, numbering and dimensioning, Principles of orthographic projections, First angle projection, Scales. | 2 | 1 |
| **2** | **Conic Sections** - Construction of Ellipse, Parabola, hyperbola and rectangular hyperbola (Eccentricity Method only). | 2 | 3 |
| **3** | **Projection (Elevation and Plan) of points** located in all quadrants. | 2 | 1 |
| **4** | **Projection (Elevation and Plan) of straight lines** inclined to both reference planes - Determination of true lengths and true inclinations by rotating line method. | 4 | 2 |
| **5** | **Projection (Elevation, Plan and End view) of planes** inclined to both reference planes by rotating object method. | 5 | 2 |
| **6** | **Projection (Elevation and Plan) of regular solids** (Prisms, Pyramids, Cylinder and cone) by rotating object method when the axis is inclined to one of the reference planes. | 5 | 3 |
| **7** | **Projection (Elevation and Plan) of sectioned solids** (Prisms, Pyramids, Cylinder and cone) and true shape of the sections, when the axis of the solid is perpendicular to horizontal plane. | 4 | 2 |
| **8** | **Development of surfaces** (base and lateral) **of sectioned regular solids** (Prisms, Pyramids, Cylinder and Cone). | 4 | 2 |
| **9** | **Isometric projection** – Principle, isometric scale, Isometric views and Isometric projections of single solid and combined | 4 | 2 |

| | | | |
|---|---|---|---|
| | solids (Prisms, Pyramids, Cylinder, Cone and sphere) when the axis is vertical. **Conversion of orthographic projections** (Elevation, Plan and End view) of solid parts / engineering components into isometric view. | | |
| 10 | **Computer Aided Drafting** (For Continuous Assessment only)**:**<br>**10.1** Overview of Computer Graphics, list of computer technologies, impact on graphical communication. Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects. Setting up of units and drawing limits. | 1 | 1 |
| | **10.2** Drawing geometric entities such as lines, arcs and circles in isometric views. Development of 3D wire-frame and shaded models. Dimensioning – Guidelines – ISO and ANSI standards for coordinate dimensioning - Defining local coordinate systems – Dimensioning in iso-metric and orthographic views. | 3 | 5 |
| | **TOTAL** | **36** | **24** |

## Question Pattern for Terminal Examination

| Question Number | Description | Type | Marks |
|---|---|---|---|
| 1 | Conic sections | Either or type | 10 |
| 2 | Projection of lines | Either or type | 15 |
| 3 | Projection of planes | Either or type | 15 |
| 4 | Projection of solids | Either or type | 15 |
| 5 | Section of solids | Either or type | 15 |
| 6 | Development of surfaces | Either or type | 15 |
| 7 | Isometric projections of combined solids<br>Or<br>Orthographic views to isometric view | Either or type | 15 |
| **Total** | | | **100** |

**Marks Allocation for Continuous Assessment:**

| Sl. No | Description | Marks |
|---|---|---|
| 1 | Plates (Drawing sheets) submission | 20 |
| 2 | Computer Aided Drafting (CAD) Exercises | 15 |
| 3 | Continuous Assessment Test (CAT) | 15 |
| **Total** | | **50** |

**Note:**

1. One test or two tests will be conducted locally by respective faculty-in- charge during regular class hours to account for continuous assessment test (CAT) marks.
2. Terminal examination (3 hrs) will be conducted centrally by the office of controller of examinations.

## Course Designers

1. Dr. A.Samuel Raja samuel1973@tce.edu
2. Prof. M.Kannan mknmech@tce.edu

| 18EG170 | ENGLISH LABORATORY | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | HSS | 0 | 0 | 2 | 1 |

## Preamble

This practical course enables the students to develop and evaluate their basic English language skills in Language Lab, equipped with English Software, through individualized learning process and immediate feedback, and facilitates students with the need-based student-centric presentation sessions in a multi-media driven classroom environment.

## Prerequisite

NIL

## Course Outcomes

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Pronounce words intelligibly through listening and watching contents on social, technical and day-to-day conversations and respond to questions related to them | Apply |
| CO2 | Apply appropriate lexicon in various contexts, by differentiating variations pertaining to spelling, pronunciation, meaning and grammar | Apply |
| CO3 | Comprehend passages on various topics like general, business and science at various levels | apply |
| CO4 | Read texts in newspapers, magazines, and articles on a variety of issues with clarity to understand and to be understood | Apply |
| CO5 | Prepare and present on a topic to a group of audience with ICT and other educational aids | Apply |

## Mapping with Programme Outcomes

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

## Assessment Pattern

**Internal:** No Continuous Assessment Test will be conducted

Students' performance will be assessed in the classroom as given below

- Spoken Task - General / Technical Presentation / BEC Speaking Tests II: 25 Marks
- Listening Task - Answering questions : 25 Marks

**External:** Tested on Phonetics, Grammar, and Vocabulary in the lab for 1 hour : 80 Marks

Submission of Students Record on Practical Tasks in the Class and Lab : 20 Marks

**List of Experiments**

| S.No | Topic | Hours |
|---|---|---|
| | LAB ACTIVITES | |
| 1 | Listening | 2 |
| 2 | Vocabulary | 2 |
| 3 | Grammar | 2 |
| 4 | Phonetics | 2 |
| 5 | Reading Comprehension – I (General) | 2 |
| 6 | Reading Comprehension – II (BEC Vantage Level) | 2 |
| | CLASSROOM ACTIVITIES | |
| 7 | Reading Practice (Extensive Reading) | 2 |
| 8 | English through Audios & Videos (Note-Taking & answering questions) | 2 |
| 9 | Presentation - I | 2 |
| 10 | Presentation - II | 2 |
| 11 | Revision | 2 |
| 12 | Model Test | 2 |
| | Total | 24 |

**Software Used:**

1. Business English Certificate-Vantage- Practice Software
2. English Software

**Extensive Reading: ( Not for Terminal Exam, Prescribed only for Spoken Tasks)**

1. Khera, Shiv, You Can Win, Macmillan Books, New York, 2003.

**Teaching Resources and Websites:**

1. Oxford / Cambridge Online English Videos
2. Free Video Downloads from Youtube
3. https://learningenglish.voanews.com/
4. https://www.ted.com/talkshttp://
5. www.esl-galaxy.com/video.htm

**Course Designers:**


| | | |
|---|---|---|
| 1 | Dr. S. Rajaram | sreng@tce.edu |
| 2 | Dr.A.Tamilselvi | tamilselvi@tce.edu |
| 3 | Mr. R. Vinoth | vino@tce.edu |
| 4 | Dr. R. K. Jaishree Karthiga | jai@tce.edu |

| 18PH180 | PHYSICS LABORATORY |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 0 | 0 | 2 | 1 |

**Preamble**

This course ensures that students learn to apply the basic physics concepts and carry out the experiments to determine the various physical parameters related to the material

- Learn the necessary theory to understand the concept involved in the experiment.
- Acquire the skills to carry out the experiment.
- Tabulate the observed data and use the formula to evaluate the required quantities.
- Plot the data in a graph and use it for calculation.

**Course Outcomes**

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Analyze mechanical ,electrical oscillations and determine their resonance frequency | Apply |
| CO2 | Analyze the diffraction and interference patterns for characterization | Apply |
| CO3 | Determine the numerical aperture and bending loss in optical fiber | Apply |
| CO4 | Determine the Planck’s constant by using LEDs | Apply |
| CO5 | Plot the VI characteristics of solar cell | Apply |
| CO6 | Determine the time constant of an RC circuit | Apply |
| CO7 | Determine the reversibility of classical and quantum logic gates | Apply |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | S | S | - | - | - | - | - | - | - | - |
| CO2 | S | S | S | S | - | - | - | - | - | - | - | - |
| CO3 | S | S | S | S | - | - | - | - | - | - | - | - |
| CO4 | S | S | S | S | - | - | - | - | - | - | - | - |
| CO5 | S | S | S | S | - | - | - | - | - | - | - | - |
| CO6 | S | S | S | S | - | - | - | - | - | - | - | - |
| CO7 | S | S | S | S | - | - | - | - | - | - | - | - |
| S- Strong; M-Medium; L-Low | | | | | | | | | | | | |

**List of Experiments**

**OSCILLATIONS AND WAVES**

1. Torsion pendulum- Determination of Moment of inertia of a disc
2. Compound pendulum –Determination of acceleration due to gravity

**OPTICS**

3. Spectrometer-Determination of Refractive index of the material of the prism.
4. Laser Diffraction – Determination of wavelength of Laser and particle size in a thin film.
5. Air wedge –Determination of diameter of wire by interference principle.
6. Fiber optics-Determination of numerical aperture and bending losses.

**QUANTUM MECHANICS**

7. Photoelectric effect-Determination of Planck's constant
8. Solar cell-Plotting and studying of V-I characteristic
9. Study of Classical and quantum Logic gates.

**ELECTROMAGNETIC THEORY**

10. RC circuit –Determination of time constant
11. LCR Circuit- Determination of resonant frequency

**Course Designers:**


1. Dr. R. Vasuki rvphy@tce.edu
2. Dr. M.Mahendran mmphy@tce.edu
3. Mr. V.Veeraganesh vvgphy@tce.edu
4. Dr. A.L.Subramaniyan alsphy@tce.edu
5. Dr.D.Ravindran drphy@tce.edu

| 18CH190 | CHEMISTRY LABORATORY |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 0 | 0 | 2 | 1 |

**Preamble**

This course aims to provide the students, a basic practical knowledge in chemistry. The objective of this course is to develop intellectual and psychomotor skills of the students by providing hands on experience in quantitative, electrochemical and photo-chemical analysis.

**Course Outcomes**

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Estimate the chemical water quality parameters of sample water | Apply |
| CO2 | Demonstrate the rate of corrosion of steel by weight loss method | Apply |
| CO3 | Estimate the strength of acidic solution and pH of soil by conductometric and pH metric titrations | Apply |
| CO4 | Illustrate the strength of oxidisable materials present in given sample by potentiometric method | Apply |
| CO5 | Adapt colorimetric method for determination of iron in water | Apply |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | M | - | - | - | L | - | L | - | - | - |
| CO2 | S | S | M | - | - | - | L | - | L | - | - | - |
| CO3 | S | S | M | - | - | - | L | - | M | - | - | - |
| CO4 | S | M | - | - | - | - | - | - | - | - | - | - |
| CO5 | S | S | M | - | - | - | L | - | - | - | - | - |

**List of Experiments**

**A. Quantitative analysis**
1. Estimation of Total hardness of water
2. Estimation of $Ca^{2+}$ and $Mg^{2+}$ individual hardness of water samples
3. Estimation of alkalinity of water sample
4. Estimation of COD of industrial effluent
5. Estimation of Chloride in a water sample
6. Estimation of rate of corrosion of steel by weight loss method

**B. Electrochemical and photochemical analysis**
1. Conductometry Titration (Strong acid vs Strong base)
2. Potentiometric redox Titration ($K_2Cr_2O_7$ vs FAS, $KMnO_4$ vs FAS)
3. Determination of pH of soil by pH metric titration
4. Estimation of iron content of water sample using colorimeter

**Course Designers:**


| | |
|---|---|
| Dr. M. Kottaisamy | hodchem@tce.edu |
| Dr. K. Radha | krchem@tce.edu |
| Dr. J. Shanmugapriya | shanamugapriya@tce.edu |
| Dr. S. Rajkumar | rajkumarsubramanian@tce.edu |
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**CURRICULUM AND DETAILED SYLLABI**

**FOR**

**B.E. EEE  DEGREE PROGRAMME**

**SECOND SEMESTER**

**FOR THE STUDENTS ADMITTED IN THE**

**ACADEMIC YEAR 2018-19 ONWARDS**

**THIAGARAJAR COLLEGE OF ENGINEERING**
(A Government Aided ISO 9001:2008 certified Autonomous Institution affiliated to Anna University)
**MADURAI – 625 015, TAMILNADU**

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**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**
**B.E. EEE Degree Programme**

**COURSES OF STUDY**
(For the candidates admitted from 2018-19)

**SECOND SEMESTER**

| Course Code | Name of the Course | Category | No. of Hours / Week | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| 18MA210 | Matrices and Ordinary Differential Equations | BS | 3 | - | - | 3 |
| 18EE220 | Materials Science for Electrical Engineering | ES | 3 | - | - | 3 |
| 18EE230 | Electric Circuit Analysis | PC | 3 | - | - | 3 |
| 18EE240 | Electromagnetic fields | PC | 2 | 1 | - | 3 |
| 18EE250 | Electronic Devices and Circuits | PC | 3 | - | - | 3 |
| **PRACTICAL** | | | | | | |
| 18EE270 | Electronic Devices and Circuits Lab | PC | - | - | 2 | 1 |
| 18EE280 | Electrical Workshop | ES | - | - | 2 | 1 |
| 18ES290 | Lateral Thinking | ES | - | - | 2 | 1 |
| **Total** | | | | | | **18** |
| **MANDATORY AUDIT COURSES** | | | | | | |
| 18CHAA0 | Environmental Science | AC | 1 | - | 1 | - |

BS : Basic Science
ES : Engineering Science
PC : Programme Core
PE : Programme Elective
L : Lecture
T : Tutorial
P : Practical

**Note**:

1 Hour Lecture/week is equivalent to 1 credit
1 Hours Tutorial/week is equivalent to 1 credit
2 Hours Practical/week is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**

**B.E. EEE Degree Programme**

**SCHEME OF EXAMINATIONS**
(For the candidates admitted from 2018-19onwards)

**SECOND SEMESTER**

| S.No. | Course Code | Name of the Course | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | 18MA210 | Matrices and Ordinary Differential Equations | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | 18EE220 | Materials Science for Electrical Engineering | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | 18EE230 | Electric Circuit Analysis | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | 18EE240 | Electromagnetic fields | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | 18EE250 | Electronic Devices and Circuits | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 6 | 18EE270 | Electronic Devices and Circuits Lab | 3 | 50 | 50 | 100 | 25 | 50 |
| 7 | 18EE280 | Electrical Workshop | 3 | 50 | 50 | 100 | 25 | 50 |
| 8 | 18ES290 | Lateral Thinking | - | 50 | 50 | 100 | 25 | 50 |
| **MANDATORY AUDIT COURSES** | | | | | | | | |
| 9 | 18CHAA0 | Environmental Science | - | 50 | 50 | 100 | 25 | 50 |

* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

| 18MA210 | MATRICES AND ORDINARY DIFFERENTIAL EQUATIONS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 3 | 0 | 0 | 3 |

## Preamble

In engineering, particularly Solid Mechanics, Aerodynamics, Fluid Flow, Heat Flow and Robotics have application that requires an understanding of Vector Calculus and Differential Equations. Also Mathematical tool Laplace Transforms is very much essential to solve ordinary differential equations that occur in the above areas. Eigen values and Eigenvectors are extremely important while creating engineering models in control systems, designing bridges, communication systems and searching algorithms. The course is designed to impart the knowledge and understanding of the above concepts to all Engineers and apply them in their areas of specialization.

## Prerequisite

18MA110 Engineering Calculus

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage in % |
|---|---|---|
| CO1 | Compute the Laplace transform and inverse Laplace transform of different functions | 10% |
| CO2 | Solve the given initial value problem using Laplace transform | 15% |
| CO3 | Apply matrix algebra techniques for transformations of conic sections into principle axes | 25% |
| CO4 | Solve the model developed for the given system using ordinary differential equation | 25% |
| CO5 | Compute divergence and curl of vector functions | 10% |
| CO6 | Apply the concepts of vector differentiation and vector integration to fluid flow and heat transfer problems | 15% |

## CO Mapping with CDIO Curriculum Framework

| CO | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | K2 | A2 | - | 1.1 |
| CO2 | TPS3 | K3 | A3 | - | 1.1 |
| CO3 | TPS3 | K3 | A3 | - | 1.1 |
| CO4 | TPS3 | K3 | A3 | - | 1.1 |
| CO5 | TPS2 | K2 | A2 | - | 1.1 |
| CO6 | TPS3 | K3 | A3 | - | 1.1 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1. | S | M | | | - | - | - | - | | - | - | |
| CO2. | S | S | S | | - | - | - | - | M | - | - | M |
| CO3. | S | S | | S | - | - | - | - | | - | - | S |
| CO4. | S | S | S | S | - | - | - | - | M | - | - | M |
| CO5. | S | M | | | | | | | | | | |
| CO6. | S | S | S | | | | | | | | | |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | | | | 10 |
| Understand | 30 | 30 | 30 | | | | 20 |
| Apply | 60 | 60 | 60 | 100 | 100 | 100 | 70 |
| Analyse | 00 | 00 | 00 | | | | 00 |
| Evaluate | 00 | 00 | 00 | | | | 00 |
| Create | 00 | 00 | 00 | | | | 00 |

## Sample Questions for Course Outcome Assessment**

**Course Outcome 1**

1. Show that Laplace transform of $\frac{1}{\sqrt{t}}$ is $\frac{\sqrt{\pi}}{s}$.
2. Identify the inverse Laplace transform of $\log\left(\frac{s^2+1}{(s-1)^2}\right)$.
3. Discuss any three properties of Laplace transforms.

**Course Outcome 2**

1. Apply Laplace transform solve $y''+9y=\delta\left(t-\frac{\pi}{2}\right)$, $y(0)=2,\ y'(0)=0$.
2. By using Laplace transform, solve $x''(t)+3x'(t)+2x(t)=2(t^2+t+1)$; with $x(0)=2, x'(0)=0$.
3. Apply convolution theorem, Solve the Voltera integral equation of the second kind $y(t)-\int_0^t y(\tau)\sin(t-\tau)d\tau=t$ .

**Course Outcome 3**

1. An elastic membrane in the $x_1\,x_2$ plane with boundary circle $x_1^{\,2}+x_2^{\,2}=1$ is stretched so that a point $P;(x_1,x_2)$ goes over into the point $Q;(y_1,y_2)$ given by
   $y_1 = 5x_1 + 3x_2$
   $y_2 = 3x_1 + 5x_2$

   Find the principal directions that is the directions of the position vector $X$ of $P$ for which the direction of the position vector $Y$ of $Q$ is the same or exactly opposite. Predict the boundary circle take under this deformation?
2. Discover the type of conic section the following quadratic form represents and transform it to principal axes: $Q = 17x_1^{\,2} - 30x_1x_2 + 17x_2^{\,2} = 128$.
3. Diagonalize the matrix $\begin{bmatrix} 6 & 0 & 0 \\ 12 & 2 & 0 \\ 21 & -6 & 9 \end{bmatrix}$

**Course Outcome 4**

1. Reduce to first order and solve $y''-y'=0$
2. Compute the general solution for $y''+y'+(\pi^2+1/4)y = e^{-x/2}\sin \pi x$
3. Solve $(x^2D^2 - 4xD - 6)y = c$

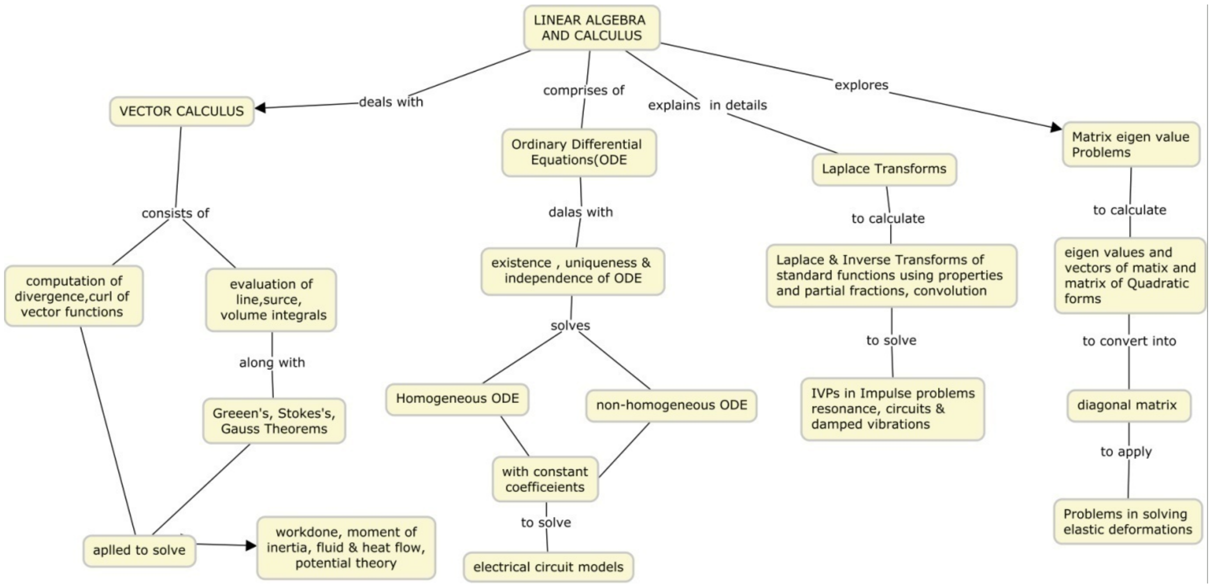
**Course Outcome 5**

1. Predict the value of $div(curl\vec{F})$.
2. If $\phi_1$ and $\phi_2$ are scalar point functions and $\vec{F}$ is a vector point function such that $\phi_1\,\vec{F} = \nabla\phi_2$ then identify $\vec{F}.curl\,\vec{F}$.
3. Estimate $curl\,\vec{v}$, where $\vec{v} = \left[e^{-z^2}, e^{-x^2}, e^{-y^2}\right]$.

**Course Outcome 6**

1. Predict the work done by the force $\vec{F} = [y^2, -x^2]$ acting on a particle in $y = 4x^2$ from (0,0) to (1,4).
2. Compute the amount of fluid that crosses the surface in a flow per unit time at any one instant, if the velocity field is $\vec{v} = y\vec{i} + x\vec{j} + z\vec{k}$ over the boundary of the region enclosed by the paraboloid z = 1- $x^2$ - $y^2$ and the plane z = 0.
3. Apply Stokes theorem to compute $\int_C \vec{F}.\vec{r}'ds$ where $\vec{F} = [y, xz^3, -zy^3]$ and $C$ is circle $x^2 + y^2 = 4, z = -3$.

## Concept Map




## Syllabus

**LAPLACE TRANSFROMS:** Laplace transform, Linearity, First Shifting theorem – Transforms of derivatives and integrals, ODEs – Unit step function, Second shifting theorem – Short Impulses, Dirac's delta function, partial fractions – Convolution, Integral Equations – Differentiation and integration of transforms. **MATRIX EIGEN VALUE PROBLEM:** The Matrix Eigen value Problem, Determining Eigenvalues and Eigenvectors – Some Applications of Eigen value Problems – Symmetric, Skew symmetric and orthogonal matrices – Eigen bases, Diagonalization, Quadratic forms. **ORDINARY DIFFERENTIAL EQUATION:** Homogeneous Linear ODEs of second order – Homogeneous Linear ODEs with constant coefficients – Euler Cauchy Equation – Existence and uniqueness of solutions, Wronskian - Nonhomogeneous ODE – Modelling: Electric Circuits- Solution by Variation of Parameters. **VECTOR CALCULUS:** Divergence of a Vector Field- Curl of a Vector Field- Line Integrals- Path independence of line integrals- Green's Theorem in the plane- Surface Integrals- Triple Integrals, Divergence Theorem of Gauss- Applications of the Divergence Theorem- Stoke's Theorem.

## Learning Resources

1. Erwin Kreszig, "Advanced Engineering Mathematics",10th edition, Wiley, 2017.
   a. Laplace transforms : [sections 6.1,6.2,6.3,6.4,6.5,6.6]
   b. Matrix eigen value problem : [sections 8.1,8.2,8.3,8.4]
   c. Ordinary differential equations : [sections 2.1,2.2,2.5,2.6,2.7,2.9,2.10]
   d. Vector calculus : [sections 9.8.9.9,10.1,10.2,10.4,10.6, 10.7,10.8,10.9]
2. Peter V.O'Neil, "Advanced Engineering Mathematics", 7th edition, Cengage Learning, 2017.
3. Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, New Delhi, 2016.
4. Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", Narosa Publications, New Delhi, 3rd Edition, 2007.

5. Made Easy Team, Engineering Mathematics, Made Easy Publications, 2018.

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1. | **LAPLACE TRANSFORMS** | | |
| 1.1 | Laplace Transform. Linearity. First Shifting Theorem (*s*-Shifting) | 2 | CO1 |
| 1.2 | Transforms of Derivatives and Integrals. ODEs | 2 | CO2 |
| 1.3 | Unit Step Function (Heaviside Function).<br>Second Shifting Theorem (*t*-Shifting) | 1 | CO1 |
| 1.4 | Short Impulses. Dirac's Delta Function. Partial Fractions | 1 | CO1 |
| 1.5 | Convolution. Integral Equations | 2 | CO2 |
| 1.6 | Differentiation and integration of transforms | 1 | CO1 |
| **2** | **MATRICES EIGEN VALUE PROBLEMS** | | |
| 2.1 | Determining Eigenvalues and Eigenvectors | 2 | CO3 |
| 2.2 | Some Applications of Eigenvalue Problems | 1 | CO3 |
| 2.3 | Symmetric, Skew-Symmetric, and Orthogonal Matrices | 2 | CO3 |
| 2.4 | Eigenbases. Diagonalization. | 2 | CO3 |
| 2.5 | Quadratic Forms | 2 | CO3 |
| **3** | **ORDINARY DIFFERENTIAL EQUATION** | | |
| 3.1 | Homogeneous Linear ODEs of Second Order | 2 | CO4 |
| 3.2 | Homogeneous Linear ODEs with Constant Coefficients | 1 | CO4 |
| 3.3 | Euler–Cauchy Equations | 1 | CO4 |
| 3.4 | Existence and Uniqueness of Solutions. Wronskian | 1 | CO4 |
| 3.5 | Nonhomogeneous ODEs | 2 | CO4 |
| 3.6 | Solution by Variation of Parameters | 2 | CO4 |
| **4** | **VECTOR CALCULUS** | | |
| 4.1 | Divergence and Curl of a Vector Field | 2 | CO5 |
| 4.2 | Line Integrals | 2 | CO6 |
| 4.3 | Green's Theorem in the Plane | 1 | CO6 |
| 4.4 | Surface Integrals | 1 | CO6 |
| 4.5 | Triple Integrals. Divergence Theorem of Gauss | 1 | CO6 |
| 4.6 | Applications of the Divergence Theorem | 1 | CO6 |
| 4.7 | Stoke's Theorem | 1 | CO6 |
| | **TOTAL No. of Hours** | 36 | |

**Course Designers**

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3. Dr.G.Jothilakshmi - gjlmat@tce.edu
4. Dr.C.S.Senthil kumar - kumarstays@tce.edu
5. Dr.R.Suresh - suresh080183@tce.edu

| 18EE220 | MATERIALS SCIENCE FOR ELECTRICAL ENGINEERS |
| --- | --- |

| Category | L | T | P | Credit |
| --- | --- | --- | --- | --- |
| ES | 3 | 0 | 0 | 3 |

## Preamble

The course work aims in imparting fundamental knowledge of materials science required for electrical engineers. The course work will introduce engineers to different types of conductors, semiconductors and dielectrics. The recent magnetic materials, Solar cell materials, superconductors and smart materials will be discussed.

## Prerequisite

Basic course (No prerequisite)

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
| --- | --- | --- |
| CO1 | **Compute** the electrical properties of metals based on classical ,quantum and band theory of solids. | 15% |
| CO2 | **Explain** the basic properties of semiconductor based on carrier concentration and generation. | 15% |
| CO3 | **Use** the knowledge of semiconductors for fabrication of optoelectronic devices. | 10% |
| CO4 | **Explain** the mechanisms of polarisations and different types of dielectrics | 15% |
| CO5 | **Explain** the behaviour of dielectrics with increasing frequency and temperature | 15% |
| CO6 | **Compute** the magnetic properties of different magnetic materials. | 15% |
| CO7 | **Explain** the properties and application of new engineering materials like nano materials ,smart material and superconductors. | 15% |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
| --- | --- | --- | --- | --- | --- |
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.1 |

| | | | | | |
|---|---|---|---|---|---|
| CO2 | TPS2 | Understand | Respond | | 1.1 |
| CO3 | TPS3 | Apply | Value | | 1.1 |
| CO4 | TPS2 | Understand | Respond | | 1.1 |
| CO5 | TPS3 | Understand | Respond | | 1.1 |
| CO6 | TPS3 | Apply | Value | | 1.1 |
| CO7 | TPS2 | Understand | Respond | | 1.1 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | | | | M | | M | | | S | S |
| CO2 | M | L | L | | | | | M | | M | | | M | M |
| CO3 | S | M | L | L | | | | M | | M | | | S | S |
| CO4 | M | L | | | | | | M | | M | | | M | M |
| CO5 | M | L | | | | | | M | | M | | | M | M |
| CO6 | S | M | L | L | | | | M | | M | | | S | S |
| CO7 | M | L | | | | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | | | | 20 |
| Understand | 30 | 30 | 30 | | | | 30 |
| Apply | 50 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |

| | |
|---|---|
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

**Sample Questions for Course Outcome Assessment****

***2 or 3 at the cognitive level of course outcome

**Course Outcome 1(CO1):**

1. Calculate the drift velocity of the free electrons in a conductor of area $10^{-4}m^2$,given the electron density to be $8x10^{28}/m^3$when a current of 5A flows through it.
2. Calculate the electron density ,if the drift velocity of electrons in a metal wire of diameter 5mm is $6x10^{-4}$m/s and the current is 10A
3. Calculate the relaxation time of free electrons in a metal of resistivity $1.54x10^{-8}$ ohm-m, if the metal has $5.8x10^{28}$ electrons/$m^3$ .Identify the possible. material and suggest the suitability for transformer winding applications.

**Course Outcome 2(CO2):**

1. Differentiate between intrinsic and extrinsic semiconductors with examples.
2. Recall the relation between Fermi velocity and Fermi energy.
3 Define the Fermi function and plot the Fermi function for T=0K and T=300K.

**Course Outcome 3(CO3):**

**1.** Calculate the intrinsic carrier density, intrinsic conductivity and resistivity at a 300K in germanium. Suppose one boron atom for every $10^5$ germanium atoms are added, Identify the new resistivity of germanium.
**2.** The electrical conductivity of germanium at 20̊C is 2 mho $m^{-1}$.What is its conductivity at 40C?.Band gap of germanium =0.72eV

**Course Outcome 4 (CO4):**

1.List the different parameters affecting power loss in a dielectric.
2. Explain the different types of polarization and justify the size dependence of electronic polarization.
3. State the factors which affect dielectric strength.

**Course Outcome 5 (CO5):**

1. Define dielectric constant of a material
2. Explain the frequency dependence of dielectric constant from power frequency to optical frequency
3. Justify the usage of dielectric for antenna applications.

**Course Outcome 6(CO6):**

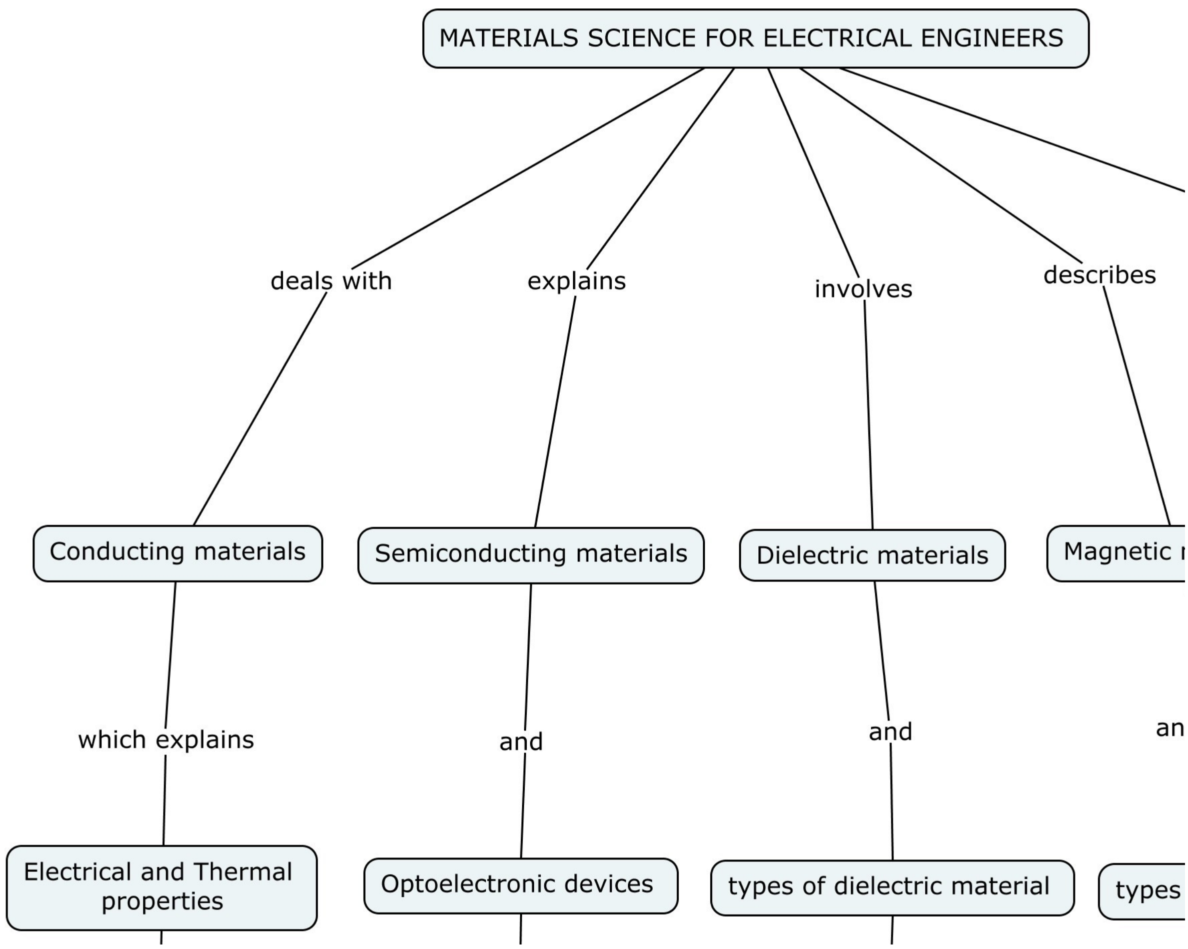
1. A magnetic material has a flux density and magnetization of 0.0044 Wb./$m^2$ and 3300 A/m respectively. Calculate the magnetizing force and relative permeability of the material. Comment on the type of magnetic material and possible applications.
2. The magnetic field strength in copper is $10^6$ A/m. If the magnetic susceptibility of copper is $-0.8X10^{-5}$, calculate the flux density and magnetization in copper

3. A para magnetic material has a magnetic field intensity of $10^4$ A/m. If the susceptibility of the material at room temperature is $3.7X10^{-3}$ calculate the magnetization and flux density in the material.

**Course Outcome 7 (CO7):**

1. Mention any four method of synthesis of nano materials.
2. Define a smart material
3. Explain the properties and applications of metallic glasses

## Concept Map




## Syllabus

### Conducting Materials

Conduction in metals- Classical free electron theory of metals- Mobility and Conductivity-Thermal Conductivity of metals, polymers and ceramics-Widemaan Franz Law . Quantum free electron theory –Fermi function,Band theory of Solids Blochs theorem-Kronig-Penny model –Application of low and High resistivity materials.

**Semiconducting Materials**

Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier-concentration and temperature, Carrier generation and recombination, Carrier transport: diffusion and drift, p-n junction, Metal-semiconductor junction (Ohmic and Schottky) Semiconductor materials of interest for optoelectronic devices-Laser diode and LED.

**Dielectric materials**

Electric polarisation-Different types of polarisation- -Internal field-Claussius Mosotti Relation-Dielectric Loss-Dielectric Breakdown-Uses of dielectrics (Capacitors and Transformers)-Frequency and temperature dependence of Polarization, Ferroelectric materials Piezoelectric materials- Multilayer Ceramic Capacitors and Memory devices.

**Magnetic materials**

Origin of magnetic moment - Comparison of magnetic materials-(Dia, Para, Ferro,) Domain theory-Hysteresis- Hard and soft magnetic materials, Ferrites –properties & applications. Epstiens frame method,Magnetic grades,Neodymium magnets.

**Advanced Engineering materials**

Metallic Glasses-Types of metallic glasses-Preparation-Properties and applications - Superconductors- High Temperature Superconductor and Applications , Nano materials-Synthesis, Properties and Applications- Smart materials-Properties and Applications. Solar cell materials-Silicon & Compound semiconductors.

**Learning Resources**


1. M.A.Wahab Solid State Physics - Structure and Properties of Materials, 3rd edition, Narosa Publishers, 2018
2. William D Callister Materials Science and Engineering – An introduction,9th edition, Wiley Publications, 2013.
3. William F Smith, Javed Hashemi, Ravi Prakash Materials Science and Engineering 4th edition, Tata McGraw Hill, 2006
4. https://nptel.ac.in/courses/115102025/
5. https://nptel.ac.in/courses/117102061/


**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1. | Conducting Materials | | |
| 1.1 | Conduction in metals - Classical free electron theory of metals - Mobility and Conductivity | 2 | CO1 |
| 1.2 | Thermal Conductivity of metals, polymers and ceramics - Wiedemaan Franz Law | 1 | CO1 |
| 1.3 | Quantum free electron theory – Fermi function | 1 | CO1 |
| 1.4 | Band theory of Solids - Bloch theorem - Kronig - Penny model | 2 | CO1 |
| 1.5 | Application of low and high resistivity materials | 1 | CO1 |
| 2. | Semiconducting Materials | | |

| | | | |
|---|---|---|---|
| 2.1 | Intrinsic and extrinsic semiconductors, Dependence of Fermi level on carrier concentration and temperature | 2 | CO2 |
| 2.2 | Carrier generation and recombination, Carrier transport | 2 | CO2 |
| 2.3 | Diffusion and drift, p-n junction | 2 | CO2 |
| 2.4 | Metal-semiconductor junction (Ohmic and Schottky), | 2 | CO3 |
| 2.5 | Semiconductor materials of interest for optoelectronic devices - Laser diode and LED | 2 | CO3 |
| 3. | Dielectric materials | | |
| 3.1 | Electric polarisation - Different types of polarisation | 2 | CO4 |
| 3.2 | Internal field - Claussius Mosotti Relation | 1 | CO5 |
| 3.3 | Dielectric Loss - Dielectric Breakdown - Uses of dielectrics(Capacitors and Transformers) | 2 | CO5 |
| 3.4 | Frequency and temperature dependence of Polarization | 2 | CO5 |
| 3.5 | Ferroelectric materials & Piezoelectric materials-- Multilayer Ceramic Capacitors and Memory devices | 2 | CO5 |
| 4. | Magnetic materials | | |
| 4.1 | Origin of magnetic moment-Comparison of magnetic materials - (Dia, Para, Ferro) | 1 | CO6 |
| 4.2 | Domain theory – Hysteresis - Hard and soft magnetic materials | 2 | CO6 |
| 4.3 | Ferrites – properties & applications - Epstiens frame method,Magnetic grades, Neodymium magnets | 2 | CO6 |
| 5. | Advanced Engineering materials | | |
| 5.1 | Metallic Glasses – Types of metallic glasses – Preparation – Properties and applications | 1 | CO7 |
| 5.2 | Superconductors – High Temperature Superconductor and Applications | 1 | CO7 |
| 5.3 | Nano materials – Synthesis, Properties and Applications | 1 | CO7 |
| 5.4 | Smart materials – Properties and Applications | 1 | CO7 |
| 5.5 | Solar cell materials-Silicon & Compound semiconductors | 1 | CO7 |
| | Total number of hours | 36 | |

**Course Designers:**


1. Dr.A.L.Subramaniyan alsphy@tce.edu
2. Dr.D.Ravindran drphy@tce.edu
3. Prof.V.Veeraganesh vvgphy@tce.edu

| 18EE230 | ELECTRIC CIRCUIT ANALYSIS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 3 | 0 | 0 | 3 |

## Preamble

Electric circuit theory is the fundamental theory upon which all branches of electrical engineering are built. Many areas of electrical engineering, such as power, electric machines, control, electronics, communications, and instrumentation, are based on electric circuit theory. Therefore, the basic electric circuit theory course is the most important course for an electrical engineering student, and always an excellent starting point for a beginner in electrical engineering education. Circuit theory is also valuable to students specializing in other branches of the engineering because circuits are a good model for the study of energy systems in general, and because of the applied mathematics, physics, and topology involved.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | **Use** Ohm's law and Kirchhoff's laws to determine the behaviour the given electric circuit | 10 |
| CO2 | **Apply** mesh analysis, nodal analysis and network theorems to interpret the behaviour of the given electrical circuit | 20 |
| CO3 | **Apply** phasor techniques under steady state to determine the behaviour of the given AC circuit | 20 |
| CO4 | **Find** the transient response of the given RL,RC and RLC circuit | 20 |
| CO5 | **Calculate** Z, Y ,h, and t parameters of the given two-port network. | 20 |
| CO6 | **Calculate** three-phase quantities of the given three phase circuit and mutual inductance of a coupled circuit | 10 |

*** Weightage depends on Bloom's Level, number of contact hours,

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.2.1 |
| CO2 | TPS3 | Apply | Value | | 1.2.1 |
| CO3 | TPS3 | Apply | Value | | 1.2.1 |
| CO4 | TPS3 | Apply | Value | | 1.2.1 |
| CO5 | TPS3 | Apply | Value | | 1.2.1 |
| CO6 | TPS3 | Apply | Value | | 1.2.1 |
| | | | | | |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | **S** | **M** | **L** | **L** | | | | **M** | | **M** | | | S | S |
| CO2 | **S** | **M** | **L** | **L** | | | | **M** | | **M** | | | S | S |
| CO3 | **S** | **M** | **L** | **L** | | | | **M** | | **M** | | | S | S |
| CO4 | **S** | **M** | **L** | **L** | | | | **M** | | **M** | | | S | S |
| CO5 | **S** | **M** | **L** | **L** | | | | **M** | | **M** | | | S | S |
| CO6 | **S** | **M** | **L** | **L** | | | | **M** | | **M** | | | S | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | | | | 10 |
| Understand | 30 | 30 | 30 | | | | 30 |
| Apply | 60 | 60 | 60 | 100 | 100 | 100 | 60 |
| Analyse | 0 | 0 | 0 | | | | 0 |
| Evaluate | 0 | 0 | 0 | | | | 0 |
| Create | 0 | 0 | 0 | | | | 0 |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **Miniproject /Assignment/Practical Component** |
|---|---|
| Perception | - |

| | |
|---|---|
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

**Sample Questions for Course Outcome Assessment****

** (2 to 3 at the cognitive level of course outcome)

**Course Outcome 1 (CO1):**

1. Consider the network shown in figure B1. If the interconnection is valid, find the total power developed in the circuit. If the interconnection is not valid, justify.

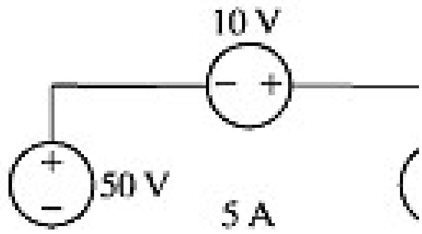



Figure B1

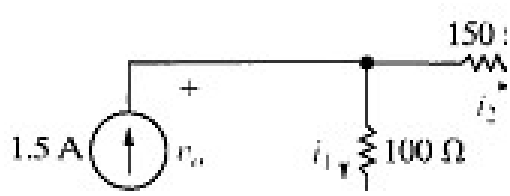
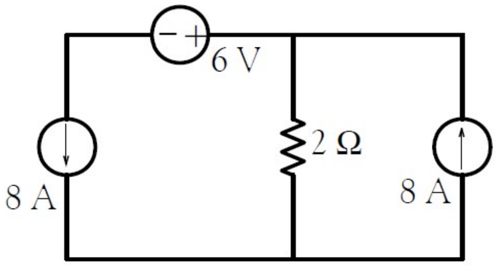



Figure B2

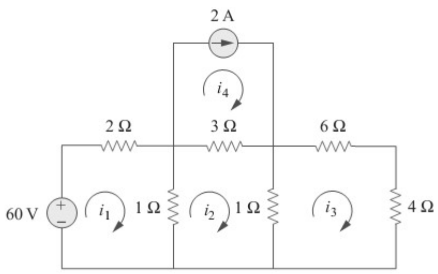
2. The voltage across the 2Ω resistor is equal to



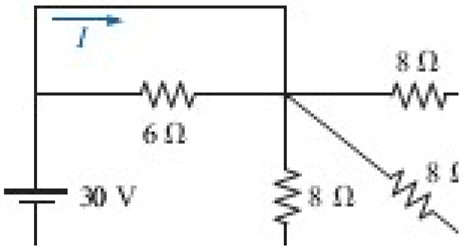

(A) 3V
(B) -3V
(C) 8V
(D) None of the above

**Course Outcome 2 (CO2):**

1. Solve mesh currents for the circuit of figure below.

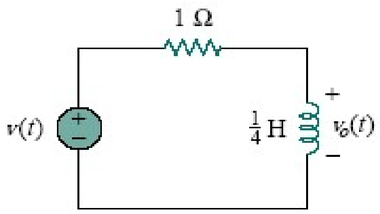


2. Determine the voltage V and current I for the network in figure below using Thevenin's theorem



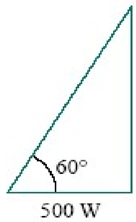

**Course Outcome 3 (CO3):**

1. At what frequency will the output voltage vo(t) in Fig. below be equal to the input voltage v(t)?

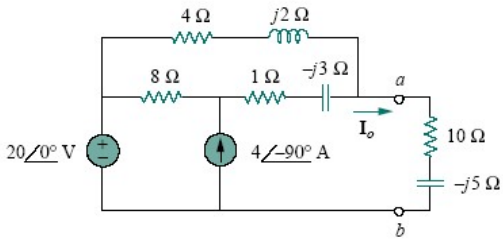



(a) 0 rad/s (b) 1 rad/s (c) 4 rad/s (d) ∞ rad/s (e) none of the above

2. In the power triangle shown in Fig. below, the reactive power is:
(a)1000 VAR leading (b) 1000 VAR lagging (c) 866 VAR leading (d) 866 VAR lagging

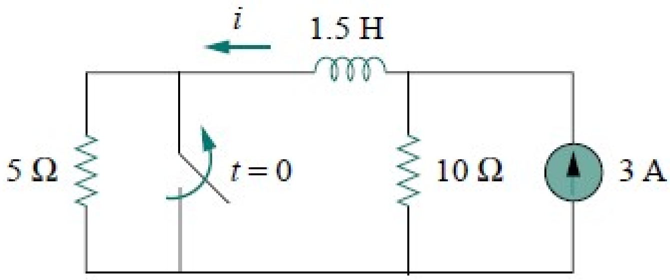



3. Determine the Norton equivalent of the circuit in Fig. Given as seen from terminals a-b. Use the equivalent to find Io.

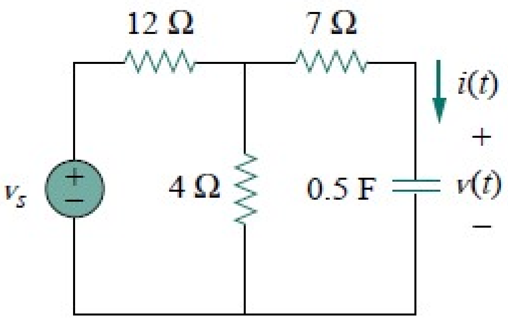


**Course Outcome 4 (CO4):**

1. The switch in figure has been closed for a long time. It opens at *t* = 0. Find *i(t)* for *t* > 0.

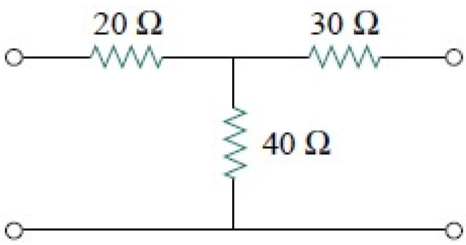



2. Find the step responses v(t) and i(t) to vs = 5u(t) V in the circuit of figure..

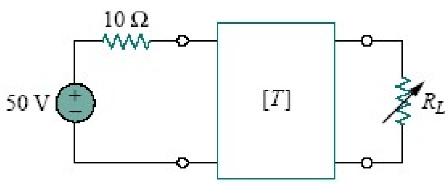



**Course Outcome 5 (CO5):**

1. Determine the *z* parameters for the circuit in Fig.




2. The ABCD parameters of the two-port network in Fig. below are $\begin{bmatrix} 4 & 20\ \Omega \\ 0.1\ \text{S} & 2 \end{bmatrix}$ The output port is connected to a variable load for maximum power transfer. Find $R_L$



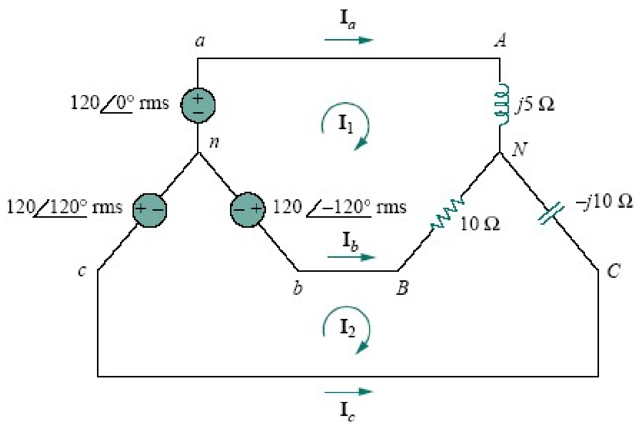
and the maximum power transferred.

**Course Outcome 6 (CO6):**

1. Write the relationship between line and phase quantities of a three phase circuit.
2. If in an acb phase sequence, Van = 100 ∠20◦, then Vcn is:

100 ∠140o (b) 100∠ 100o (c)100 ∠50o (d) 100∠ 10o

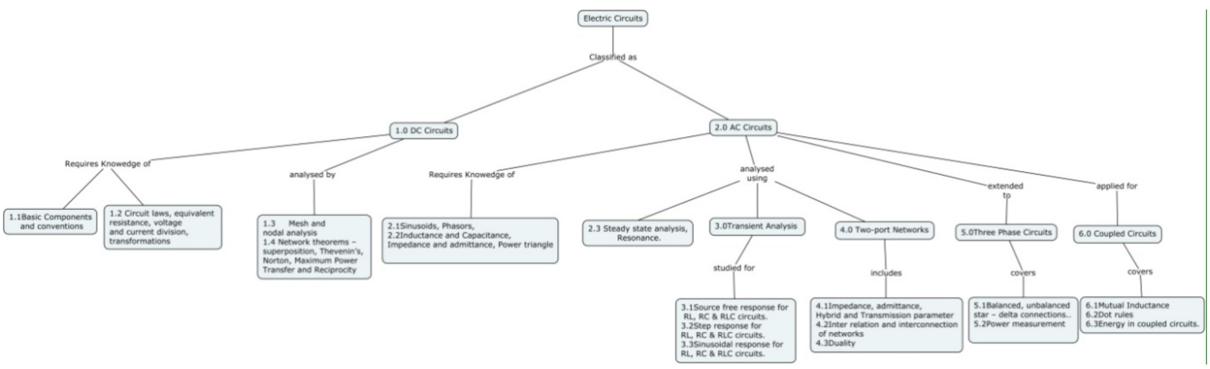
3. For the unbalanced circuit in Fig. below, find: (a) the line currents, (b) the total complex power absorbed by the load, and (c) the total complex power supplied by the source.




4. If in an acb phase sequence, Van = 100 ∠20◦, then Vcn is:

(a) 100 ∠140° (b) 100∠ 100° (c)100 ∠50° (d) 100∠ 10°

## Concept Map




## Syllabus

**DC Circuits**: Basic Components and conventions, Circuit laws, equivalent resistance, voltage and current division, transformations, mesh and nodal analysis, network theorems – Superposition, Thevenin's, Norton's, Maximum Power Transfer and Reciprocity.

**AC Circuits:** Sinusoids, Phasors, Inductance and Capacitance, Impedance and admittance, Power triangle, steady state analysis, Resonance.

**Transient Analysis**: Source free, Step and sinusoidal response for RL, RC & RLC circuits.

**Two-port Networks:** Impedance, admittance, Hybrid and Transmission parameter, Inter relation and interconnection of networks, Duality.

**Three Phase Circuits:** Balanced, unbalanced star – delta connections. Power measurement.

**Coupled Circuits:** Mutual Inductance, Dot rules, Energy in coupled circuits.

**Learning Resources**

1. W.H. Hayt & J.K. Kemmerly and Steven M. Durbin, "Engineering circuit analysis", Tata McGraw Hill, 7th edition, New Delhi, 2007
2. Charles K. Alexander, Matthew N.O. Sadiku, "Fundamentals of Electric Circuits", Tata McGraw Hill, 5th edition, 2013
3. Mahmood Nahvi, Joseph A Edminister, "Electric Circuits", Tata McGraw - Hill Education, 5th Edition, 2010.
4. Sudhakar A and Shyam Mohan SP, "Electric Circuit Analysis", Tata McGraw Hill, New Delhi, 2008
5. NPTEL E-Learning Courses: Basic Electrical Circuits https://onlinecourses.nptel.ac.in/noc17_ee13
6. https://www.electrical4u.com

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1.0 | **DC Circuits** | | |
| 1.1 | Basic Components and conventions | 1 | CO1 |
| 1.2 | Circuit laws, equivalent resistance, voltage and current division, transformations | 2 | CO1 |
| 2.1 | Mesh and nodal analysis | 2 | CO2 |
| 2.2 | Network theorems – Superposition, Thevenin's, Norton's | 2 | CO2 |
| 2.2 | Network theorems – Maximum Power Transfer and Reciprocity | 2 | CO2 |
| 3.0 | **AC Circuits** | | |
| 3.1 | Sinusoids, Phasors. | 2 | CO3 |
| 3.2 | Inductance and Capacitance, Impedance and admittance, Power triangle | 3 | CO3 |
| 3.3 | Steady state analysis, Resonance. | 3 | CO3 |
| 4.0 | **Transient Analysis** | | |
| 4.1 | Source free response for RL, RC & RLC circuits. | 2 | CO4 |

| | | | |
|---|---|---|---|
| 4.2 | Step response for RL, RC & RLC circuits. | 2 | CO4 |
| 4.3 | Sinusoidal response for RL, RC & RLC circuits. | 3 | CO4 |
| 5.0 | **Two-port Networks** | | |
| 5.1 | Impedance and admittance parameters | 3 | CO5 |
| 5.1 | Hybrid and Transmission parameters | 2 | CO5 |
| 5.2 | Inter relation and interconnection of networks | 2 | CO5 |
| 5.3 | Duality | 1 | CO5 |
| 6.0 | **Three Phase Circuits** | | |
| 6.1 | Balanced, unbalanced star – delta connections. | 2 | CO6 |
| 6.2 | Power measurement | 1 | CO6 |
| 6.3 | Mutual Inductance, Dot rule in coupled circuit | 1 | CO6 |
| | TOTAL | 36 | |

**Course Designers:**

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| 18EE240 | ELECTROMAGNETIC FIELDS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 2 | 1 | 0 | 3 |

## Preamble

The Course is designed to impart knowledge of fundamentals of vector calculus, concept of electric and magnetic fields (both static and time varying) applicable to electrical engineering. The course exposes the students to the concept of resistance, capacitance, and Inductance. Students will get an idea about behaviour of field in materials (magnetic, conducting, insulating materials) at the interface of two different materials and their applications to Electrical Engineering. Force, torque, generator and transformer working principles are explained with Electromagnetic Fields.

## Prerequisite

18PHB20 : Physics

18MA110 : Engineering Mathematics - I

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Describe the coordinate systems and vector calculus applicable to electric and magnetic fields. | 15 |
| CO2 | Explain the behaviour of Electric and Magnetic field in free space and in material space with the help of fundamental laws. | 15 |
| CO3 | Explain Voltage, Current and basic circuit laws | 10 |
| CO4 | Demonstrate Resistance, Inductance and capacitance with materials of different resistivity/Permeability/Permittivity and of different dimensions. | 35 |
| CO5 | Calculate force on a current carrying conductor and torque on a current loop subjected to magnetic fields | 10 |
| CO6 | Relate dynamic electric and magnetic fields with help of | 15 |

| | | |
|---|---|---|
| | Faraday's Law and Maxwell's Equation, and, their applications to electrical machines | |

*** Weightage depends on Bloom's Level, number of contact hours,

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.2.2, |
| CO2 | TPS2 | Understand | Respond | | 1.2.2, |
| CO3 | TPS2 | Understand | Respond | | 1.2.2 |
| CO4 | TPS3 | Apply | Value | Mechanism | 1.2.2, 2.3.1, 2.5.1, 3.1.1, 3.2.6 |
| CO5 | TPS3 | Apply | Value | Mechanism | 1.2.2, 2.3.1 |
| CO6 | TPS4 | Understand | Respond | | 1.2.2, 2.3.1, 3.2.6 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | L | | | | | M | | M | | | M | M |
| CO2 | M | L | L | | | | | M | | M | | | M | M |
| CO3 | M | L | L | | | | | M | | M | | | M | M |
| CO4 | S | M | M | L | S | | | M | | M | | | S | S |
| CO5 | M | L | L | | S | | | M | | M | | | M | M |
| CO6 | M | L | L | | | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 10 | | | | 10 |
| Understand | 60 | 40 | 50 | 100 | | | 50 |
| Apply | 20 | 40 | 40 | | 40 | 40 | 40 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **Assignment 2 & 3** |
|---|---|
| Perception | |
| Set | |
| Guided Response | 30 |
| Mechanism | 30 |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

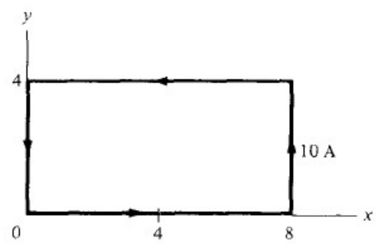
**Sample Questions for Course Outcome Assessment****

**Course Outcome 1 (CO1):**

1. Given points P(l, - 3 , 5), *Q(2,* 4, 6), and *R(0,* 3, 8), find: (a) the position vectors of *P* and *R,* (b) the distance vector $r_{qr}$(c) the distance between *Q* and *R,*
2. Determine the divergence of these vector fields:
   (a) $P = x^2yz\,\hat{x} + xz\,\hat{z}$
   (b) $Q = \rho \sin\phi\,\hat{\rho} + \rho^2 z\hat{\phi} + z\cos\phi\,\hat{z}$
3. Determine the flux of $\bar{D} = \rho^2 \cos^2\phi\,\hat{\rho} + z\sin\phi\,\hat{\phi}$ over the closed surface of the cylinder $0 \le z \le 1$, $\rho = 4$. Verify the divergence theorem for this case.

**Course Outcome 2 (CO2):**

1. A homogeneous dielectric ($\varepsilon_r = 2.5$) fills region 1 ($x \le 0$) while region 2 ($x \ge 0$) is free space.
   (a) If $\bar{D}_1 = 12\hat{x} - 10\hat{y} + 4\hat{z}$ nC/m$^2$, find $\bar{D}_2$ and $\theta_2$.
   (b) If $\bar{E}_2 = 12$ V/m and $\theta_2 = 60°$, find $\bar{E}_1$ and $\theta_1$.
2. A charge distribution in free space has $\rho_v = 2r$ nC/m$^3$ for $0 \le r \le 10$ m and zero otherwise. Determine $\bar{E}$ at r = 2 m and r = 12 m.
3. A rectangular loop carrying 10 A of current is placed on *z* = 0 plane as shown in Figure below. Evaluate $\bar{H}$at



(2, 2, 0)

(4, 2, 0)

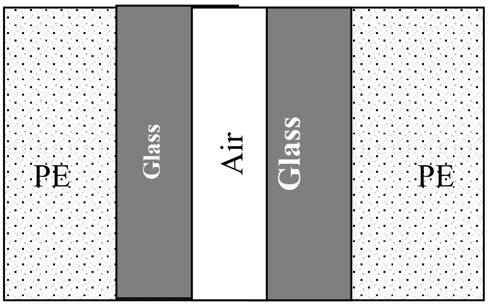
(4, 8, 0)

**Course Outcome 3 (CO3):**

1. Two point charges - 4 μC and 5 μC are located at ( 2 , - 1 , 3) and (0, 4, - 2 ) , respectively. If a third point charge of 3 μC is located at the origin. Find the potential at ( - 1 , 5, 2) assuming V(∞) = 0.
2. Prove that R = V/I.
3. How do you relate law of conservation of charges with Kirchhoff's law?

**Course Outcome 4 (CO4):**

1. Two parallel sheets of glass ($\varepsilon_r$ = 8.5) mounted vertically are separated by a uniform air gap between their inner surface. The sheets, properly sealed, are covered with polyethylene ($\varepsilon_r$ = 3.0) as shown in Fig. below. A uniform electric field of strength 2000 V/m in the horizontal direction exists in the oil. Calculate the magnitude and direction of the electric field in the glass and in the enclosed air gap when (a) the field is normal to the glass surfaces, and (b) the field in the oil makes an angle of 75° with a normal to the glass surfaces. Ignore edge effects.




1. A toroid of circular cross section whose center is at the origin and axis the same as the z-axis has 1000 turns with total *radius* 10 cm, core radius of 1 cm. If the toroid carries a 100 mA, current, find ***H*** at,
   (3 c m , - 4 cm, 0)

   (6 cm, 9 cm, 0)

2. A composite conductor 10 m long consists of an inner core of steel of radius 1.5 cm and an outer sheath of copper whose thickness is 0.5 cm
   (a) Determine the resistance of the conductor.

   (b) If the total current in the conductor is 60 A, what current flows in each metal?

(c) Find the resistance of a solid copper conductor of the same length and cross-sectional areas as the sheath. Take the resistivity of copper and steel as $1.77 * 10^{-8}$ and $11.8 * 10^{-8}$ $\Omega$m, respectively

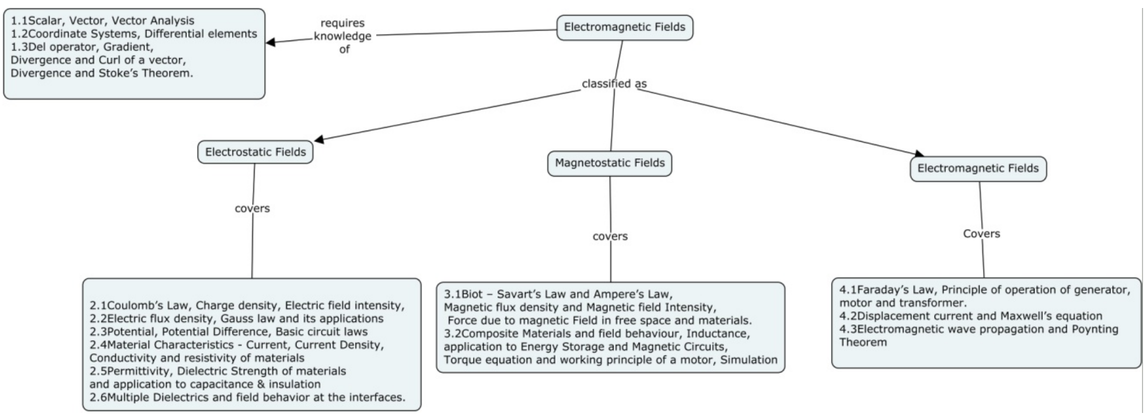
**Course Outcome 5 (CO5):**

1. Two conductors carrying current in same direction are place side by side. Obtain the force developed between the two conductors and draw the magnetic field lines around it. If the direction of current in one of the conductor is reversed discuss the change in force and field lines.
2. A current loop of dimensions 2 cm by 4 cm extends from x=0 and x=2 cm and y=0 and y =4 cm. It is free to rotate about its axis of the lengthier side. It carries a current of 40mA in the anticlockwise direction and is subjected to a uniform magnetic field $2\hat{x} + 4\hat{z}$.. Find the torque on the current loop. What is the net force on the loop.

**Course Outcome 6 (CO6):**

1. Justify the presence of displacement current and hence modification in Ampere's law.
2. Derive the Maxwell's equation for static fields.
3. Derive the transformer Equation using Faradays Law.

## Concept Map




## Syllabus

### Mathematical Foundation

Scalar, Vector, Vector addition, Subtraction and Multiplication, Coordinate Systems, Differential elements, Del operator, Gradient, Divergence and Curl of a vector, Divergence and Stoke's Theorem.

### Electrostatic Fields

Review (Quantitative) of Coulomb's Law, Charge density, Electric field intensity, Electric flux density, Gauss law, Potential, Potential Difference, Basic circuit laws - verifications.

Material Characteristics - Current, Current Density, Conductivity of materials. Permittivity / Dielectric Strength of materials and application to capacitance & electrical insulation. Multiple Dielectrics and field behavior at the interfaces. Calculation of capacitance for various applications and energy storage. Capacitance of Transmission lines and cables. Simulation of Electric Fields using FEM packages.

**Magneto static Fields**

Review (Quantitative) of Biot – Savart's Law and Ampere's Law, Magnetic flux density and Magnetic field Intensity, Field behaviour at interface of magnetic materials, Inductance, application to Energy Storage and Magnetic Circuits. Inductance of Transmission lines and cables. Simulation of Magnetic Fields using FEM packages.

**Force and Torque**

Force on a current carrying conductor subjected to a magnetic field, Torque on a current loop subjected to a magnetic field and working principle of motor.

**Dynamic Fields**

Faraday's Law of Electromagnetic Induction, Principle of operation of generator and transformer, Displacement current , Maxwell's equations, Poynting Theorem.

**ASSIGNMENTS**

1. Simulation of Electrical and Magnetic Fields using FEM packages.
2. Demonstration of Electric and Magnetic fields using simple experiments
3. Seminar on practical applications of electric and magnetic fields like working of XEROX machine, MRI Scan etc.
4. Development of R, L and C components for various applications

**Learning Resources**


1. William Hayt Jr. and John A. Buck , "Engineering Electromagnetics", TMH publishing co. ltd., 7th Edition, 2006.
2. John D. Kraus, "Electromagnetics", Mcgraw – Hill International Editions, 4th Edition, 1992.
3. Mathew N.O. Sadiku, "Principles of Electromagnetic Fields", 4th Edition, Oxford University Press, 2010.


**Course Contents and Lecture Schedule**

| Module No. | Topics | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| 1.0 | **Vector Calculus** | | |
| 1.1 | Scalar, Vector, Vector addition, Subtraction and Multiplication | 2 | CO1 |
| 1.2 | Coordinate Systems, Differential elements | 2 | CO1 |
| 1.3 | Del operator, Gradient, Divergence and Curl of a vector, Divergence and Stoke's Theorem. | 3 | CO1 |
| 2.0 | **Electrostatic Field** (Quantitative Review) | | |
| 2.1 | Coulomb's Law, Charge density, Electric field intensity, | 2 | CO2 |
| 2.2 | Electric flux density, Gauss law and its applications | 2 | CO2 |
| 2.3 | Potential, Potential Difference, Basic circuit laws - verifications | 2 | CO3 |
| 2.4 | Material Characteristics - Current, Current Density, Conductivity of materials | 3 | CO3 |

| | | | |
|---|---|---|---|
| 2.5 | Permittivity, Dielectric Strength of materials and application to capacitance & insulation | 3 | CO4 |
| 2.6 | Multiple Dielectrics and field behavior at the interfaces. | 1 | CO4 |
| 2.7 | Calculation of capacitance for various application and energy storage. Simulation of electric fields | 3 | CO4 |
| 2.8 | Calculation of capacitance of transmission lines and cables. | 1 | CO4 |
| 3.0 | **Magneto static Fields** (Quantitative Review) | | |
| 3.1 | Biot – Savart's Law and Ampere's Law, Magnetic flux density and Magnetic field Intensity, Field behaviour at the interface of magnetic materials | 3 | CO2 |
| 3.2 | Inductance, application to Energy Storage and Magnetic Circuits | 2 | CO4 |
| 3.3 | Inductance of a Transmission line and Cable | 1 | CO4 |
| 3.4 | Simulation of magnetic fields | 1 | CO6 |
| 4.0 | **Force and Torque** | | |
| 4.1 | Force on a Current carrying conductor subjected to magnetic field. | 1 | CO5 |
| 4.2 | Torque on a current carrying loop subjected to magnetic field, working principle of a motor | 1 | CO5 |
| 5.0 | **Dynamic Fields** | | |
| 5.1 | Faraday's Law, Principle of operation of generator and transformer. | 1 | CO6 |
| 5.2 | Displacement current and Maxwell's equations | 1 | CO6 |
| 5.3 | Poynting Theorem | 1 | CO6 |
| | **Total** | **36** | |

**Course Designers:**

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**18EE250 ELECTRONIC DEVICES AND CIRCUITS**

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 3 | 0 | 0 | 3 |

**Preamble**

Signals contain information about a variety of things and activities in our physical world. An observer, be it a human or a machine, invariably needs to condition and process the signals in some predetermined manner to extract the required information from the signal. This signal conditioning/processing is usually most conveniently performed by electronic systems. The signal conversion/conditioning/processing is done by using different semiconductor/signal conditioning devices like diodes, transistors and voltage regulator ICs, etc. These could involve rectification, amplification, filtering, regulation modulation, demodulation, mixing, frequency synthesizing etc.

**Prerequisite**

Basics of Electrical and Electronics Engineering

**Course Outcomes**

On the successful completion of the course, students will be able to

| CO No. | COURSE OUTCOMES | Weightage % |
|---|---|---|
| CO1 | **Explain** the characteristics and applications of diode, special diodes, BJTs ,UJT and MOSFETs | 40 |
| CO2 | **Design** rectifier, clipper and clamper circuits for the given specifications | 10 |
| CO3 | **Design** BJT and MOSFET based amplifier for the given specifications. | 25 |
| CO4 | **Explain** the operation of Class A,B,C and D power amplifiers | 5 |
| CO5 | **Design** feedback amplifiers and oscillators for the given specifications | 10 |
| CO6 | **Explain** the operation of opto-electronic devices | 10 |

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | **1.2.3** |
| CO2 | TPS3 | Apply | Value | | **1.2.3** |
| CO3 | TPS3 | Apply | Value | | **1.2.3** |

| | | | | | |
|---|---|---|---|---|---|
| CO4 | TPS2 | Understand | Respond | | **1.2.3** |
| CO5 | TPS3 | Apply | Value | | **1.2.3** |
| CO6 | TPS3 | Understand | Respond | | **1.2.3** |

## Mapping with Programme Outcomes

| COs | PO 1 | PO2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO9 | PO1 0 | PO 11 | PO 12 | PSO 1 | PS O2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | S | M | L | L | | | | M | | M | | | | S |
| CO3 | S | M | L | L | | | | M | | M | | | | S |
| CO4 | M | L | | | | | | M | | M | | | | M |
| CO5 | S | M | L | L | | | | M | | M | | | | S |
| CO6 | M | L | | | | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 30 | 30 | 30 | - | - | - | 30 |
| Apply | 50 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | 0 | 0 | 0 | | | | 0 |
| Evaluate | 0 | 0 | 0 | | | | 0 |
| Create | 0 | 0 | 0 | | | | 0 |

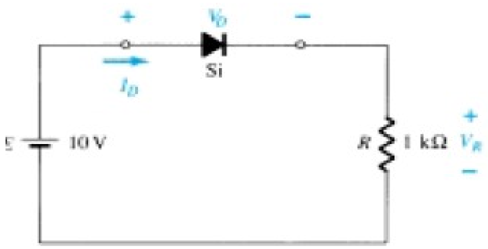
## Course Level Assessment Questions

**Course Outcome 1 (CO1)**:

1. Explain the ideal characteristics of diode.
2. Explain the three regions in output characteristics of transistor.
3. Explain the characteristics of UJT.

**Course Outcome 2 (CO2)**:

1. Compare the characteristics of silicon and a germanium diode and determine which you would prefer to use for most practical applications. Give some details. Refer to a manufacturer's listing and compare the characteristics of a germanium and a silicon diode of similar maximum ratings.
2. For the series diode configuration shown in figure 1 employing the diode characteristics of Figure 2. Determine: (a) *VDQ* and *IDQ*. (b) *VR*.



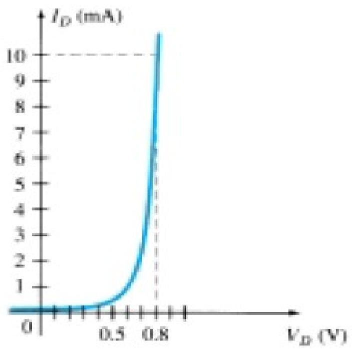
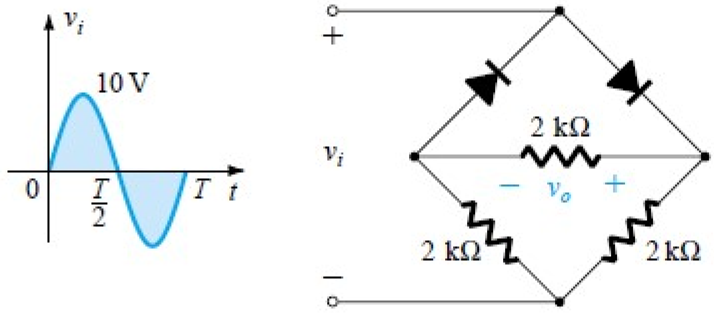




Figure 1 Figure 2

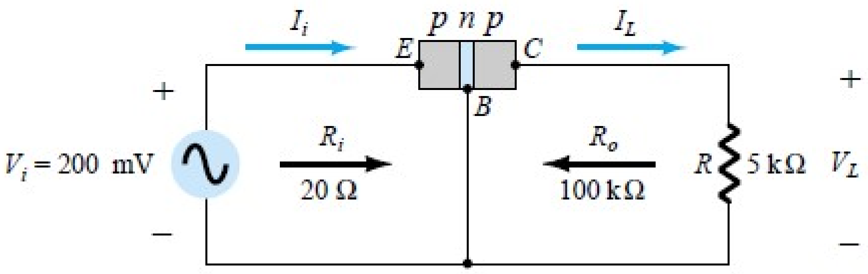
3. Determine the output waveform for the network of Figure and calculate the output dc level and the required PIV of each diode.




**Course Outcome 3 (CO3):**

1. Explain the input and output characteristics of BJT in CE configuration
2. Calculate the voltage gain (*Av*= *VL*/*Vi*) for the network shown in figure if *Vi* = 500 mV and

   *R*= 1 kΩ (The other circuit values remain the same.)



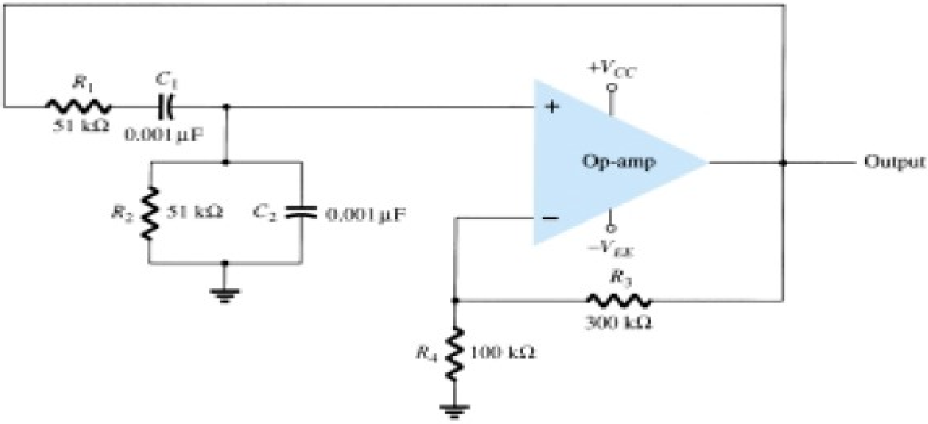

3. Explain the construction and characteristics of n-channel depletion MOSFET

**Course Outcome 4(CO4):**

1. Explain the difference between Class A and Class B amplifiers.
2. Explain the construction and operation of series fed class A amplifier.
3. Describe the operation of Transformer-Coupled Push–Pull amplifier using suitable sketch.

**Course Outcome 5 (CO5):**

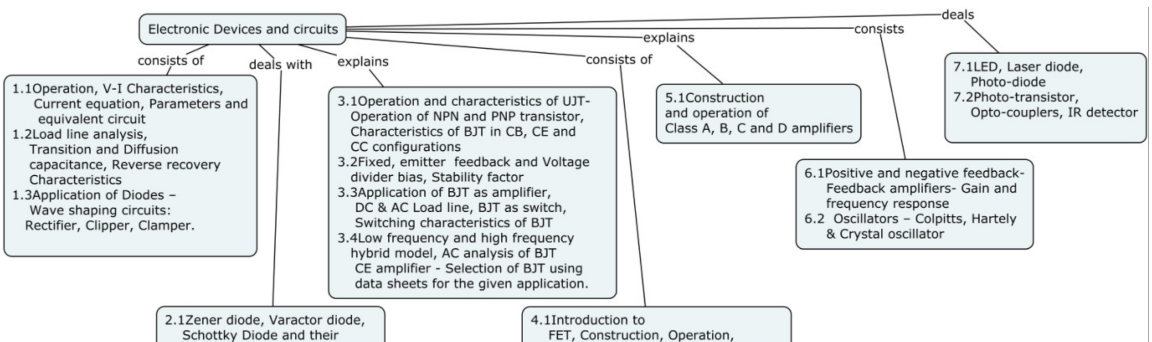
1. Draw the block diagram of feedback amplifier.
2. Determine the voltage gain, input, and output impedance with feedback for voltage series feedback having *A*=-100, *Ri* = 10 kΩ, *Ro* = 20 kΩ for feedback of (a) β=-0.1 and (b) β=-0.5
3. Calculate the resonant frequency of the Wien bridge oscillator




**Course Outcome 6 (CO6):.**

1. **Explain the** Spectral response of Se, Si, and the naked eye.
2. Determine the energy associated with the photons of green light if the wavelength is 5000 Å. Give your answer in joules and electron volts.

## Concept Map:




## Syllabus

**Diode** – Operation, V-I Characteristics, Current equation, Parameters and equivalent circuit, Load line analysis, Transition and Diffusion capacitance, Reverse recovery Characteristics, Application of Diodes – Wave shaping circuits: Rectifier, Clipper, Clamper.

**Special Diodes:** Zener diode, Varactor diode, Schottky Diode and their application - Selection of diode using data sheets for the given application.

**UJT and BJTs** – Operation and characteristics of UJT-Operation of NPN and PNP transistor, Characteristics of BJT in CB, CE and CC configurations, Fixed, emitter feedback and Voltage divider bias, Stability factor, Application of BJT as amplifier, DC and AC Load line, BJT as switch, Switching characteristics of BJT, Low frequency and high frequency hybrid model, AC analysis of BJT CE amplifier - Selection of BJT using data sheets for the given application.

**MOSFETs:** Introduction to FET, Construction, Operation, Characteristics and Parameters of MOSFET, MOSFET as a voltage controlled resistor, Voltage divider bias, Small signal model of MOSFET- Selection of MOSFET using data sheets for the given application. Precaution in handling MOSFET

**Power Amplifiers:** Construction and operation of Class A, B, C and D amplifiers

**Feedback amplifiers & Oscillators:** Positive and negative feedback- Feedback amplifiers- Gain and frequency response - Oscillators – Colpitts, Hartely & Crystal oscillator

**Opto-electronic Devices:** LED**,** Laser diode, Photo-diode, Photo-transistor, Opto-couplers, IR detector

## Learning resources


1. Robert Boylestad and Lowis Nashelsky, “Electronic Devices and Circuit Theory”, 10th Edition, Pearson Education, 2009.
2. Floyd T.L,” Electronic Devices”, 7th Edition, Pearson Education, 2009
3. David A. Bell, “ Electronic Devices and Circuits”, 5th Edition, Prentice Hall India, 2010
4. Albert Malvino and David J.Bates, “Electronic Principles”,7th Edition, Tata Mc-Graw Hill, 2007
5. Jacob Millman, Halkias C.C and Satyabrata Jit, “Electronic Devices and Circuits”, 3rd Edition, Tata Mc-Graw Hill, 2010
6. Sedra A.S. and Smith K.C, “Microelectronic Circuits”, 5th Edition, Oxford press, 2006
7. Donald A.Neamen, “Electronic circuit analysis and design”, Second edition, Tata Mc-Graw Hill, 2003.


## Course Contents and Lecture Schedule

| S.No. | Topics | No. of Lectures | CO |
|---|---|---|---|
| **1.** | **Diode** : | | |
| 1.1 | Operation, V-I Characteristics, Current equation, Parameters and equivalent circuit | 2 | CO1 |
| 1.2 | Load line analysis, Transition and Diffusion capacitance, Reverse recovery Characteristics | 1 | CO1 |
| 1.3 | Application of Diodes – Wave shaping circuits: Rectifier, Clipper | 2 | CO2 |
| 1.4 | Clamper. | 2 | CO2 |
| 2. | **Special Diodes:** | | |
| 2.1 | Zener diode, Varactor diode, Schottky Diode and their application - Selection of diode using data sheets for the given application. | 2 | CO1 |
| 3. | **UJT and BJTs:** | | |
| 3.1 | Operation and characteristics of UJT-Operation of NPN and PNP transistor, Characteristics of BJT in CB, CE and CC configurations | 2 | CO1 |
| 3.2 | Fixed, emitter feedback and Voltage divider bias, Stability factor | 2 | CO3 |
| 3.3 | Application of BJT as amplifier, DC & AC Load line, BJT as switch | 2 | CO3 |
| 3.4 | Switching characteristics of BJT | 1 | CO3 |
| 3.5 | Low frequency and high frequency hybrid model, AC analysis of BJT CE amplifier - Selection of BJT using data sheets for the given application. | 2 | CO1 |
| 4. | **MOSFETs:** | | |
| 4.1 | Introduction to FET, Construction, Operation, Characteristics and Parameters of MOSFET | 2 | CO1 |
| 4.2 | MOSFET as a voltage controlled resistor, Voltage divider bias | 2 | CO3 |
| 4.3 | Small signal model of MOSFET- AC analysis of MOSFET CS amplifier- Small signal model of MOSFET - | 2 | CO1 |
| 4.4 | Selection of MOSFET using data sheets for the given application- Precaution in handling MOSFET. | 2 | CO1 |
| 5. | **Power Amplifiers:** | | |
| 5.1 | Construction and operation of Class A, B, C and D amplifiers | 2 | CO4 |

| | | | |
|---|---|---|---|
| 6. | **Feedback amplifiers & Oscillators:** | | |
| 6.1 | Positive and negative feedback- Feedback amplifiers- Gain and frequency response | 2 | CO5 |
| 6.2 | Oscillators – Colpitts, Hartely & Crystal oscillator | 2 | CO5 |
| 7. | **Opto-electronic Devices:** | | |
| 7.1 | LED, Laser diode, Photo-diode | 2 | CO6 |
| 7.2 | Photo-transistor, Opto-couplers, IR detector | 2 | CO6 |
| | **Total** | **36** | |

**Course Designers:**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2. Dr.V.Suresh Kumar vskeee@tce.edu
3. Dr.S.Arockia Edwin xavier saexeee@tce.edu

| 18EE270 | ELECTRONIC DEVICES AND CIRCUITS LAB | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PC | 0 | 0 | 2 | 1 |

## Preamble

This laboratory gives a practical exposure to the students to learn the characteristics of various electronic devices such as diodes, BJT, UJT and MOSFET that are used nowadays in most of the electronic circuits. The students also learn the design and the construction of different electronic circuits based on the above electronic devices. To validate the experimental results, the use of simulation tools for the performance analysis of the circuits is also introduced to the students.

## Prerequisite

Basics of Electrical and Electronics Engineering

## Course Outcomes

On the successful completion of the course, students will be able to:

| CO No. | Course outcomes | Weightage in % |
|---|---|---|
| CO1. | **Find** the equivalent circuit parameters of the given Diode, BJT, MOSFET, and UJT experimentally | 30 |
| CO2. | **Analyze** the characteristics of the designed zener regulator for the given specifications experimentally | 10 |
| CO3. | **Analyze** the performance of the diode rectifier circuit for the given specifications experimentally | 10 |
| CO4. | **Analyze** the performance of the diode wave shaping circuits (Clippers and Clampers) designed for the given specifications experimentally | 20 |
| CO5 | **Analyze** the performance of the designed amplifiers and oscillators to meet the given specifications experimentally | 20 |
| CO6 | **Analyze** the performance of the analog device characteristics and circuits using simulation tools | 10 |

## Mapping with Programme Outcomes

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | S | | | M | M | M | | | | S |
| CO2 | S | S | S | M | S | | | M | M | M | | | | S |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO3 | **S** | **S** | **S** | **M** | **S** | | | **M** | **M** | **M** | | | | **S** |
| CO4 | **S** | **S** | **S** | **M** | **S** | | | **M** | **M** | **M** | | | | **S** |
| CO5 | **S** | **S** | **S** | **M** | **S** | | | **M** | **M** | **M** | | | | **S** |
| CO6 | **S** | **S** | **s** | **M** | **S** | | | **M** | **M** | **M** | | | | **S** |

S- Strong; M-Medium; L-Low

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | **Cognitive** | **Affective** | **Psychomotor** | |
| **CO1** | TPS3 | Apply | Value | Mechanism | **1.2.3, 2.2.3** |
| **CO2** | TPS4 | Analyze | Organize | Complex Overt Responses | **1.2.3 2.2.3,** |
| **CO3** | TPS4 | Analyze | Organize | Complex Overt Responses | **1.2.3 2.2.3** |
| **CO4** | TPS4 | Analyze | Organize | Complex Overt Responses | **1.2.3 2.2.3** |
| **CO5** | TPS4 | Analyze | Organize | Complex Overt Responses | **1.2.3 2.2.3** |
| **CO6** | TPS4 | Analyze | Organize | Complex Overt Responses | **1.2.3 2.2.3** |

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Model Examination | Terminal Examination |
|---|---|---|
| **Remember** | | |
| **Understand** | | |
| **Apply** | **20** | **20** |
| **Analyse** | **50** | **50** |
| **Evaluate** | | |
| **Create** | | |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Practical Component |
|---|---|
| **Perception** | |
| **Set** | |
| **Guided Response** | |
| **Mechanism** | **30** |
| **Complex Overt Responses** | |
| **Adaptation** | |
| **Origination** | |

**List of experiments**

| E.No | Name of the experiment | CO | No.of sessions |
|---|---|---|---|
| **1.** | Familiarization of CRO,DSO,AFO, Bread board ,Deives, Data sheet | CO1 to CO6 | **2** |
| 2. | Characteristics of PN junction diode, Zener diode and Opto Isolators | CO1 | 1 |
| 3. | Characteristics of BJT, MOSFET and UJT | CO1 | 2 |
| 4. | Design of DC voltage regulator using zener diode | CO2 | 1 |
| 5. | Design of Rectifier with and without filter | CO3 | 1 |
| 6. | Design of Wave shaping circuits (clipper and clamper) | CO4 | 2 |
| 7. | Design of CE amplifier and LC Oscillator | CO5 | 2 |
| 8. | Analyze the characteristics of analog devices and circuits using PSPICE/PSIM/Simulink/NI-MY DAQ | CO6 | 1 |

**Course Designers**

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| 18EE280 | ELECTRICAL WORKSHOP |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| ES | 0 | 0 | 2 | 1 |

**Preamble**

The course is designed to provide students a widespread knowledge and understanding of the basic Electrical Systems Components and Laws. The indispensable and pervasive knowledge of electrical wiring and the electronic circuits will give the students an insight to their practical approach in our daily life.

**Prerequisite**

NIL

**Course Outcomes**

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Analyze the resistance of various dimensions with different resistivity's experimentally | 10 |
| CO2 | Analyze the inductance of various core dimensions and winding configurations experimentally | 10 |
| CO3 | Analyze the capacitance of various shapes and materials experimentally | 10 |
| CO4 | Analyze Electric field lines and equi-potential lines of different electrode configurations experimentally. | 10 |
| CO5 | Analyze the B-H curve of various materials at various frequencies experimentally | 10 |
| CO6 | Practice assembling, soldering and testing of the given simple electronic circuit using PCB | 10 |
| CO7 | Verify Electrical circuit laws, and theorems for the electric circuit using hardware and simulation software | 20 |
| CO8 | Verify series resonance phenomena in a RLC circuit experimentally | 10 |
| CO9 | Analyze the transient behavior of the given RL, RC, RLC circuits experimentally | 10 |

*** Weightage depends on Bloom's Level, number of contact hours,

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS4 | Analyze | Organise | Complex Overt | 1.2.2. ,2.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | Responses | |
| CO2 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.2 ,2.2.3 |
| CO3 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.2 ,2.2.3 |
| CO4 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.2 ,2.2.3 |
| CO5 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.2 ,2.2.3 |
| CO6 | TPS3 | Apply | Value | Mechanism | 1.2.1 ,2.2.3 |
| CO7 | TPS3 | Apply | Value | Mechanism | 1.2.1. ,2.2.3 |
| CO8 | TPS3 | Apply | Value | Mechanism | 1.2.1 ,2.2.3 |
| CO9 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.1 ,2.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | M | M | S | | | M | M | M | | | | S | S |
| CO2 | S | S | M | M | S | | | M | M | M | | | | S | S |
| CO3 | S | S | M | M | S | | | M | M | M | | | | S | S |
| CO4 | S | S | M | M | S | | | M | M | M | | | | S | S |
| CO5 | S | S | M | M | S | | | M | M | M | | | | S | S |
| CO6 | S | S | M | M | S | | | M | M | M | | | | S | S |
| CO7 | S | S | M | M | S | | | M | M | M | | | | S | S |
| CO8 | S | S | M | M | S | | | M | M | M | | | | S | S |
| CO9 | S | S | M | M | S | | | M | M | M | | | | S | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Model Examination | Terminal Examination |
|---|---|---|
| Remember | | |
| Understand | | |
| Apply | 30% | 30% |
| Analyse | 40% | 40% |
| Evaluate | | |
| Create | | |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Mini project /Practical Component/Observation |
|---|---|
| Perception | |

| | |
|---|---|
| Set | |
| Guided Response | |
| Mechanism | 30% |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**List of Experiments/Activities with CO Mapping**

| Experiment | CO |
|---|---|
| Familiarization of magnetic and electric field lines.<br>Familiarization of basic protective devices (fuse, MCB, ELCB)<br>Familiarization of ammeter, voltmeter, wattmeter, rheostat , power supply | C01 to CO9 |
| Design, Develop and Analyze the resistance of various dimensions with different resistivity's experimentally | CO1 |
| Design, Develop and Analyze the inductance of various core dimensions and winding configurations experimentally | CO2 |
| Design, Develop and Analyze the capacitance of various shapes and materials experimentally | CO3 |
| Plot and analyze Electric field lines and equipotential lines of different electrode configurations experimentally. | CO4 |
| Analyze the B-H curve of various materials at various frequencies. | CO5 |
| Assembling, Soldering and Testing of Simple electronic Circuit using PCB | CO6 |
| Verification of Electrical laws for the electric circuit using hardware and simulation software | CO7 |
| Verification of superposition, Thevenin and maximum power transfer theorems for the electric circuit using hardware and simulation software | CO7 |
| Verification of series resonance phenomena in a RLC circuit | CO8 |
| Analyze the transient behaviour of the given RL ,RC,RLC circuits | CO9 |

**Learning Resources**

1. Electrical Workshop Manual prepared by TCE Staff Members

**Course Designers:**

1. Dr.V.Saravanan vseee@tce.edu

| 18ES290 | LATERAL THINKING | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | ES | 0 | 0 | 2 | 1 |

## Preamble

The purpose of thinking is to collect information and to make the best possible use of it. Vertical thinking is concerned with proving or developing concept patterns. Lateral thinking is concerned with restructuring such patterns (insight) and provoking new ones (creativity). Lateral and vertical thinking are complementary. Skill in both is necessary. Although the emphasis in education has always been exclusively on vertical thinking, the need for lateral thinking arises from the limitations of the behaviour of mind as a self-maximizing memory system. Lateral thinking can be learned, practised and used. It is possible to acquire skill in it just as it is possible to acquire skill in mathematics. The course provides formal opportunities to practise lateral thinking and also an explanation of the processes involved.

## Prerequisite

NIL

## Course Outcomes

On the successful completion of the course students will be able to

| CO # | Course Outcome Statement | Weightage in % |
|---|---|---|
| CO1 | Explain the concept of lateral thinking, distinguish it from vertical thinking. | 10 |
| CO2 | Use lateral thinking for problem solving | 10 |
| CO3 | Generate Alternatives, challenge assumptions and suspend judgment and Practice lateral thinking in design process | 20 |
| CO4 | Apply the concept of factorization and reversal method for restructuring | 20 |
| CO5 | Organize brainstorming sessions | 10 |
| CO6 | Use PO for innovation | 10 |
| CO7 | Aware of limitation of established patterns and practice lateral thinking in small projects | 20 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | - | 2.3.1, 3.2.6 |

| | | | | | |
|---|---|---|---|---|---|
| CO2 | TPS3 | Apply | Value | - | 2.4.1, 2.4.2, 2.4.3 |
| CO3 | TPS3 | Apply | Value | - | 2.4.1, 2.4.2, 2.4.3, 2.4.5, 2.4.6 |
| CO4 | TPS3 | Apply | Value | - | 2.3.1, 2.4.2, 2.4.3 |
| CO5 | TPS4 | Analyse | Organize | - | 3.1.1, 3.1.2, 3.2.1, 3.2.2 |
| CO6 | TPS3 | Apply | Value | - | 2.1.4, 2.3.1, 2.4.1, 2.4.2, 2.4.3, 2.4.6 |
| CO7 | TPS5 | Evaluate | Characterize | - | 2.3.4, 4.5.1, 4.6.1 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| CO # | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | - | - | - | - | - | - | - | - | - | L |
| CO2 | S | M | L | - | - | - | - | - | - | - | - | L |
| CO3 | S | M | L | - | - | - | - | S | L | L | - | L |
| CO4 | S | M | L | - | - | - | - | S | L | L | - | L |
| CO5 | S | S | M | L | - | - | - | S | S | S | - | L |
| CO6 | S | M | L | - | - | - | - | | | | | L |
| CO7 | S | S | S | M | - | S | - | - | S | S | - | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

**Continuous Assessment**

Worksheets (5) : 20 Marks

Case Studies (3) : 30 Marks

**Terminal Examination**

Ability Test : 50 Marks

Case Study (Best) Presentation and Viva Voce : 50 Marks

**Syllabus**

The way the mind works, Difference between lateral and vertical thinking, Attitudes towards lateral thinking, Basic nature of lateral thinking, The use of lateral thinking Techniques, The generation of alternatives, Challenging assumptions, Innovation, Suspended judgment, Design, Dominant ideas and crucial factors, Fractionation, The reversal method, Brainstorming, Analogies, Choice of entry point and attention area, Random stimulation, Concepts/divisions/polarization, The new word PO, Blocked by openness, Description/problem solving/design

**Learning Resources**

1. Edward de Bono, “Lateral Thinking: Creativity Step by Step”, Happer Collins Publisher, 1990.
2. Edward de Bono, “Six Thinking Hats”, Little Brown and Company Publisher, 1985.

3. Edward de Bono's Thinking Course, Video Lecture, Weblink: https://www.yputube.com/watch?v=AUq_AL2LNEw

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1. | The way the mind works | 1 | CO1 |
| 1.1 | Difference between lateral and vertical thinking | 1 | CO1 |
| 1.2 | Attitudes towards lateral thinking | 1 | CO2 |
| 2. | Basic nature of lateral thinking | 1 | CO2 |
| 2.1 | The use of lateral thinking techniques | 1 | CO2 |
| 2.2 | The generation of alternatives | 1 | CO3 |
| 2.3 | Challenging assumptions | 1 | CO3 |
| 2.4 | Innovation | 1 | CO3 |
| 2.5 | Suspended judgment | 1 | CO3 |
| 3. | Design | 1 | CO3 |
| 3.1 | Dominant ideas and crucial factors | 1 | CO3 |
| 3.2 | Fractionation | 1 | CO4 |
| 4. | The reversal method | 1 | CO4 |
| 4.1 | Brainstorming | 1 | CO5 |
| 4.2 | Analogies | 1 | CO5 |
| 4.3 | Choice of entry point and attention area | 1 | CO5 |
| 4.4 | Random stimulation | 1 | CO5 |
| 4.5 | Concepts/divisions/polarization | 1 | CO5 |
| 4.6 | The new word PO | 2 | CO6 |
| 5. | Blocked by openness | 2 | CO7 |
| 5.1 | Description/problem solving/design | 2 | CO7 |

**Course Designers:**

S J. Thiruvengadam sjtece@tce.edu

| 18CHAA0 | ENVIRONMENTAL SCIENCES |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| ES | 1 | 0 | 1 | - |

**Preamble**

The objective of this course is intended to make the students to understand the basic concepts of environment, ecology and pollution of the current environmental issues and to participate in various activities on conserving and protecting the environment.

**Prerequisite**

NIL

**Course Outcomes**

On the successful completion of the course students will be able to

| CO Number | Course Outcome | Weightage*** in % |
|---|---|---|
| CO1 | Describe the importance and progression of ecological system | 15% |
| CO2 | Explain the significance of natural resources | 10% |
| CO3 | Demonstrate the effects of pollution on environment and human beings | 15% |
| CO4 | Practice the suitable management method during disaster episode | 10% |
| CO5 | Explain the ethics and values related to Environment | 15% |
| CO6 | Describe the Traditional values and Impact of modernization on Environment | 10% |
| CO7 | Carry out group activities | 25% |

*** Weightage depends on Bloom's Level, number of contact hours,

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | Guided Response | 1.1,2.3.1,2.3.2,2.3.4 |
| CO2 | TPS2 | Understand | Respond | Guided Response | 1.1,2.3.1,2.3.2,2.3.4 |
| CO3 | TPS3 | Apply | Value | Mechanism | 1.1,2.1.1,2.1.5,2.4.1,4.1.2 |

| | | | | | |
|---|---|---|---|---|---|
| CO4 | TPS3 | Apply | Value | Mechanism | 1.1,2.4.1,2.4.7,4.1.1,4.1.2 |
| CO5 | TPS2 | Understand | Respond | Guided Response | 1.1,2.5.1,2.5.2, |
| CO6 | TPS2 | Understand | Respond | Guided Response | 1.1,2.4.7,2.5.4, |
| CO7 | TPS4 | Analyse | Organise | Complex Overt Responses | 3.1.1,3.1.2,3.1.3,3.1.4,4.1.1,4.1.2 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | - | - | - | - | L | S | - | - | - | - | - |
| CO2 | M | - | - | - | - | L | - | L | - | - | - | - |
| CO3 | M | M | - | - | L | M | S | - | - | - | - | - |
| CO4 | M | - | L | L | L | M | M | - | - | - | - | - |
| CO5 | L | - | - | - | - | - | - | M | - | - | - | - |
| CO6 | L | L | - | - | - | - | M | - | - | - | - | - |
| CO7 | S | M | M | M | M | M | - | - | S | M | M | - |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment#** | | | **Terminal Examination***** |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 0 | 20 | 0 | NA | NA | NA | Presentation on Case study report |
| Understand | 0 | 40 | 0 | | | | |
| Apply | 0 | 40 | 0 | | | | |
| Analyse | 0 | 0 | 0 | | | | |
| Evaluate | 0 | 0 | 0 | | | | |
| Create | 0 | 0 | 0 | | | | |

# Assignment: Marks will be given for the review I, II & III of case study presentation.

*** Case study presentation and evaluation

- Each group comprise of maximum three students
- Students will submit the case study report similar to final year project report
- Evaluation of case study presentation is based on the approved rubrics

**Method of Evaluation**

**a)Internal assessment**

| **S.No** | **Description** | **Max.marks** | **Final conversion** |
|---|---|---|---|
| 1 | CAT -II | 50 | 40 |
| 2 | Assignment marks ( from Review I,II & III) | 3 X 10 =30 | 10 |

| | |
|---|---|
| Total | 50 |

b) **End semester examination – Case study presentation**

| **Performance Index** | **Marks per Individual** |
|---|---|
| Originality of the work | 20 |
| Data collected | 20 |
| Suggestion to overcome for the identified issues | 20 |
| Final Presentation | 40 |
| Total | 100 |

1. **Model Titles for Case Study**:
2. 1. Environmental impacts of quarry industries in Melur Taluk.
3. 2. A study on impacts of tanneries on ground water and soil quality in Dindigul district.
4. 3. Effect of pharmaceutical industry on groundwater quality in poikaraipatty village, Alagar
5. Kovil.
6. 4. Solid waste and waste water management in TCE hostel.
7. 5. Environmental effect of Kudankulam atomic power plant.
8. 6. Case study on effect of Sterlite industry.
9. 7. Effect on ground water and soil quality by dyeing industries in Tiruppur.
10. 8. Effect of textile wastes in Karur District.
11. 9. Segregation of waste and its recycling by Madurai Municipality at Vellakkal
12. 10. Effect of fire work waste on atmosphere in Sivakasi region

**Sample Questions for Course Outcome Assessment****

**Course Outcome 1(CO1):**

4. Describe the Universal Energy flow model in an Ecosystem.
5. Discuss the conversion of one ecosystem into another ecosystem with example.
6. Explain the multidisciplinary nature of the environment.

**Course Outcome 2 (CO2):**

1. Summarize the importance of Natural resources to animals and human beings.
2. Describe the role of an individual in the conservation of Natural resources.

**Course Outcome 3(CO3):**

1. Demonstrate the effects and control measures of air pollution
2. Investigate the sources and management methods of e-waste.

**Course Outcome 4(CO4):**

1. Dramatize the mitigation methods adopted in severe cyclone affected areas.
2. Suggest the precautionary steps to prevent life from flood.

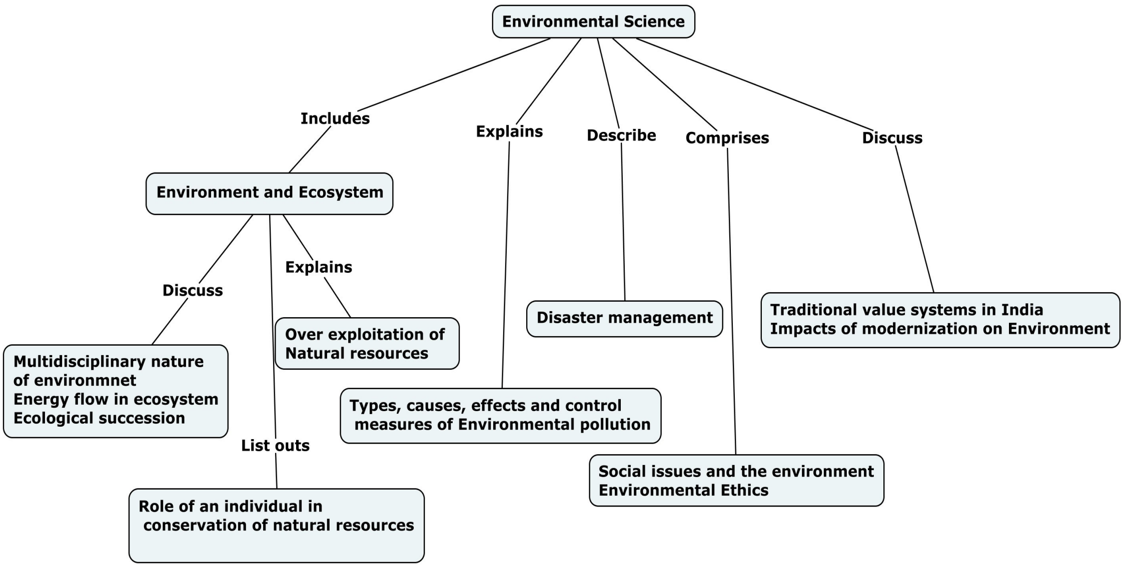
**Course Outcome 5 (CO5):**

1. Discuss the need for public awareness on environmental protection.
2. Identify the requirement for the equitable utilization of natural resources.

**Course Outcome 6(CO6):**

1. Describe the traditional value systems of India.
2. Recall the environmental related points discussed in our Indian Vedas.
3. List out the impacts of modernization on environment

## Concept map:




## Syllabus

**Environment and Ecosystem -** Multidisciplinary nature of environment- Ecosystem- Energy flow in ecosystem-Ecological succession-Over exploitation of Natural resources-Role of an individual in conservation of natural resources. **Environmental pollution and control -**

Environmental pollution – types, causes, effects and control measures - Disaster management strategies. **Environmental Ethics and Values -** Social issues and the environment -need for public awareness, Environmental Ethics- need for equitable utilization of natural resources- Traditional value systems in India, Impacts of modernization on Environment

**Awareness and actual activities:**

- ✓ Group meeting on water management, promotion of recycle use, reduction of waste,
- ✓ Plantation
- ✓ Cleanliness drive
- ✓ Drive on segregation of waste
- ✓ Energy saving
- ✓ Lectures by Environmentalist
- ✓ Slogan and poster making event

**Learning Resources**

1. Kaushik,A & Kaushik.C.P, Environmental Science and Engineering, 6th Edition, New Age International, 2018.
2. Erach Bharucha, Text book of Environmental studies for Undergraduate courses, 2nd Edtion, UGC, 2013.
3. Gilbert M.Masters, Introduction to Environmental Engineering and Sciences, 2nd Edition, Pearson , 2004.
4. Garg S.K & Garg, Ecological and Environmental studies, Khanna Publishrers, 2006.
5. Wright &Nebel, Environmental science towards a sustainable future, 8th Editon,Prentice Hall of Indial Ltd, 2002.
6. Documentary titled "HOME" by Yves Bertrand, Video Link: https://www.youtube.com/watch?v=jqxENMKaeCU

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1.0 | **Environment and Ecosystem** | | |
| 1.1 | Multidisciplinary nature of environment-Ecosystem | 1 | CO1 |
| 1.2 | Energy flow in ecosystem – Universal energy flow model | 1 | CO1 |
| 1.3 | Ecological succession | 1 | CO1 |
| 1.4 | Over exploitation of Natural resources | 1 | CO2 |
| 1.5 | Role of individual in conservation of natural resources | 1 | CO2 |

| | | | |
|---|---|---|---|
| 2.0 | **Environmental pollution and control** | | |
| 2.1 | Environmental pollution – types( Air, Water,soil,Marine), | 2 | CO3 |
| 2.2 | causes (gaseous, liquid, solid, plastic, e-waste, biomedical waste and radiations), | 2 | CO3 |
| 2.3 | **E**ffects and control measures of Pollution | 2 | CO3 |
| 2.4 | Disaster managements during cyclone, Tsunami, flood, draught and earthquake | 2 | CO4 |
| 3.0 | **Environmental Ethics and Values** | | |
| 3.1 | Social issues and the environment -need for public awareness | 1 | CO5 |
| 3.2 | Environmental Ethics- need for equitable utilization of natural resources | 1 | CO5 |
| 3.3 | Traditional value systems in India, | 1 | CO6 |
| 3.4 | Impacts of modernization on Environment | 2 | CO6 |
| 4.0 | **Awareness and actual activities** | | |
| 4.1 | Group meeting on water management, promotion of recycle use, reduction of waste | 2 | CO7 |
| 4.2 | Plantation | 1 | CO7 |
| 4.3 | Cleanliness drive | 1 | CO7 |
| 4.4 | Drive on segregation of waste | 1 | CO7 |
| 4.5 | Energy saving | 1 | CO7 |
| 4.6 | Lectures by Environmentalist | 1 | CO7 |
| 4.7 | Slogan and poster making event | Through online | CO7 |

**Course Designers:**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**CURRICULUM AND DETAILED SYLLABI**

**FOR**

**B.E. EEE DEGREE PROGRAMME**

**THIRD & FOURTH SEMESTER**

**FOR THE STUDENTS ADMITTED IN THE**

**ACADEMIC YEAR 2018-19 ONWARDS**

**THIAGARAJAR COLLEGE OF ENGINEERING**
(A Government Aided Autonomous Institution affiliated to Anna University)
**MADURAI – 625 015, TAMILNADU**

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**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**
**B.E. EEE Degree Programme**

**COURSES OF STUDY**
(For the candidates admitted from 2018-19)

**THIRD SEMESTER**

| Course Code | Name of the Course | Category | No. of Hours / Week | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| 18EE310 | Numerical methods and Complex variables | BS | 3 | - | - | 3 |
| 18EE320 | DC machines and Transformers | PC | 3 | - | - | 3 |
| 18EE330 | Linear Integrated circuits | PC | 3 | - | - | 3 |
| 18EE340 | Digital Systems | PC | 2 | 1 | - | 3 |
| 18EE350 | Signals and Systems | PC | 3 | - | - | 3 |
| **THEORY CUM PRACTICAL** | | | | | | |
| 18EE360 | C and C++ Programming | ES | 2 | - | 2 | 3 |
| 18ES390 | Design Thinking | ES | 1 | - | 2 | 2 |
| **PRACTICAL** | | | | | | |
| 18EE370 | DC Machines and Transformers Lab | PC | - | - | 2 | 1 |
| 18EE380 | Integrated Circuits Lab | PC | - | - | 2 | 1 |
| **Total** | | | | | | **22** |

**FOURTH SEMESTER**

| Course Code | Name of the Course | Category | No. of Hours / Week | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| 18EE410 | Probability and Random processes | BS | 3 | - | - | 3 |
| 18EE420 | AC Machines | PC | 3 | - | - | 3 |
| 18EE430 | Measurements and Instrumentation | PC | 3 | - | - | 3 |
| 18EE440 | Control Systems | PC | 2 | 1 | - | 3 |
| 18YYFX0 | Foundation Elective I | PC | 3 | - | - | 3 |
| 18EE490 | Project Management | HSS | 3 | - | - | 3 |
| **THEORY CUM PRACTICAL** | | | | | | |
| 18EG470 | Professional Communication | HSS | - | 1 | 2 | 2 |
| **PRACTICAL** | | | | | | |
| 18EE470 | Measurement and Instrumentation Lab | PC | - | - | 2 | 1 |
| 18EE480 | AC Machines Lab | PC | - | - | 2 | 1 |
| **Total** | | | | | | **22** |
| **MANDATORY AUDIT COURSE** | | | | | | |
| 18CH2B0 | Constitution of India | AC | 2 | - | - | - |

BS : Basic Science
ES : Engineering Science
PC : Programme Core
PE : Programme Elective
L : Lecture
T : Tutorial
P : Practical

**Note**:

1 Hour Lecture/week is equivalent to 1 credit
1 Hours Tutorial/week is equivalent to 1 credit
2 Hours Practical/week is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**
**B.E. EEE Degree Programme**

**SCHEME OF EXAMINATIONS**
(For the candidates admitted from 2018-19onwards)

**THIRD SEMESTER**

| S.No. | Course Code | Name of the Course | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | 18EE310 | Numerical methods and Complex variables | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | 18EE320 | DC machines and Transformers | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | 18EE330 | Linear Integrated circuits | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | 18EE340 | Digital Systems | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | 18EE350 | Signals and Systems | 3 | 50 | 50 | 100 | 25 | 50 |
| 6 | 18ES390 | Design Thinking | - | 50 | 50 | 100 | 25 | 50 |
| **THEORY CUM PRACTICAL** | | | | | | | | |
| 7 | 18EE360 | C and C++ Programming | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 6 | 18EE370 | DC Machines and Transformers Lab | 3 | 50 | 50 | 100 | 25 | 50 |
| 7 | 18EE380 | Integrated Circuits Lab | 3 | 50 | 50 | 100 | 25 | 50 |

* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

## FOURTH SEMESTER

| S.No. | Course Code | Name of the Course | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | 18EE410 | Probability and Random processes | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | 18EE420 | AC Machines | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | 18EE430 | Measurements and Instrumentation | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | 18EE440 | Control Systems | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | 18YYFX0 | Foundation Elective I | 3 | 50 | 50 | 100 | 25 | 50 |
| 6 | 18EE490 | Project Management | 3 | 50 | 50 | 100 | 25 | 50 |
| **THEORY CUM PRACTICAL** | | | | | | | | |
| 7 | 18EG470 | Professional Communication | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 6 | 18EE470 | Measurement and Instrumentation Lab | 3 | 50 | 50 | 100 | 25 | 50 |
| 7 | 18EE480 | AC Machines Lab | 3 | 50 | 50 | 100 | 25 | 50 |
| **MANDATORY AUDIT COURSES** | | | | | | | | |
| 8 | 18CHAB0 | Constitution of India | - | 50 | 50 | 100 | 25 | 50 |

* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

| 18EE310 | NUMERICAL METHODS AND COMPLEX VARIABLES | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | BS | 3 | 0 | 0 | 3 |

## Preamble

A Electrical engineering student needs to know sufficient numerical tools and techniques for solving engineering problems arises in their field. This course aims at developing the ability to formulate an engineering problem in a mathematical form appropriate for subsequent computational treatment and to choose an appropriate numerical approach. Analytic functions and Contour integration are extremely important while creating engineering models in control systems, communication systems, searching algorithms. The course is designed to impart the knowledge and understanding of the above concepts to Electrical Engineers and apply them in their areas of specialization.

## Prerequisite

18MA110 Engineering Calculus

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage in % |
|---|---|---|
| CO1 | Solve the system of linear algebraic equations and single non linear equations | 15% |
| CO2 | Estimate the intermediate value in discrete data by means of continuous functions | 15% |
| CO3 | Apply suitable methods to find numerical integration, numerical differentiation. | 15% |
| CO4 | Solve the Initial Value Problems in ODE using single step and multi step methods and Boundary Value Problems in PDE using finite difference methods | 20% |
| CO5 | Construction of analytic functions. | 15% |
| CO6 | Determine the value of integrals of functions of complex variable using Cauchy's integral formula, Cauchy's integral theorem, Cauchy's Residue theorem. | 20% |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.5,4.3.3,4.4.1 |
| CO2 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.5,4.3.3,4.4.1 |
| CO3 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.5,4.3.3,4.4.1 |
| CO4 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.5,4.3.3,4.4.1 |
| CO5 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.5, ,4.3.3,4.4.4. |
| CO6 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.5, ,4.3.3,4.4.4. |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1. | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO2. | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO3. | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO4. | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO5. | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO6. | S | M | L | L | - | - | - | M | M | M | - | M | S | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | - | - | - | - |
| Understand | 20 | 20 | 20 | - | - | - | 30 |
| Apply | 70 | 70 | 70 | 100 | 100 | 100 | 70 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

**Sample Questions for Course Outcome Assessment**

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

**1.** Solve using bisection method the equation $x^3 - 5x + 3 = 0$

**2.** Solve by Gauss Jordan method $x+2y+3z=6; 2x+4y+z=7 \;;\; 3x+2y+9z=11.$

**3.** An oscillating current in an electric circuit is described by $i = 9e^{-t}\cos(2\pi t)$, where $t$ is in seconds. Determine a value of $t$ such that $i = 3.5$. Using Newton's method.

**Course Outcome 2(CO 2):**

1. Use Newton Gregory formulae to find the value of y @ x=1.05 from the following

   a. X: 1.0 1.1 1.2 1.3 1.4 1.5
   b. Y: 0.841 0.891 0.912 0.964 0.985 1.015

2. Use Lagrange's formula to interpolate y @ x=5 given

   a. X: 1 2 3 4 7
   b. Y: 2 4 8 16 128

3. You measure the voltage drop *V* across a resistor for a number of different values of current *i*. The results are

| *i* | 0.25 | 0.75 | 1.25 | 1.5 | 2.0 |
|---|---|---|---|---|---|
| *V* | −0.45 | −0.6 | 0.70 | 1.88 | 6.0 |

Fit a fourth-order polynomial interpolation to estimate the voltage drop for $i = 1.15$. Interpret your results.

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

**1.** Using Newton formulae for derivatives find the first and second derivative of $\sqrt{x}$ at x=15 and at x = 25 from the following

X: 15 17 19 21 23 25

$\sqrt{x}$: 3.873 4.123 4.359 4.583 4.796 5.000

**2.** Use Gauss's two point and three point quadrature formulae to find the value of

$$\int_0^{\frac{\pi}{2}} \frac{d\theta}{1+\sin^2\theta}.$$

**3.** Faraday's law characterizes the voltage drop across an inductor as $V_{L=}L\frac{di}{dt}$ where $V_L$=voltage drop (V), $L$=inductance (in henrys; 1H=1 V ・s/A), $i$ =current (A), and $t$ = time (s). Determine the voltage drop as a function of time from the following data for an inductance of 4 H.

| | | | | | | |
|---|---|---|---|---|---|---|
| *t* | 0 | 0.1 | 0.2 | 0.3 | 0.5 | 0.7 |
| *i* | 0 | 0.16 | 0.32 | 0.56 | 0.84 | 2.0 |

**Course Outcome 4(CO4):**

1. Using improved Euler's method find y(0.2) and y(0.4) given $y' = y + x^2$ ; $y(0) = 1$. with h=0.2
2. Use Adam's Predictor and corrector formulae to evaluate y(0.8)given $y' = y - x^2$ ; $y(0) = 1$ ; $y(0.2) = 1.9218; y(0.4) = 14682; y(0.6) = 1.7379.$
3. The voltage drop may be nonlinear and the circuit dynamics is described by a relationship such as $L\frac{di}{dt} + R\left[\frac{i}{I} - \left(\frac{i}{I}\right)^3\right] = 0$, where *i* = current, *L* = inductance, and *R* = resistance. Solve for *i*, if *L* = 1, *R* = 1.5, and *i*(0) =0.5 and *I* is a known reference current equal to 1 Solve this problem with a numerical method.

**Course Outcome 5(CO5):**

**1.** Show that $\psi = x^2 - y^2 - 3x - 2y + 2xy$ can represent the stream function of an incompressible fluid flow.. Also find the corresponding velocity potential and the complex potential

**2.** Find the equation of the orthogonal trajectories of the family of curves given by $2x - x^3 + 3xy^2 = a$

**3.** Find the image of the region $2 < |z| < 3$ under the transformation $w = z^2$.

**Course Outcome 6 (CO6):**

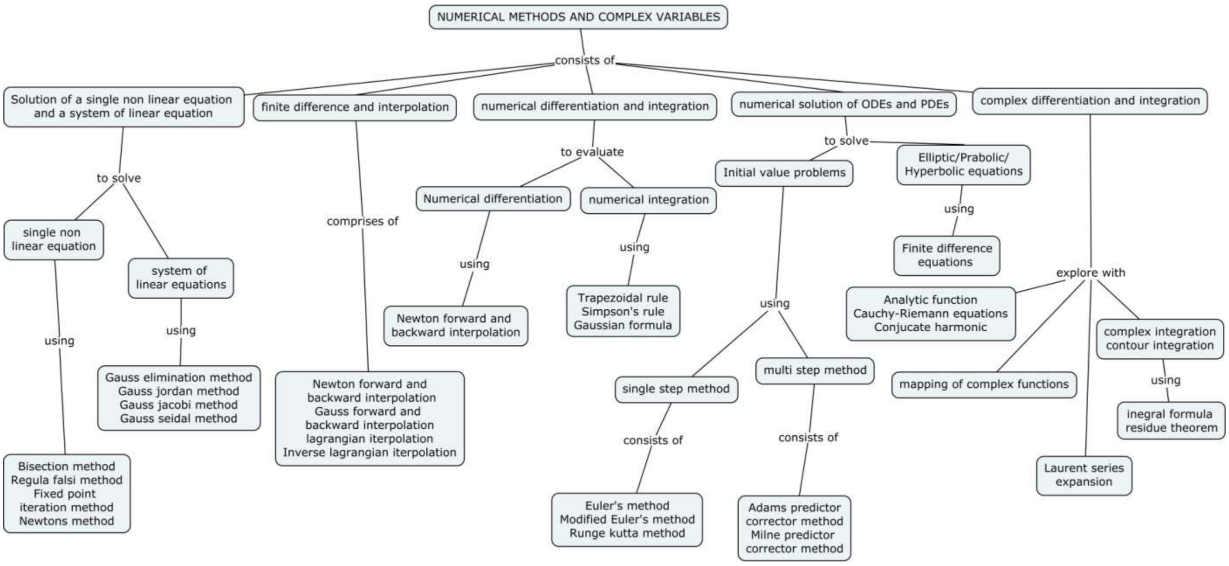
**1.** Evaluate using contour integration : $\int_0^\infty \frac{x^2}{(x^2+1)(x^2+4)}\,dx$

2. Evaluate using Cauchy's integral formula $\int_C \frac{e^{2z}}{(z+1)^4}\,dz$ where C is $|z| = 2$

3. Find the Laurent's series for $f(z) = \frac{z^2 - 1}{(z+2)(z+3)}$ valid in the region

   i) $|z| < 2$ $ii)$ $2 < |z| < 3$ $iii)$ $|z| > 3$.

## Concept Map




## Syllabus

**Solution to a Single Non Linear Equation and a System of Linear Equations (6 hours)**

Introduction to Numerical solution - Bisection method – Regula - Falsi method – Fixed point iteration method- Newton Raphson method method-Gauss elimination method – Gauss-Jordan method – Gauss Jacobi method and Gauss Seidel methods

**Finite Differences and Interpolation (5 hours)**

Introduction to finite differences – Operators-Newton's forward and backward interpolation formula - Gauss forward and backward interpolation formula – Lagrange's interpolation formula for unequal intervals – Inverse interpolation .

**Numerical Differentiation and Integration (5 hours)**

Introduction to Numerical differentiation - Newton' forward and backward formula for derivative – Introduction to Numerical integration -Trapezoidal rule – Simpson's rules – Gauss 2- point and 3- point formula .

**Numerical Solution of ODEs and PDEs (8 Hours)**

Introduction to Numerical solution -Euler' method – Modified Euler's method –Runge –Kutta methods of order 4 – Predictor corrector methods – Adam's predictor corrector formula- Milne's Predictor corrector formula- Introduction to PDEs- types – Solution to Elliptic, Parabolic and Hyperbolic PDEs.

**Complex Differentiation and Integration (12 hours)**

Introduction to functions of complex variables - Analytic functions – C-R equations – Conjugate harmonics – Standard functions (or mappings)z of a complex variable – z , 1/z , exp( z) – Laurent's series - Singularities – Residues – Cauchy's integral formula – Cauchy's residue theorem – Contour integration .

## Learning Resources


1. Steven C. Chapra, Raymond P. Canale, "**Numerical Methods for Engineers**", Mc Graw Hill Higher Education, 2016.
2. S. R. K. Iyengar, R. K. Jain, Mahinder Kumar Jain, "**Numerical methods for Scientific and Engineering Computations**", New Age International publishers , 7th Edition, 2019.
3. Glyn James, "**Advanced Modern Engineering Mathematics**", Pearson Education, New Delhi, 2018.


## Course Contents and Lecture Schedule

| Module No. | Topic | No. Of Hours | Course Outcome |
|---|---|---|---|
| 1. | **Single Non Linear Equation and a System of Linear Equations** | | |
| 1.1 | Bisection, Regula Falsi methods | 2 | CO 1 |
| 1.2 | Fixed point iteration method and Newton Raphson method | 2 | CO 1 |
| 1.3 | Gauss elimination and Gauss Jordan Methods | 1 | CO 1 |
| 1.4 | Gauss Jacobi and Gauss Seidel methods | 1 | CO 1 |
| **2** | **FINITE DIFFERENCES AND INTERPOLATION** | | |
| 2.1 | Introduction to operators and Newton forward and backward formulae | 2 | CO 2 |
| 2.2 | Gauss forward and backward formulae | 1 | CO 2 |
| 2.3 | Lagrange's formula and inverse interpolation | 2 | CO 2 |
| **3** | **NUMERICAL DIFFERENTIATION AND INTEGRATION** | | |
| 3.1 | Introduction Newton's formula for derivatives | 1 | CO 3 |
| 3.2 | Trapezoidal rule and Simpson's rules for numerical integration | 2 | CO 3 |
| 3.3 | Gauss 2 point and 3 point formulae | 2 | CO 3 |
| **4** | **Numerical Solution of ODEs and PDEs** | | |
| 4.1 | Introduction-Euler' method – Modified Euler's method | 1 | CO 4 |
| 4.2 | Runge-Kutta methods | 2 | CO 4 |
| 4.3 | Adam's and Milne's Predictor –Corrector methods | 1 | CO 4 |
| 4.4 | Introduction to PDE and Solution of Elliptic equations | 2 | CO 4 |
| 4.5 | Solution of Parabolic equations using Bender Schmidt and Crank Nicholson schemes | 1 | CO 4 |
| 4.6 | Solution to Hyperbolic equations by explicit scheme | 1 | CO 4 |
| 5 | **Complex Differentiation and Integration** | | |
| 5.1 | Introduction and complex differentiation | 2 | CO 5 |
| 5.2 | Analytic functions and harmonic conjugates | 2 | CO5 |
| 5.3 | Standard mappings | 2 | CO 6 |
| 5.4 | Complex integration and Cauchy's integral formula | 2 | CO 6 |

| | | | |
|---|---|---|---|
| 5.5 | Cauchy’s Residue theorem and Laurent’s series | 2 | CO 6 |
| 5.6 | Contour integration | 2 | CO 6 |
| | **TOTAL No. of Hours** | 36 | |

**Course Designers**

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| 18EE320 | DC MACHINES AND TRANSFORMERS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 3 | 0 | 0 | 3 |

## Preamble

The course aims in imparting fundamental knowledge of construction, types, Operation of Transformers and Direct current (DC) machines. DC machine is a highly versatile energy converting device. They can be designed to give a wide variety of voltage-current or speed- torque characteristics for both dynamic and steady-state operation. Due to their flexibility in speed control, DC motors are widely used in applications requiring a wide range of motor speeds or precise control of motor output. A transformer is a device used to transfer electrical energy from one circuit to another. It changes electricity from one level to other level of voltage using the properties of electricity.

## Prerequisite

18EE230 : Electric Circuit Analysis

## Course Outcomes

On the successful completion of the course, students will be able to

| COs | Course outcomes | Weightage*** in % |
|---|---|---|
| CO1 | Explain the basic principles and construction of single phase, three phase transformer and application specific transformers | 10 |
| CO2 | Explain the transformer working theory at no load and loaded conditions | 15 |
| CO3 | Determine the performance of the given single transformer using equivalent circuit diagram and testing methods | 20 |
| CO4 | Explain the construction, principle of operation and various types of DC machines. | 15 |
| CO5 | Determine the characteristics and performance of DC machines at loaded conditions. | 20 |
| CO6 | Explain the starting methods, speed control, and testing of DC Motors. | 20 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| CO1 | TPS2 | Understand | Respond | | 1.2.4, |
| CO2 | TPS 2 | Understand | Respond | | 1.2.4, 2.2.1, 2.3.1 |
| CO3 | TPS 3 | Apply | Value | | 1.2.4, 2.1.2,2.2.4 |
| CO4 | TPS 3 | Apply | Value | | 1.2.4, 2.2.1, 2.3.1 |
| CO5 | TPS 2 | Understand | Respond | | 1.2.4, 2.1.2,2.2.4 |
| CO6 | TPS 3 | Apply | Value | | 1.2.4, 2.2.1, 2.3.1 |

## Mapping with Programme Outcomes

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | |
| CO2 | M | L | | | | | | M | | M | | | M | |
| CO3 | S | M | L | L | | | | M | | M | | | S | |
| CO4 | S | M | L | L | | | | M | | M | | | S | |
| CO5 | M | L | | | | | | M | | M | | | M | |
| CO6 | S | M | L | L | | | | M | | M | | | S | |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 10 | - | - | - | 10 |
| Understand | 50 | 30 | 20 | - | - | - | 20 |
| Apply | 30 | 50 | 70 | 100 | 100 | 100 | 70 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. Derive the EMF equation of single phase transformer.

2. Define the term transformation ratio in Transformer.
3. Mention the advantages of shell type transformer over core type transformer.

**Course Outcome 2 (CO2):**

1. Draw the phasor diagram representing the various electrical parameters of the transformer with Resistive load and inductive load conditions.
2. A 400/200Volts Single phase transformer is supplying a load of 30 Amperes at a power factor of 0.8 lagging. On no-load the current and power factor is 2.1 Amperes & 0.2 lagging respectively on high voltage side. Calculate the current taken from the supply.
3. A 300kVA transformer has a primary winding resistance of 0.4Ω and a secondary winding resistance of 0.0015Ω. The iron loss is 2kW and the primary and secondary voltages are 4kV and 200V respectively. If the power factor of the load is 0.78, determine the efficiency of the transformer (a) on full load, and (b) on half load.

**Course Outcome 3 (CO3)**

1. A transformer has 600 primary turns and 150 secondary turns. The primary and secondary resistance's are 0.25Ω and 0.01Ω respectively and the corresponding leakage reactance's are 1.0Ω and 0.04Ω respectively. Determine (a) the equivalent resistance referred to the primary winding, (b) the equivalent reactance referred to the primary winding, (c) the equivalent impedance referred to the primary winding, and (d) the phase angle of the impedance.
2. The resistance and reactance of a 10 kVA, 400/200Volts, Three phase transformer are 2% and 10% respectively. If the constant losses in the machine is 1%, Calculate the maximum possible percentage efficiency of the transformer.
3. 250kVA transformer has a full load copper loss of 3kW and an iron loss of 2kW. Calculate (a) the output kVA at which the efficiency of the transformer is a maximum, and (b) the maximum efficiency, assuming the power factor of the load is 0.80.

**Course Outcome 4 (CO4)**

1. Explain the operation of on-load tap changer used in Transformer.
2. List the advantages of three phase transformers.
3. Explain the operation of welding transformers.

**Course Outcome 5 (CO5)**

1. Draw the circuit diagrams for conducting Open Circuit Test and Short circuit test on a single phase transformer. Also explain, how the efficiency and voltage regulation can be estimated by these test.
2. Two similar 250/1000 Volts, 10 KVA Transformers are being tested by the sumpner's test method. At rated voltage of 250volts on the Low voltage side the wattmeter reading is found 250watts and ammeter reading is 4Ampers. On the series connected High voltage side, a voltage of 80Volts drives a rated full load current of

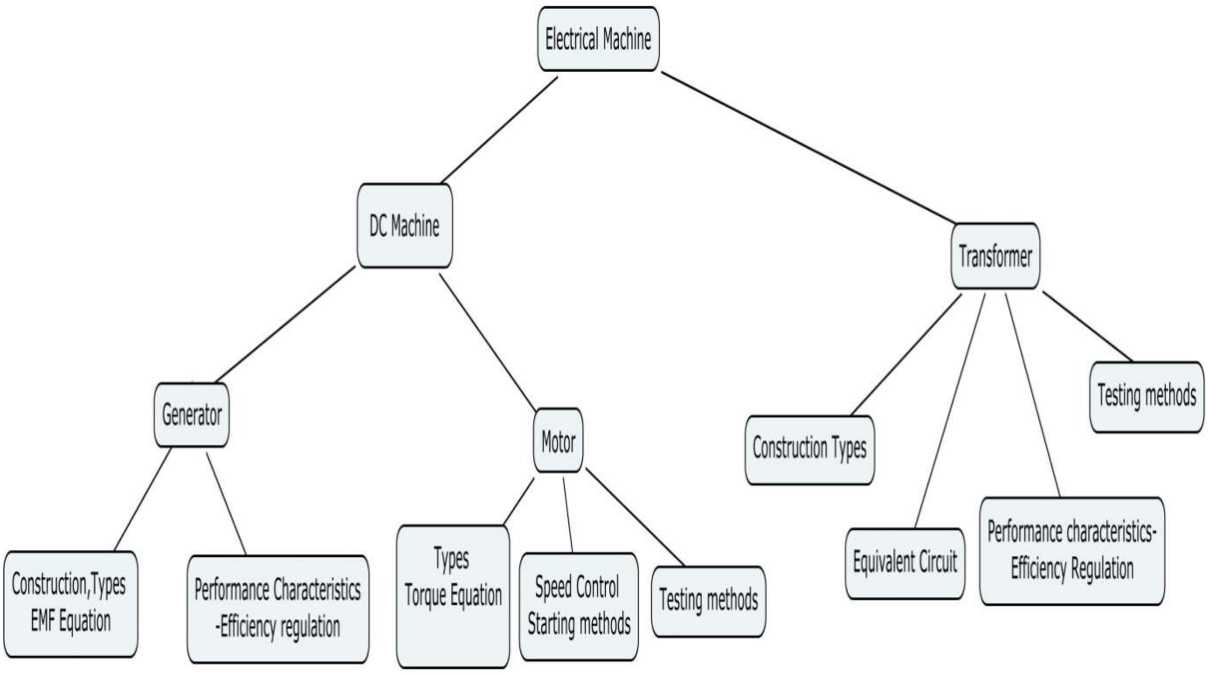
10 Amperes. Calculate the efficiency of the transformer at 80% of its full load at 0.9 Power factor leading?

3. State the advantages of Sumpner's test for Transformer.

**Course Outcome 6 (CO6)**

1. A DC series motor drives a load, the torque of which varies as the square of the speed. The motor takes a current of 20 A when the speed is 800 rpm. Calculate the speed and current when the motor field winding is shunted by a diverter of the same resistance as that of the field winding.
2. A 4 pole lap wound 900 rpm shunt generator has an armature resistance of 0.2Ω and field resistance of 230Ω. There are 30 slots with 15 conductors/slot. If the load resistance is 10Ω and terminal voltage is 230 V, find the useful flux/pole. The contact drop/brush is 1 V.
3. A long shunt generator running at 1000 rpm supplies 22 Kw at 220 V. Ra=0.05Ω, Rsh=110Ω, Rse=0.06Ω. The overall efficiency at above load is 88%. Find (a) copper loss (b) iron and friction loss.
4. Explain the methods of sped control of DC shunt motors.

## Concept Map




## Syllabus

**DC Generators**

Construction-Principle of operation, Emf equation-types, Armature reaction-commutation, Characteristics of generators, Losses & efficiency, Regulation, parallel operation, Applications

**DC Motors**

Principle of operation, Torque equation, Types-characteristics, Losses-Efficiency, Speed control and starters, Swinburne's Test ,Heat run Test ,Hopkinson's Test

**Transformers**

Transformer construction and principle, Ideal Transformer, EMF equation, Transformer on no load & load Losses, efficiency and regulation, All day efficiency, Auto transformer, three phase transformer connections, Parallel operation of Transformers, Welding transformers, Tap changers on load & off load , OC&SC Test on transformers, Sumpners Test

## Learning Resources

1. D.P.Kothari & I.J.Nagrath, " Electrical Machines", Tata-McGrawhill, Newdelhi, 5th Edition, 2010.
2. R.K.Rajput, " Electrical Technology", Laxmi Publications, 3rd edition, 2005.
3. Vincent Deldoro ," Electromechanical Energy Conversion " PHI III edition,
4. M.G.Say, Theory and performance of electrical machines, Tata-Mcgraw hill

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 1 | **DC Generators** | | |
| 1.1 | Construction-Principle of operation | 1 | CO4 |
| 1.2 | Emf equation-types | 1 | CO4 |
| 1.3 | Armature reaction-commutation | 1 | CO5 |
| 1.4 | Characteristics of generators | 2 | CO5 |
| 1.5 | Losses & efficiency | 2 | CO5 |
| 1.6 | Condition for maximum efficiency | 1 | CO5 |
| 1.7 | Regulation-parallel operation-Applications | 1 | CO5 |
| 2.0 | **DC Motors** | | |
| 2.1 | Principle of operation | 1 | CO4 |
| 2.2 | Torque equation | 1 | CO4 |
| 2.3 | Types-characteristics | 1 | CO4 |
| 2.4 | Losses-Efficiency | 1 | CO5 |
| 2.5 | Speed control and starters | 1 | CO5 |
| 2.6 | Starter motor -Applications | 1 | CO5 |
| 3.0 | **Transformers** | | |
| 3.1 | Transformer construction and principle | 2 | CO1 |
| 3.2 | Ideal Transformer, EMF equation | 2 | CO2 |
| 3.3 | Transformer on no load & load | 2 | CO2 |
| 3.4 | Equivalent circuit of the transformer | 3 | CO3 |
| 3.5 | Losses, efficiency and regulation, All day efficiency | 3 | CO3 |
| 3.6 | Auto transformer , three phase transformer connections | 2 | CO3 |
| 3.7 | Parallel operation of Transformers, Welding transformers, Tap changers on load & off load. | 1 | CO1 |
| 4.0 | **Testing of DC Machines and transformers** | | |

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 4.1 | OC&SC Test on transformers | 1 | CO6 |
| 4.2 | Sumpners Test | 1 | CO6 |
| 4.3 | Swinburne's Test | 1 | CO6 |
| 4.4 | Heat run Test | 1 | CO6 |
| 4.5 | Hopkinson's Test | 1 | CO6 |
| 4.6 | Testing standards | 1 | CO6 |
| | TOTAL | 36 | |

**Course Designers:**

| | | |
|---|---|---|
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| 3 | Dr.V.Mahesh | maheshv@tce.edu |

| **18EE330** | **LINEAR INTEGRATED CIRCUITS** |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 3 | - | - | 3 |

## Preamble

A linear integrated circuit is a solid-state analog device characterized by a theoretically infinite number of possible operating states. It operates over a continuous range of input levels. Linear ICs are employed in audio amplifiers, Analog to Digital converters, averaging amplifiers, differentiators, DC amplifiers, integrators, multivibrators, oscillators, audio filters, and sweep generators. Some devices contain several amplifiers within a single housing.

## Prerequisite

18EE250 - Electronics Circuits and devices

18EE270- Electronics Circuits and devices Lab

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the Linear Integrated Circuits fabrication techniques | 10 |
| CO2 | Explain the operation amplifier and its characteristics. | 10 |
| CO3 | Design the various circuits using operational amplifiers for the given specifications | 50 |
| CO4 | Design Multivibrator circuits using 555 timer IC | 10 |
| CO5 | Design voltage regulators using fixed and variable voltage regulator ICs | 10 |
| CO6 | Explain the Phase Locked Loops, Analog to digital converters and Digital to Analog converters | 10 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| | | | | | |
| CO1 | TPS2 | Understand | Respond | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4,3.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO2 | TPS2 | Understand | Respond | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO3 | TPS3 | Apply | Value | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO5 | TPS3 | Apply | Value | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4 3.2.3 |
| CO6 | TPS2 | Understand | Respond | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4 3.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | M | L | | | | | | M | | M | | | | M |
| CO3 | S | M | L | L | | | | M | | M | | | | S |
| CO4 | S | M | L | L | | | | M | | M | | | | S |
| CO5 | S | M | L | L | | | | M | | M | | | | S |
| CO6 | M | L | | | | | | M | | M | | | | M |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 50 | 40 | 40 | - | - | - | 40 |
| Apply | 30 | 40 | 40 | 100 | 100 | 100 | 40 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. What are the advantages of IC over discrete component circuits?
2. Mention the two basic thick film processes.
3. Explain the different process involved in IC fabrication.

**Course Outcome 2 (CO2):**

1. What is a scale changer?
2. Determine Input Offset voltage for inverting amplifier.
3. Explain the differential amplifier with neat sketch.

**Course Outcome 3 (CO3)**

1. Design a non-inverting summing amplifier with a gain of 2.
2. Explain the working of a positive and negative clipper for both +ve and –ve reference values.
3. Explain the working of an instrumentation amplifier with neat sketch

**Course Outcome 4(CO4)**

1. Define free running oscillator.
2. Design a monostable multivibrator for a time delay of 1ms using 555 Timer IC
3. Design a astable multivibrator for a frequency of 1 KHz using 555 Timer IC

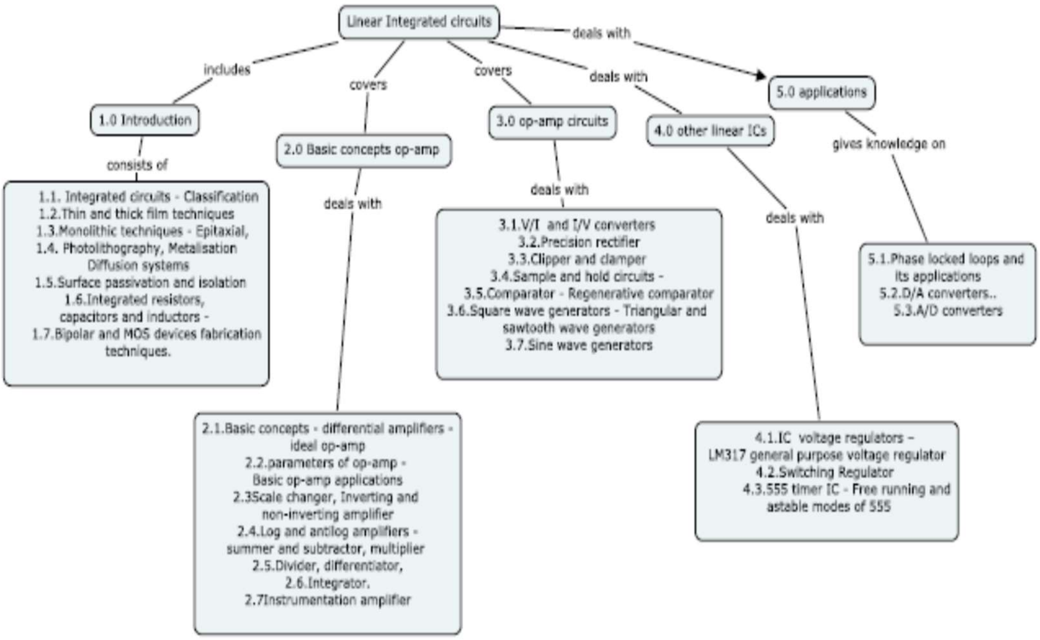
**Course Outcome 5 (CO5)**

1. Design a voltage regulator using 723 to get voltage output of 3V
2. What is the function of voltage regulator?
3. Explain the protections used in 78xx voltage regulator.

**Course Outcome 6 (CO6)**

1. Explain the operation of PLL with neat block diagram.
2. Discuss the applications of a PLL as a frequency translator and frequency divider.
3. Explain the VCO with neat sketch.

**Concept Map**




## Syllabus

**Introduction**: Integrated circuits – Classification, Thin and thick film techniques Monolithic techniques - Epitaxial, Photolithography, Metalisation, Diffusion systems Surface passivation and isolation Integrated resistors, capacitors and inductors - Bipolar and MOS devices fabrication techniques.

**Operational amplifier**: Basic concepts - differential amplifiers - ideal op-amp parameters of op-amp - Basic op-amp applications Scale changer, Inverting and non-inverting amplifier summer and subtractor, Log and antilog amplifiers multiplier Divider, differentiator**,** Integrator. Instrumentation amplifier

**Op-amp circuits:** V/I and I/V converters Precision rectifier Clipper and clamper Sample and hold circuits - Active filters - Comparator - Regenerative comparator Square wave generators - Triangular and saw tooth wave generators Sine wave generators**,** Application of Non linear Op Amp**.**

**Other Linear ICs** :IC voltage regulators – LM317 general purpose voltage regulator Switching Regulator 555 timer IC - Free running and Astable modes of 555 Applications, Phase locked loops and its applications, D/A converters, A/D converters, Introduction to Field Programmable Analog Array(FPAA)

## Learning Resources

1. Ramakant A. Gayakwad, Op-amps and Linear Integrated Circuits, Pearson Education; Fourth edition, 2015
2. K.R.Botkar, Integrated Circuits, Hanna Publishers, 2008
3. Roy choudhury and shall B.Jain, Linear Integrated circuits, Wiley Eastern Ltd, 2010 4th edition
4. Jacob Millman & Christos C.Halkias- Integrated electronics, McGraw Hill Education; 2 edition (1 July 2017)
5. Robert F. Coughlin &Frederick F DriscollOperational Amplifiers and Linear Integrated Circuits, Pearson; 4 edition (1 November 1990)
6. NPTEL courses web:http://nptel.ac.in/courses/108106068/
7. MOOCs course link: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/


## Course Contents and Lecture Schedule

| S.No | Topics | No. of Periods | COs |
|---|---|---|---|
| 1 | **Introduction** | | |
| 1.1 | Integrated circuits - Classification | 1 | CO1 |
| 1.2 | Thin and thick film techniques | 1 | CO1 |
| 1.3 | Monolithic techniques - Epitaxial, | 1 | CO1 |
| 1.4 | Photolithography, Metalisation, Diffusion systems | 1 | CO1 |
| 1.5 | Surface passivation and isolation | 1 | CO1 |
| 1.6 | Integrated resistors, capacitors and inductors - | 1 | CO1 |
| 1.7 | Bipolar and MOS devices fabrication techniques. | 1 | CO1 |
| 2 | **Operational amplifier** | | |
| 2.1 | Basic concepts - differential amplifiers - ideal op-amp | 2 | CO2 |
| 2.2 | parameters of op-amp - Basic op-amp applications | 1 | CO2 |
| 2.3 | Scale changer, Inverting and non-inverting amplifier | 1 | CO2 |
| 2.4 | Log and antilog amplifiers -summer and subtractor, | 1 | CO2 |
| 2.5 | Multiplier Divider, | 1 | CO2 |
| 2.6 | Differentiator, Integrator. | 2 | CO2 |
| 2.7 | Instrumentation amplifier | 1 | CO2 |
| 3 | **Op-amp circuits** | | |
| 3.1 | V/I and I/V converters | 1 | CO3 |
| 3.2 | Precision rectifier | 1 | CO3 |
| 3.3 | Clipper and clamper | 1 | CO3 |
| 3.4 | Active Filters | 2 | CO3 |
| 3.5 | Comparator - Regenerative comparator - Sample and hold circuits | 1 | CO3 |
| 3.6 | Square wave generators - Triangular and sawtooth wave generators | 2 | CO3 |
| 3.7 | Sine wave generators | 1 | CO3 |
| 4 | **Other Linear ICs** | | |
| 4.1 | IC voltage regulators – LM317 general purpose voltage regulator | 1 | CO5 |

| | | | |
|---|---|---|---|
| 4.2 | Switching Regulator | 2 | CO5 |
| 4.3 | 555 timer IC –Astable and monostable modes of 555 | 2 | CO4 |
| 5 | **Applications** | | |
| 5.1 | Phase locked loops and its applications | 2 | CO6 |
| 5.2 | D/A converters. | 2 | CO6 |
| 5.3 | A/D converters | 2 | CO6 |
| | Total | 36 | |

**Course Designers:**

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| 18EE340 | DIGITAL SYSTEMS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 2 | 1 | 0 | 3 |

## Preamble

Digital systems encompass the circuits, that process signals by discrete bands of analog levels, rather than by continuous ranges (as used in analog electronics). All levels within a band represent the same signal state. Because of this discretization, relatively small changes to the analog signal levels due to manufacturing tolerance, signal attenuation or parasitic noise do not leave the discrete envelope, and as a result are ignored by signal state sensing circuitry. In most cases the number of these states is two, and they are represented by two voltage bands: one near a reference value typically termed as "ground", and the other a value near the supply voltage. These correspond to the "false" ("0"), and "true" ("1"), values of the Boolean domain, respectively, yielding binary code. Digital electronic circuits are usually made from large assemblies of logic gates. Computer-controlled digital systems can be controlled by software, allowing new functions to be added without changing hardware.

## Prerequisite

**NIL**

## Course Outcomes

On the successful completion of the course, students will be able to :

| CO Number | Course Outcome | Weightage*** in % |
|---|---|---|
| CO1 | Represent the given data in different number systems and perform arithmetic operations and Explain various digital codes | 8 |
| CO2 | Explain the operation of logic gates and digital logic families | 10 |
| CO3 | Apply Boolean algebra for minimizing the given function to represent in standard and canonical forms | 5 |
| CO4 | Design combinational logic circuits for the given applications | 30 |
| CO5 | Design synchronous sequential circuits for the given requirement | 20 |
| CO6 | Explain the characteristics and working of asynchronous sequential logic circuits | 8 |
| CO7 | Implement simple combinational and sequential circuits using verilog simulation tool | 7 |
| CO8 | Implement the given digital application using Programmable Logic Devices and illustrate the function of memories. | 12 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |

| | | | | | |
|---|---|---|---|---|---|
| CO1 | TPS2 | Understand | Respond | | 1.2.6, 2.3.2 |
| CO2 | TPS2 | Understand | Respond | | 1.2.6, 2.3.1, 2.5.4 |
| CO3 | TPS3 | Apply | Value | | 1.2.6, 2.3.4 |
| CO4 | TPS3 | Apply | Value | | 1.2.6, 2.1.1, 2.1.5, 2.3.1, 2.4.3, 2.4.4 |
| CO5 | TPS3 | Apply | Value | | 1.2.6, 2.1.1, 2.1.5, 2.3.1, 2.4.3, 2.4.4 |
| CO6 | TPS2 | Understand | Respond | | 1.2.6 |
| CO7 | TPS3 | Apply | Value | | 1.2.6, 2.5.4 |
| CO8 | TPS3 | Apply | Value | | 1.2.6, 2.5.4 |

## Mapping with Programme Outcomes

| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1. | M | L | | | | | | M | | M | | | | M |
| CO2. | M | L | | | | | | M | | M | | | | M |
| CO 3 | S | M | L | L | | | | M | | M | | | | S |
| CO 4 | S | M | L | L | | | | M | | M | | | | S |
| CO 5. | S | M | L | L | | | | M | | M | | | | S |
| CO 6 | M | L | | | | | | M | | M | | | | M |
| CO 7 | S | M | L | L | M | | | M | | M | | | | S |
| CO 8 | S | M | L | L | | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 50 | 30 | 30 | - | - | - | 30 |
| Apply | 30 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. Perform the following binary operations:
   10110110+10111000
   11111000-10101010
2. Convert the given hexa-decimal numbers to binary numbers:
   9BC2, FDA5.A2

**Course Outcome 2 (CO2):**

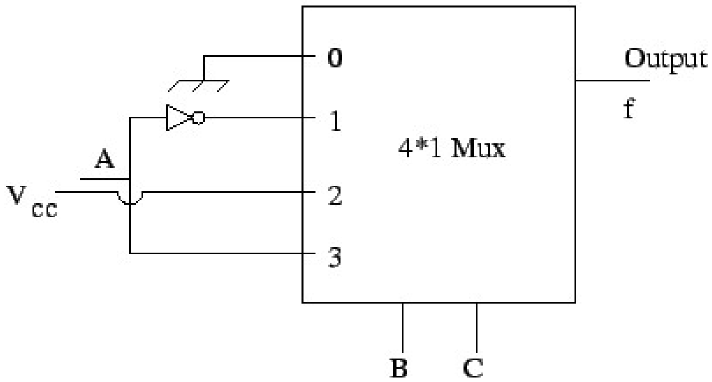
1. Explain the operation of CMOS 2 input NAND gate with circuit diagram.
2. List the characteristics of TTL and CMOS logic families.
3. Define Propagation delay, fan-in and fan-out of a logic gate.

**Course Outcome 3 (CO3)**

1. Simplify the given logic expression using Demorgan's theorem:
   Y=(A+B+(AB)'+CD)'
2. Prove the commutative and distributive laws in Boolean algebra.
3. Simplify the given logic expression:
   Y=ABC+AB'C+A'B'C'+AB'C'

**Course Outcome 4 (CO4)**

1. Simplify the logic function F(A,B,C,D)= Σm(0,1,2,5,6,8,)+d(3,4,7,14) using K-map in SOP form and implement it using NAND gates. Write Verilog code.
2. Obtain the Boolean expression for ' f ' in the following circuit




3. Construct a Karnaugh Map for the Boolean function Y= ABC+ABC'+A'B'C+A'BC and simplify the function.

**Course Outcome 5 (CO5)**

1. In an industrial process, it is required to count down the product in the presence of a sensor signal x. Design a 2-bit count - down counter with two J-K flip-flops and one input x for this purpose. When x= 0, the state of the flip-flops does not change. When x=1, the state sequence is 11,10,01,00 and repeat. Provide suitable state diagram and table. Also provide characteristic and excitation table of J-K flip flop.

2. A sequential circuit consists of two T flip flops and one input x and one output y. Obtain the state table and logic diagram if the flip flop input equations and output equation are as follows
   TA = Ax+B'
   TB= A'x+B
   Y=x'

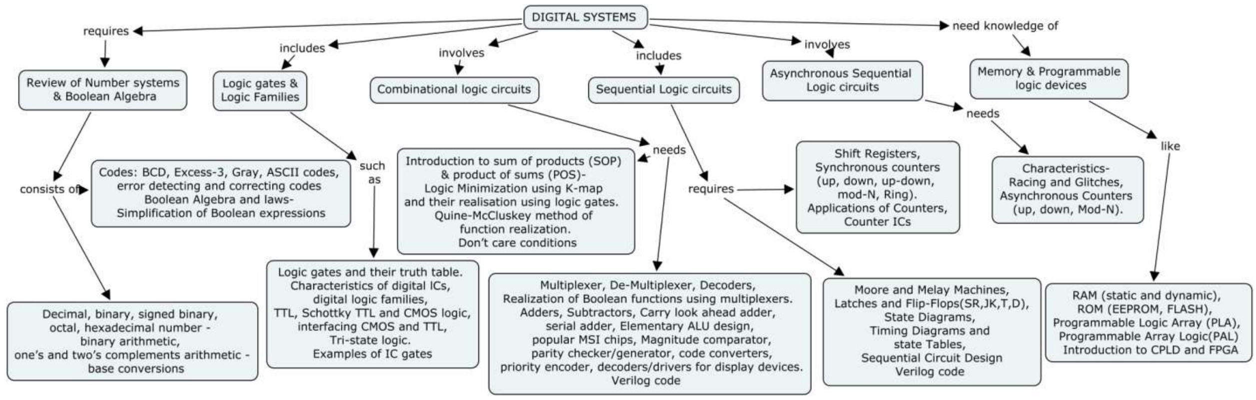
**Course Outcome 6 (CO6)**

1. Design Mod-10 ripple down counter using T flipflops.
2. Define Glitch in a digital circuit.

**Course Outcome 7 (CO7)**

1. Design a combination circuit using PLA with three inputs and three outputs. When binary input is 0,1,2,3, the binary output is one greater than the input. When the binary input is 4,5,6,7, the binary output is one lesser than the input.
2. Design a 2-bit comparator circuit using PAL with three outputs representing equal, greater than and lesser than.

## Concept Map




## Syllabus

**Review of Number systems & Boolean Algebra:** Decimal, binary, signed binary, octal, hexadecimal number - binary arithmetic, one's and two's complements arithmetic - base conversions - C**odes:** BCD, Excess-3, Gray, ASCII codes, error detecting and correcting codes, Boolean Algebra and laws- Simplification of Boolean expressions – Canonical and Standard forms

**Logic gates & Logic Families:** Logic gates and their truth table**.** Characteristics of digital ICs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic. Examples of IC gates

**Combinational logic circuits:** Introduction to sum of products (SOP) & product of sums (POS)- Logic Minimization using K-map and their realisation using logic gates. **Quine-**

**McCluskey** method of function realization. Don't care conditions, Multiplexer, De-Multiplexer, Decoders, Realization of Boolean functions using multiplexers. Adders, Subtractors, Carry look ahead adder, serial adder, Elementary ALU design, popular MSI chips, Magnitude comparator, parity checker/generator, code converters, priority encoder, decoders/drivers for display devices.

**Sequential Logic circuits:** Moore and Melay Machines, Latches and Flip-Flops(SR,JK,T,D), State Diagrams, Timing Diagrams and state Tables, Sequential Circuit Design, Shift Registers, Synchronous counters (up, down, up-down, mod-N, Ring). Applications of Counters, Counter ICs

**Asynchronous Sequential Logic circuits: C**haracteristics- Racing and Glitches**,** Asynchronous Counters (up, down, Mod-N).

**Introduction to Verilog simulation tool:** Verilog code for combinational and sequential circuits

**Memory & Programmable logic devices:** RAM (static and dynamic), ROM (EEPROM, FLASH), Programmable Logic Array (PLA), Programmable Array Logic(PAL) Introduction to CPLD and FPGA

## Learning Resources

1. M.Morris Mano and Michael D.Ciletti, Digital Design, Sixth Edition, Pearson Prentice Hall, 2018
2. RP Jain, Modern Digital Electronics,fourth edition, Tata Mcgraw Hill Publishers,2010
3. Floyd and Jain, Digital Fundamentals, 8th Edition, Pearson Education, 2009
4. Charles H.Roth and Lizy K.John, Digital system design using VHDL, 2nd edition, Cengage learning, 2007
5. Donald Leach, Albert Malvino and Goutam Saha, Digital Principles and Applications, McGraw Hill Publishers,2010
6. J. F. Wakerly Digital Design Principles and Practices, 4th edition, Prentice Hall of India, 2008.
7. NPTEL course: https://onlinecourses.nptel.ac.in/noc18_ee33

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lecture Hours | COs |
|---|---|---|---|
| 1 | **Review of Number systems & Boolean Algebra:** | | |
| 1.1 | Decimal, binary, signed binary, octal, hexadecimal number | 1 | CO1 |
| 1.2 | binary arithmetic, one's and two's complements arithmetic - base conversions ,C**odes:** BCD, Excess-3, Gray | 2 | CO1 |
| 1.3 | ASCII codes, error detecting and correcting codes | 1 | CO1 |

| | | | |
|---|---|---|---|
| 1.4 | Boolean Algebra and laws, Simplification of Boolean expressions, Canonical and Standard forms | 2 | CO3 |
| 2 | **Logic gates & Logic Families:** | | |
| 2.1 | Logic gates and their truth table**.** Characteristics of digital ICs, digital logic families, TTL, Schottky TTL and CMOS logic, | 2 | CO2 |
| 2.2 | Interfacing CMOS and TTL, Tri-state logic. Examples of IC gates | 2 | CO2 |
| 3 | **Combinational logic circuits:** | | |
| 3.1 | Introduction to sum of products (SOP) & product of sums (POS)- Logic Minimization using K-map and their realisation using logic gates | 2 | CO4 |
| 3.2 | **Quine-McCluskey** method of function realization. Don't care conditions, Multiplexer, De-Multiplexer, | 3 | CO4 |
| 3.3 | Decoders, Realization of Boolean functions using multiplexers. Adders, Subtractors, Carry look ahead adder, serial adder, | 2 | CO4 |
| 3.3 | Elementary ALU design, popular MSI chips, Magnitude comparator, parity checker/generator, code converters, priority encoder, decoders/drivers for display | 2 | CO4 |
| 4 | **Sequential Logic circuits:** | | |
| 4.1 | Moore and Melay Machines, Latches and Flip-Flops(SR,JK,T,D), | 2 | CO5 |
| 4.2 | State Diagrams, Timing Diagrams and state Tables, | 2 | CO5 |
| 4.3 | Sequential Circuit Design, Shift Registers, Synchronous counters (up, down, up-down, mod-N, Ring). | 3 | CO5 |
| 4.4 | Applications of Counters, Counter ICs | 1 | CO5 |
| 5 | **Asynchronous Sequential Logic circuits:** | | |
| 5.1 | **C**haracteristics- Racing and Glitches | 1 | CO6 |
| 5.2 | Asynchronous Counters (up, down, Mod-N) | 2 | CO6 |
| 6 | **Introduction to Verilog simulation tool:** | | |
| 6.1 | Verilog code for combinational and sequential circuits | 2 | CO7 |
| 7 | **Memory, ADC, DAC & Programmable logic devices:** | | |
| 7.1 | RAM (static and dynamic), ROM (EEPROM, FLASH) | 2 | CO8 |
| 7.2 | Programmable Logic Array (PLA), Programmable Array Logic(PAL) | 2 | CO8 |
| 7.3 | Introduction to CPLD and FPGA | 1 | CO8 |
| | **Total** | **36** | |

**Course Designers:**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| | | |
|---|---|---|
| 3. | Dr.B.Ashok Kumar | ashokudt@tce.edu |

| 18EE350 | SIGNALS AND SYSTEMS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 3 | - | - | 3 |

## Preamble

Signal processing plays an extremely important and continually growing role in a wide variety of engineering systems. Furthermore, technology and algorithms for signal processing continue to develop rapidly. While only a short time ago signal processing systems were predominantly analog, integrated circuit technology has made digital signal processing often preferable and more cost-effective. This course is an introduction to the basic concepts and theory of analog and digital signal processing.

## Prerequisite

- 18MA110 Engineering Calculus
- 18MA210 Matrices and Ordinary Differential Equations
- 18EE230 Electric Circuit Analysis

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Indentify the type of given signals and systems. | 10 |
| CO2 | Analyze the Time domain behaviour of a given Continuous time LTI system using Laplace Transform. | 20 |
| CO3 | Analyze the Time domain behaviour of a given Discrete Time LTI system using Z-Transform. | 20 |
| CO4 | Apply Fourier transform for frequency domain analysis of a given Continuous time LTI system | 20 |
| CO5 | Apply Discrete Fourier transform for frequency domain analysis of a given Discrete time LTI system | 20 |
| CO6 | Explain the concept of sampling, sampled spectra and reconstruction of signals. | 10 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.2.7, 2.1.1, 2.1.5, 2.3.1, |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 2.4.4, 3.2.3 |
| CO2 | TPS4 | Analyse | Organise | | 1.2.7, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO3 | TPS4 | Analyse | Organise | | 1.2.7, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.2.7, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO5 | TPS3 | Apply | Value | | 1.2.7, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO6 | TPS2 | Understand | Respond | | 1.2.7, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | S | M | L | L | L | | | M | | M | | | | S |
| CO3 | S | M | L | L | L | | | M | | M | | | | S |
| CO4 | S | M | L | L | | | | M | | M | | | | S |
| CO5 | S | M | L | L | | | | M | | M | | | | S |
| CO6 | M | L | | | | | | M | | M | | | | M |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

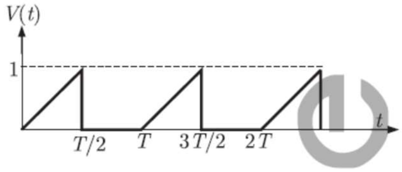
| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 40 | 40 | 40 | - | - | - | 40 |
| Apply | 40 | 40 | 40 | 50 | 50 | 100 | 40 |
| Analyse | | | | 50 | 50 | - | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO1):**

1. Find the period of the signal $x(t) = 8\sin(0.8\pi t + \pi/4)$.

2. The system represented by the input –output relationship$y(t) = \int_{-\infty}^{5t} x(\tau)\, d\tau, t > 0$ check whether the system is linear and causal.
3. For the triangular wave from shown in the figure, find the RMS value of the Voltage.




**Course Outcome 2(CO2):**

1. Given two continuous time signals $x(t) = e^{-t}$ and $y(t) = e^{-2t}$ which exist for $t > 0$, find the convolution $z(t) = x(t)*y(t)$
2. Let the Laplace transform of a function $f(t)$ which exists for $t > 0$ be $F1(s)$ and the Laplace transform of its delayed version $f(t - \tau)$ be $F2(s)$. Let $F1*(s)$ be the complex conjugate of $F1(s)$ with the Laplace variable set $s = \sigma + j\omega$. If $G(s) = \frac{F2(S)F1*(S))}{|F1(S)|^2}$ then determine the inverse Laplace transform of $G(s)$.
3. The response $h(t)$ of a linear time invariant system to an impulse $\delta(t)$, under initially relaxed condition is $h(t) = e^{-t} + e^{-2t}$. Find the response of this system for a unit step input $u(t)$.

**Course Outcome 3(CO3):**

1. If $x[n] = (1/3)^{n} - (1/2)^{n}u[n]$, then find the region of convergence (ROC) of its $z$ -transform in the $z$ –plane.

2. The z-transform of a signal $x[n]$ is given by $4z^{-3} + 3z^{-1} + 2 - 6z^{2} + 2z^{3}$ It is applied to a system, with a transfer function $H(z) = 3z^{-1} - 2$, Determine the output $y[n]$.

3. Given $X(z) = \frac{z}{(z-a)^2}$ with $|z| > a$, find the residue of $X(z)z^{n-1}$ at $z = a$ for $n \geq a$ .

**Course Outcome 4 (CO4):**

1. Define Fourier transform pair.
2. Let $x(t)$ be a periodic signal with time period $T$ , Let $y(t) = x(t - t_0) + x(t + t_0)$
for some $t_0$. The Fourier Series coefficients of $y(t)$ are denoted by $b_k$ . If $b_k = 0$

for all odd $k$ , then find $t_0$.

3. Consider an LTI system initially at rest described by the difference equation
$y[n] - ay[n-1] = x[n], |a| < 1$. Find frequency response $H(e^{jw})$

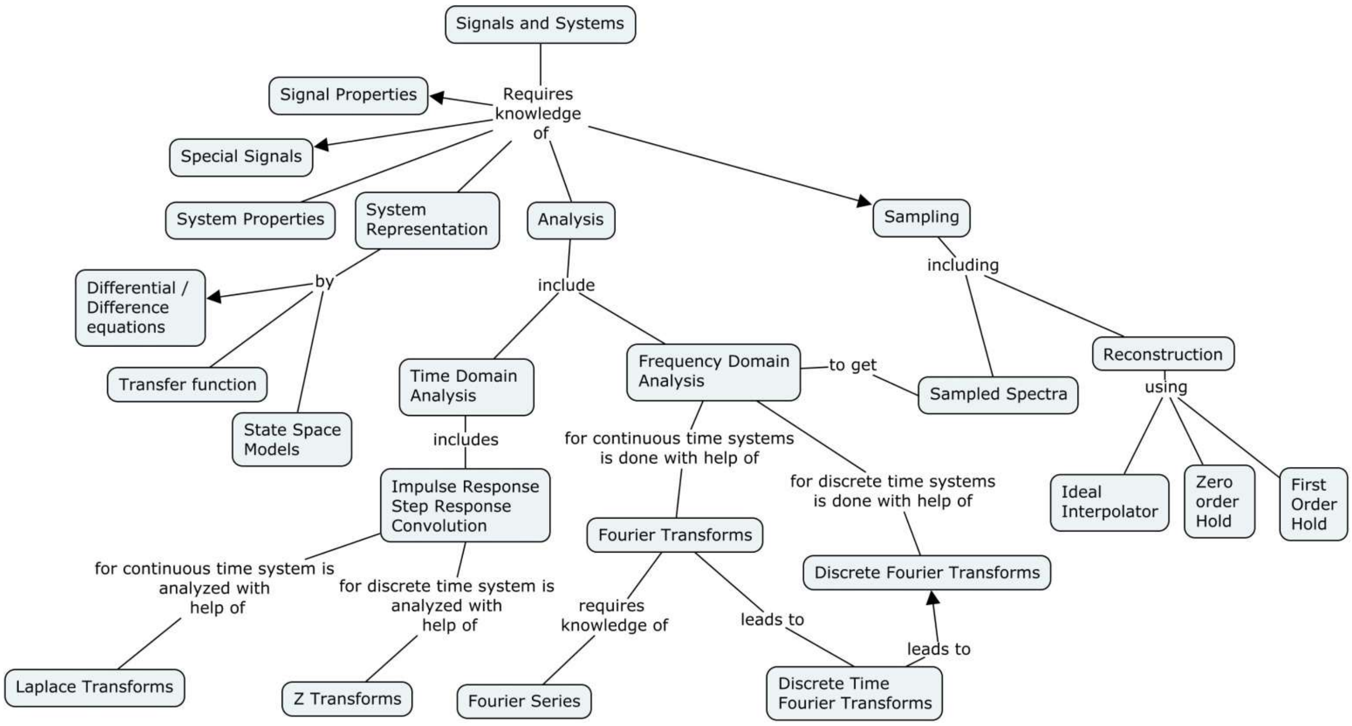
**Course Outcome 5 (CO5):**

1. State time and frequency shifting properties of DFT.
2. Find 4- point DFT of the given sequence $x(n)=(1/4)^n$. Plot its magnitude and phase.
3. Consider two real sequences $x_1(n) = \{3,4,0,2,\}$ $and$ $x_2(n) = \{3,2,1,2\}$ . Find $x_3(n)$ such that $X_3(k) = X_1(k) X_2(k)$ and also obtain the valve of $x_3(n)$

**Course Outcome 6(CO6):**

1. Define Shannon's sampling theorem.
2. Find the discrete sequence for given continuous signal $x(t)=\cos 200\pi t+ 10\sin 2000\pi t$.Assume fs=Nyquist rate.
3. Find the quantization error (using truncation) for the given signal. $X(n)=1.2^n$; $0\le n\le 4$.

## Concept Map




## Syllabus

**Introduction to Signals and Systems:**

Classification of Signals and systems- Signal properties: periodicity, absolute integrability, determinism and stochastic character. Test signals: 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. Examples.

**Time domain behaviour 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. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.

**Fourier, Laplace and z- Transforms**

Laplace Transform for continuous time signals and systems, 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. 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 DiscreteTime Fourier Transform (DTFT), the Discrete Fourier Transform (DFT) its properties. Parseval's Theorem, Fast Fourier Transform (FFT) - radix 2

**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. Applications of signal and system- introduction to waveletTransform

**Learning Resources**

1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, “Signals and Systems”, Pearson India Education Services Pvt. Ltd, 2016.
2. H. P. Hsu, “Signals and systems”, Schaum’s series, McGraw Hill Education, 2010.
3. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms, and Applications”, Pearson, 2006.
4. S. Haykin and B. V. Veen, “Signals and Systems”, John Wiley and Sons, 2007.
5. https://nptel.ac.in/courses/117101055/
6. https://www.edx.org/course/signals-and-systems

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1. | **Introduction to Signals and Systems** | | |
| 1.1 | Classification of Signals and systems | 2 | CO1 |
| 1.2 | Signal properties: periodicity, absolute integrability, determinism and stochastic character | 2 | CO1 |
| 1.3 | Test signals: The unit step, the unit impulse, the sinusoid, the complex exponential signals | 1 | CO1 |
| 1.4 | Time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals | 1 | CO1 |
| 1.5 | System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, | 2 | CO1 |

| | | | |
|---|---|---|---|
| | realizability. Examples. | | |
| 2 | **Time domain behaviour of continuous and discrete time LTI systems** | | |
| 2.1 | Impulse response and step response | 1 | CO2 &CO3 |
| 2.2 | Convolution | 1 | CO2 &CO3 |
| 2.3 | Input-output behaviour with aperiodic convergent inputs, cascade interconnections. | 1 | CO2 &CO3 |
| 2.4 | Characterization of causality and stability of LTI systems. | 1 | CO2 &CO3 |
| 2.5 | System representation through differential equations and difference equations | 2 | CO2 &CO3 |
| 2.6 | State-space Representation of systems. | 2 | CO2 &CO3 |
| 2.7 | Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response. | 1 | CO4 |
| 3 | **Fourier, Laplace and z- Transforms** | | |
| 3.1 | The Laplace Transform for continuous time signals and systems, | 1 | CO2 |
| 3.2 | System functions, poles and zeros of system functions and signals, | 2 | CO2 |
| 3.3 | Laplace domain analysis, solution to differential equations and system behaviour | 2 | CO2 |
| 3.4 | The z-Transform for discrete time signals and systems | 2 | CO3 |
| 3.5 | System functions, poles and zeros of systems and sequences, z-domain analysis | 2 | CO3 |
| 3.6 | Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients | 2 | CO4 |
| 3.7 | Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response | 1 | CO4 |
| 3.8 | The Discrete Time Fourier Transform (DTFT) and its properties | 2 | CO5 |
| 3.9 | The Discrete Fourier Transform (DFT) and its properties , Fast Fourier Transform - radix 2 | 2 | CO5 |
| 3.10 | Parseval's Theorem | 1 | CO5 |
| 4 | **Sampling and Reconstruction** | | |
| 4.1 | The Sampling Theorem and its implications | 1 | CO6 |
| 4.2 | Spectra of sampled signals | 1 | CO6 |
| 4.3 | Reconstruction: ideal interpolator, zero-order hold, first-order hold | 1 | CO6 |
| 4.4 | Aliasing and its effects. | 1 | CO6 |
| 4.5 | Relation between continuous and discrete time systems | 1 | CO6 |
| 4.6 | The applications of signal and system | 1 | CO6 |
| | Total | 40 | |

**Course Designers:**


| | |
|---|---|
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| Prof M.Varatharajan | varatharajan@tce.edu |

| 18EE360 | C AND C++ PROGRAMMING |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| ES | 2 | 0 | 2 | 3 |

## Preamble

C is a general-purpose programming language which features economy of expression, modern control flow and data structures, and a rich set of operators. C++ language has powerful object-oriented and template features that can improve software design and simultaneously reducing code complexity and the risk of error.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the basic concepts, data types, operators and statements in C programming | 20 |
| CO2 | Analyse the developed C program for solving the given problem using control statements/ functions/structures/files /pointers | 30 |
| CO3 | Explain the basic concepts, operators and statements in C++ programming | 5 |
| CO4 | Explain the class and objects in C++ programming | 5 |
| CO5 | Apply the concept ofclass and objects for solving the given problem in C++ programming | 10 |
| CO6 | Analyze the given C and C++ program | 30 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.1 |
| CO2 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.1, 2.1.5, 2.4.4, 3.1.2, 3.2.3, 3.2.5 |
| CO3 | TPS2 | Understand | Respond | | 1.1 |
| CO4 | TPS2 | Understand | Respond | | 1.1 |
| CO5 | TPS4 | Apply | Value | Mechanism | 1.1, 2.1.4, 3.1.2 |

| | | | | | |
|---|---|---|---|---|---|
| CO6 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.1, 2.1.5, 2.4.4, 3.1.2, 3.2.3, 3.2.5 |

## Mapping with Programme Outcomesand Programme Specific Outcomes

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | M | L | | | | | | M | | M | | | M | M |
| CO 2 | S | S | M | M | M | | | M | S | S | | | S | S |
| CO 3 | M | L | | | | | | M | | M | | | M | M |
| CO 4 | M | L | | | | | | M | | M | | | M | M |
| CO 5 | S | M | L | L | | | | M | S | S | | | S | S |
| CO 6 | S | S | M | M | M | | | M | S | S | | | S | S |

S- Strong; M-Medium; L-Low

## AssessmentPattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Practical Test | Terminal Examination$ |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | | |
| Remember | 10 | 10 | 10 | - | 10 |
| Understand | 30* | 30* | 30* | - | 30* |
| Apply | 40 | 40 | 40 | 30 | 40 |
| Analyse | 20 | 20 | 20 | 40 | 20 |
| Evaluate | | | | | |
| Create | | | | | |

*In Bloom's understand category, 20 Marks is allotted for multiple choice questions

$ - Theory Examination.

## AssessmentPattern: Psychomotor

| Psychomotor Skill | ~~Miniproject /Assignment/~~Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 20 |
| Complex Overt Responses | 10 |
| Adaptation | |

| | |
|---|---|
| Origination | |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. Explain different types of operators in C with suitable example.
2. Explain different types of ‘if’ statements with suitable programs.
3. Explain different modes of operation on files?

**Course Outcome 2 (CO2):**

1. Write a C program to determine all possible roots of a quadratic equation with suitable algorithm and draw a necessary flowchart.
2. Write a C program to find the largest number among the given three numbers and draw a necessary flowchart.
3. Write a C program to sort given numbers in ascending orderusing file operation.

**Course Outcome 3 (CO3):**

1. Write the syntax for *cin* and *cout* commands.
2. Write the role of switch statement.
3. Differentiate nested if loop and switch statements.

**Course Outcome 4 (CO4):**

1. Write the syntax of class in C++.
2. List the operators which cannot be overloaded in C++.
3. What is meant by inheritance and explain different types of inheritance with simple diagram

**Course Outcome 5 (CO5):**

1. Write a C++ program to add two complex numbers using operator overloading concept
2. Write a C++ program to explain the concept of class and objects.
3. Explain the use of object as function argument with a C++ program.

**Course Outcome 6 (CO6):**

1. What is the output of the below code snippet?

```
#include<stdio.h>

main()

{
```

```
for(1;2;3)

printf("Hello");

}
```

A - Infinite loop B - Prints "Hello" once. C - No output D - Compile error

2. What is the output of the following program?

```
#include<stdio.h>

void f(int a[])

{

int i;

for(i=0; i<3; i++)

a[i]++;

}

main()

{

inti,a[] = {10, 20, 30};

f(a);

for(i=0; i<3; ++i)

  {

printf("%d ",a[i]);

  }

}
```

A - 10 20 30 B - 11 21 31 C - Compile error D - Runtime error

3. Which of the following statement shows the correct implementation of nested conditional operation by finding greatest number out of three numbers?

A - max = a>b ? a>c?a:c:b>c?b:c B - a=b ? c=30;

C - a>b : c=30 : c=40; D - return (a>b)?(a:b) ?a:c:b

4. Which among following is not a valid visibility mode in c++ program?

A – Private B - Public C – Protected D – Limited

5. How we can define member function outside the class ?

A - Using union B - Using structure C - Using pointers D - Using scope resolution

6. The major goal of inheritance in C++ is ?

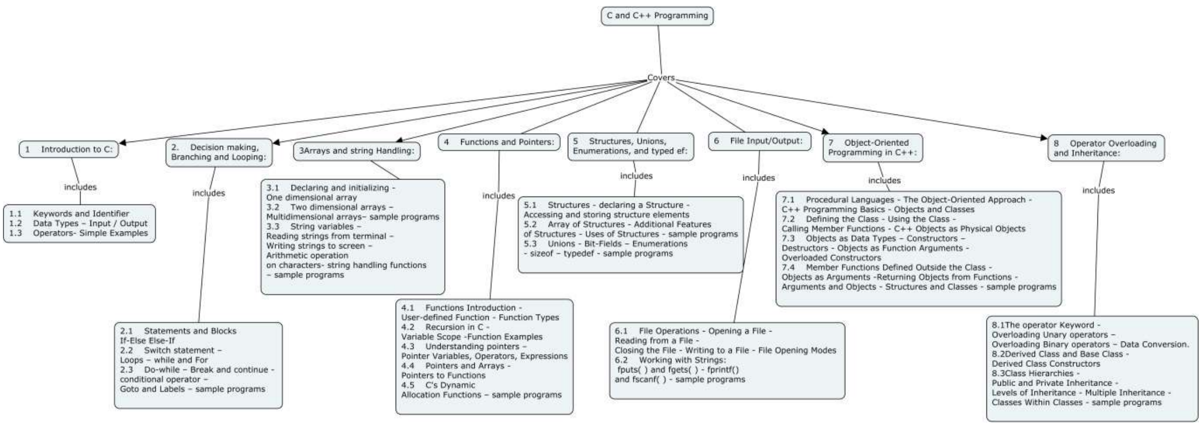
A -To facilitate the reusability of code    B - To help modular programming

C -To facilitate the conversion of data types    D - To extend the capabilities of a class

**List of sample programs:**

1. Draw the flowchart, write algorithm and C program to solve the given quadratic equations.
2. Draw the flowchart, write algorithm and C program to solve the given mesh/nodal equations.
3. Write a C program to find the product of two matrices. Create a function mul() to do the calculation.
4. Write a C program to obtain equivalent circuit parameters of a given transformer.
5. Write a C program to predetermine the efficiency of DC machine.
6. Write the algorithm and C program to find the transient response of RLC series circuit.
7. Draw the flowchart, write algorithm and C++ program to solve the given equations $f(x) = x^3 - 6x^2 - 72x - 27 = 0$
8. Write a C++ program to add two complex numbers using operator overloading concept
9. Draw the flowchart, write algorithm and C++ program to simulate a clock model

## Concept Map




## Syllabus

**Introduction to C:**

Keywords and Identifier- Variables - Constants - Data Types – Input / Output – Operators- Simple Examples

**Decision making, Branching and Looping:**

Statements and Blocks If-Else Else-If - Switch statement – Loops – while and For – Do-while – Break and continue - conditional operator – Goto and Labels – sample programs

**Arrays and string Handling:**

Declaring and initializing - One dimensional array – Two dimensional arrays – Multidimensional arrays– sample programs. String variables – Reading strings from terminal – Writing strings to screen –Arithmetic operation on characters- string handling functions – sample programs

**Functions:**

Functions introduction - User-defined function - Function types -Recursion in C - Variable scope -Function examples

**Pointers:**

Understanding pointers – Pointer variables, Operators, Expressions - Pointers and Arrays - Pointers to Functions - C's Dynamic allocation functions – sample programs

**Structures, Unions, Enumerations, and typedef:**

Structures - declaring a structure - Accessing and storing structure elements – Array of Structures - Additional features of structures - Uses of structures - sample programs. Unions - Bit-Fields – Enumerations - sizeof – typedef - sample programs

**File Input/Output:**

File Operations - Opening a File - Reading from a File - Closing the File - Writing to a File - File opening modes - Working with Strings: fputs( ) and fgets( ) - fprintf() and fscanf( ) - sample programs

**Object-Oriented Programming in C++:**

Procedural Languages - The Object-Oriented approach - C++ programming basics - Objects and Classes – Defining the Class - Using the Class - Calling member functions - C++ Objects as physical Objects - Objects as data Types – Constructors – Destructors - Objects as function arguments - Overloaded constructors - Member functions defined outside the Class - Objects as arguments -Returning objects from functions - Arguments and Objects - Structures and Classes - sample programs

**Learning Resources**


1. Herbert Schildt, “C: the Complete Reference”, Osborne McGraw-Hill, 1995
2. Yashavant P. Kanetkar, “Let us C”, 14th Edition, BPB Publications
3. Robert Lafore, “Object-Oriented Programming in C++”, Pearson Education, 2002.
4. E.Balagurusamy, Programming in ANSI C, 3rd Edition, Tata McGraw Hill, Publication Company, 2006
5. Brain W.Kernigan and Dennis M.Ritchie, “The C Programming Language - ANSI C”, Prentice Hall of India, 1990.
6. E.Balagurusamy, Object Oriented Programming with C++, 5th Edition, Tata McGraw Hill Publication Company, 2011
7. www.programiz.com/c-programming
8. https://www.tutorialspoint.com/cprogramming
9. http://www.cprogramming.com/tutorial/c-tutorial.html
10. https://www.coursera.org/course/cprogramming
11. http://nptel.ac.in/courses/106104128/


**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 1 | **Introduction to C:** | | |

| | | | |
|---|---|---|---|
| 1.1 | Keywords and Identifier- Variables - Constants | 1 | CO1 |
| 1.2 | Data Types – Input / Output | 1 | CO1 |
| 1.3 | Operators- Simple Examples | 1 | CO1 |
| 2. | **Decision making, Branching and Looping:** | | |
| 2.1 | Statements and Blocks If-Else Else-If | 2 | CO2 |
| 2.2 | Switch statement – Loops – while and For | 2 | CO2 |
| 2.3 | Do-while – Break and continue - conditional operator – Goto and Labels – sample programs | 2 | CO6 |
| **3** | **Arrays and string Handling:** | | |
| 3.1 | Declaring and initializing - One dimensional array | 2 | CO2 |
| 3.2 | Two dimensional arrays – Multidimensional arrays– sample programs | 2 | CO2 |
| 3.3 | String variables – Reading strings from terminal – Writing strings to screen –Arithmetic operation on characters- string handling functions – sample programs | 2 | CO6 |
| **4** | **Functions and Pointers:** | | |
| 4.1 | Functions Introduction - User-defined Function - Function Types | 2 | CO2 |
| 4.2 | Recursion in C - Variable Scope -Function Examples | 1 | CO2 |
| 4.3 | Understanding pointers – Pointer Variables, Operators, Expressions | 2 | CO2 |
| 4.4 | Pointers and Arrays - Pointers to Functions | 1 | CO2 |
| 4.5 | C's Dynamic Allocation Functions – sample programs | 1 | CO6 |
| **5** | **Structures, Unions, Enumerations, and typedef:** | | |
| 5.1 | Structures - declaring a Structure - Accessing and storing structure elements | 1 | CO2 |
| 5.2 | Array of Structures - Additional Features of Structures - Uses of Structures - sample programs | 2 | CO2 |
| 5.3 | Unions - Bit-Fields – Enumerations - sizeof – typedef - sample programs | 1 | CO6 |
| **6** | **File Input/output:** | | |
| 6.1 | File Operations - Opening a File - Reading from a File - Closing the File - Writing to a File - File Opening Modes | 2 | CO2 |
| 6.2 | Working with Strings: fputs( ) and fgets( ) - fprintf() and fscanf( ) - sample programs | 1 | CO2 |
| **7** | **Object-Oriented Programming in C++:** | | |
| 7.1 | Procedural Languages - The Object-Oriented Approach - C++ Programming Basics - Objects and Classes | 1 | CO3 |
| 7.2 | Defining the Class - Using the Class - Calling Member Functions - C++ Objects as Physical Objects | 1 | CO4 |
| 7.3 | Objects as Data Types – Constructors – Destructors - Objects as Function Arguments - Overloaded Constructors | 1 | CO3 |
| 7.4 | Member Functions Defined Outside the Class - Objects as Arguments -Returning Objects from Functions - Arguments and Objects - Structures and Classes - sample programs | 1 | CO5 |
| **8** | **Operator Overloading and Inheritance:** | | |

| | | | |
|---|---|---|---|
| 8.1 | The operator Keyword - Overloading Unary operators – Overloading Binary operators – Data Conversion. | 1 | CO3 |
| 8.2 | Derived Class and Base Class - Derived Class Constructors | 1 | CO4 |
| 8.3 | Class Hierarchies - Public and Private Inheritance - Levels of Inheritance - Multiple Inheritance - Classes Within Classes - sample programs | 1 | CO6 |
| | **Total** | **36** | |

**Course Designers:**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3. Dr. S. Charles Raja charlesrajas@tce.edu

| | | | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|---|
| **18EE370** | **DC MACHINES AND TRANSFORMERS LAB** | | PC | - | - | 2 | 1 |

## Preamble

This laboratory gives a practical exposure to the students to learn the characteristics of Transformers and DC Machines that are used nowadays in Electrical Systems. The students also learn to select the suitable DC Electrical Machines for an application based on its characteristics. To familiarize the standard testing procedures of DC Machines and Transformers.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course, students will be able to

| COs No. | Course outcomes | Weightage % |
|---|---|---|
| CO1. | Obtain the characteristics of DC Generator (Shunt, Series & Compound ) independently | 20 |
| CO2. | Obtain the characteristics of DC Motor (Shunt & Series) independently | 20 |
| CO3. | Obtain the Voltage Regulation and Efficiency characteristics of Transformer independently | 20 |
| CO4. | Testing of Transformer for Efficiency Calculation & Modeling | 20 |
| CO5. | Testing of DC Machine to monitor efficiency and enhance it | 10 |
| CO6. | Obtain Thermal & Vibration characteristics of DC Machines and Transformers | 10 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | Mechanism | 1.2.4, 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.5.1, 3.1.1, 3.1.2. 3.2.3 |
| CO2 | TPS3 | Apply | Value | Mechanism | 1.2.4, 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.4.3, 2.5.1, 3.1.2, 3.1.1, 3.2.3 |
| CO3 | TPS3 | Apply | Value | Mechanism | 1.2.4, 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.4.3,2.5.1, 3.1.2, 3.1.1, 3.2.3 |
| CO4 | TPS3 | Apply | Value | Mechanism | 1.2.4, 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.4.3,2.5.1, 3.1.2, 3.1.1, 3.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO5 | TPS3 | Apply | Value | Mechanism | 1.2.4, 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.5.1, 3.1.2 3.1.1, 3.2.3 |
| CO6 | TPS2 | Understand | Respond | Guided Response | 1.2.4, 2.2.3, 2.2.4,2.3.1, 2.5.1, 3.1.2, 3.1.1, 3.2.3 |

**Mapping with Programme Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | | | | M | S | L | | | S | |
| CO2 | S | M | L | L | | | | M | S | L | | | S | |
| CO3 | S | M | L | L | | | | M | S | L | | | S | |
| CO4 | S | M | L | L | | | | M | S | L | | | S | |
| CO5 | S | M | L | L | | | | M | S | L | | | S | |
| CO6 | M | L | | | S | | | M | S | L | | | M | |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Model Examination | Terminal Examination |
|---|---|---|
| Remember | | |
| Understand | 10 | 10 |
| Apply | 40 | 40 |
| Analyse | 20 | 20 |
| Evaluate | | |
| Create | | |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Miniproject /Practical Component/Observation |
|---|---|
| Perception | |
| Set | |
| Guided Response | 10 |
| Mechanism | 20 |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**List of Experiments/Activities with CO Mapping**

| E.No | Name of the experiment | CO | No. of sessions |
|---|---|---|---|
| **DC Machine** | | | |
| 1. | Load characteristics of DC Generators | CO1 | 1 |
| 2. | Methods of Excitation and Voltage Control of DC Generators | CO1 | 1 |
| 3. | Measuring the resistance of Armature and Field Windings | CO1 | 1 |
| 4. | Methods of Starting and Speed Control of DC Motors | CO2 | 1 |
| 5. | Load Characteristics of DC Motors | CO2 | 1 |
| 6. | Swinburne's & Hopkinson's tests | CO5 | 1 |
| 7. | Thermal and Vibration Analysis of DC Machines | CO6 | 1 |
| **Transformers** | | | |
| 8. | Performance estimation using various load | CO3 | 1 |
| 9. | Performance calculation using equivalent circuit | CO4 | 1 |
| 10 | Measurement of Winding Resistance and Inductance | CO4 | 1 |
| 11 | Sumpner's test | CO4 | 1 |
| 12 | Thermal and Vibration Analysis of Transformer | CO6 | 1 |

**Learning Resources**

1. D.P.Kothari & I.J.Nagrath, " Electrical Machines", Tata-McGrawhill, Newdelhi, 5th Edition, 2010.
2. R.K.Rajput, " Electrical Technology", Laxmi Publications, 3rd edition, 2005.
3. Vincent Deldoro ," Electromechanical Energy Conversion " PHI III edition,
4. M.G.Say, Theory and performance of electrical machines, Tata-Mcgraw hill

**Course Designers**

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3. Dr. V. Mahesh vmeee@tce.edu

| | | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| **18EE380** | **INTEGRATED CIRCUITS LABORATORY** | PC | - | - | 2 | 1 |

## Preamble

This laboratory gives a practical exposure to the students to learn the characteristics of analog and digital ICs that are used in most of the electronic circuits. Student can also conceive ideas on different electronics circuits have analog and digital ICs and can be able to design and implement it for particular applications.

## Prerequisite

**18EE250** - Electronics Circuits and devices

**18EE270** - Electronics Circuits and devices Lab

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Obtain the characteristics of the given Op-amp by conducting suitable experiments. | 10 |
| CO2 | Analyze the performance of the designed circuits like amplifier, filters using operational amplifier for the given applications. | 30 |
| CO3 | Analyze the performance of the Multivibrator designed using 555 timers for the given specifications. | 5 |
| CO4 | Analyze the performance of the voltage regulators designed using linear Regulator ICs. | 5 |
| CO5 | Analyze the performance of the designed Combinational circuits for the given requirements using suitable digital ICs. | 20 |
| CO6 | Analyze the performance of the designed sequential circuits for the given requirements using suitable digital ICs. | 20 |
| CO7 | Evaluate the performance of the designed IC based system for the conceived problem | 20 |

*** Weightage depends on Bloom's Level, number of contact hours

## CO Mapping with CDIO Curriculum Framework

| CO | TCE | Learning Domain Level | CDIO Curricular Components |
|---|---|---|---|

| # | Proficiency Scale | Cognitive | Affective | Psychomotor | (X.Y.Z) |
|---|---|---|---|---|---|
| CO1 | TPS3 | Apply | Value | Mechanism | 1.2.5, 1.2.6, 2.1.2, 2.1.5, 2.2.3, 2.4.2, 3.1.1, 3.2.3 |
| CO2 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.2.5, 1.2.6, 2.1.2, 2.1.5, 2.2.3, 2.4.2, 3.1.1, 3.2.3 |
| CO3 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.2.5, 1.2.6, 2.1.2, 2.1.5, 2.2.3, 2.4.2, 3.1.1, 3.2.3 |
| CO4 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.2.5, 1.2.6, 2.1.2, 2.1.5, 2.2.3, 2.4.2, 3.1.1, 3.2.3 |
| CO5 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.2.5, 1.2.6, 2.1.2, 2.1.5, 2.2.3, 2.4.2, 3.1.1, 3.2.3 |
| CO6 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.2.5, 1.2.6, 2.1.2, 2.1.5, 2.2.3, 2.4.2, 3.1.1, 3.2.3 |
| CO7 | TPS5 | Evaluate | Organise | Adaptation | 1.2.5, 1.2.6, 2.1.2, 2.1.5, 2.2.3, 2.3.1, 2.3.2, 2.4.2, 2.4.4, 2.4.7, 3.1.1, 3.2.3, 4.3.1, 4.4.1, 4.5.1, 4.6.1 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | S | M | | M | M | M | | | | S |
| CO2 | S | S | M | M | S | M | | M | M | M | | | | S |
| CO3 | S | S | M | M | S | M | | M | M | M | | | | S |
| CO4 | S | S | M | M | S | M | | M | M | M | | | | S |
| CO5 | S | S | M | M | S | M | | M | M | M | | | | S |
| CO6 | S | S | M | M | S | M | | M | M | M | | | | S |
| CO7 | S | S | S | S | S | M | | M | M | M | | | | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| **Cognitive Levels** | **Model Examination** | **Terminal Examination** |
|---|---|---|
| Remember | | |
| Understand | | |
| Apply | 40 | 40 |
| Analyze | 30 | 30 |
| Evaluate | | |
| Create | | |

## Assessment Pattern: Psychomotor

| **Psychomotor Skill** | **~~Miniproject~~ /Practical Component/~~Observation~~** |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 20 |
| Complex Overt Responses | 10 |
| Adaptation | |
| Origination | |

## List of Experiments/Activities with CO Mapping

| **E.No** | **Name of the experiment** | **CO** | **No. of sessions** |
|---|---|---|---|
| 1. | Characteristics of given Operational Amplifier | CO1 | 1 |
| 2. | Design of Comparator, Amplifier, Integrator, differentiator and Precision rectifiers using OP-AMP (Hardware /Simulation) | CO2 | 1 |
| 3. | Design of Instrumentation Amplifier, Second order active filters using OP AMP/ FPAA (Hardware /Simulation) | CO2 | 1 |
| 4. | Design of V to I , I to V converter, and Oscillator circuits using OP AMP/FPAA (Hardware /Simulation) | CO2 | 1 |
| 5. | Design of Multivibrator circuits using 555 Timer ICs (Hardware /Simulation) | CO3 | 1 |
| 6. | Design of Voltage Regulator | CO4 | 1 |
| 7. | Realization of Boolean expression using universal gates. | CO5 | 1 |
| 8. | Realization of Full adder, Subtractor, Multiplexer, Demultiplexer, Decoder using suitable Digital ICs.(Hardware/ verilog simulation) | CO5 | 1 |
| 9. | Realization of shift Registers and counters using suitable | CO6 | 1 |

| | | | |
|---|---|---|---|
| | Digital ICs. (Hardware/ verilog simulation) | | |
| 10 | Development of IC based electronic system for a real-world applications (selected by group of students) | CO7 | 2 |

**Learning Resources**

1. Roy Choudhury and shall B.Jain, Linear Integrated circuits, Wiley Eastern Ltd, 4th edition, 2010
2. Jacob Millman & Christos C.Halkias- Integrated electronics, McGraw Hill Education; 2 edition ,2017
3. M.Morris Mano and Michael D.Ciletti, Digital Design, Fourth Edition, Pearson Prentice Hall, 2008

**Course Designers:**

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3. Dr.B.Ashok Kumar -ashokudt@tce.edu

| 18ES390 | DESIGN THINKING |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| ES | 1 | - | 2 | 2 |

## Preamble

Design has been defined as a "systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints". Human-centered design is defined as a process and a set of techniques used to create new solutions for the world. Solutions include products, services, environments, organizations, and modes of interaction. The reason this process is called "human-centered" is because it starts with the people we are designing for. This course facilitates the development of students' professional skills through their team engagement in developing conceptual design for a local community problem.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage in % |
|---|---|---|
| CO1 | Identify a specific social need to be addressed | 20 |
| CO2 | Identify stakeholder's requirements for the societal project | 20 |
| CO3 | Develop measurable criteria in which design concepts can be evaluated | 10 |
| CO4 | Develop prototypes of multiple concepts using user's feedback | 30 |
| CO5 | Select the best design solution among the potential solutions with its functional decomposition | 20 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | Mechanism | 1.1, 1.2, 2.1.1, 3.1.2, 3.2.3, 3.2.6, 4.1.2 |
| CO2 | TPS3 | Apply | Value | Mechanism | 1.1, 1.2, 2.1.2, 2.5.1, 2.5.2, 3.1.2, 3.2.3, 3.2.6, 4.1.2 |
| CO3 | TPS3 | Apply | Value | Mechanism | 1.1, 1.2, 2.1.3, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.3.1 |
| CO4 | TPS3 | Apply | Value | Mechanism | 1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1 |
| CO5 | TPS5 | Evaluate | Organise | Adaptation | 1.1, 1.2, 2.1.5, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | - | - | M | M | M | L | M | M | S |
| CO2 | S | M | L | - | - | M | M | M | L | M | M | S |
| CO3 | S | M | L | - | - | M | M | M | L | M | M | S |
| CO4 | S | M | L | - | M | M | M | M | L | M | M | S |
| CO5 | S | S | M | L | M | M | M | M | L | M | M | S |

S- Strong; M-Medium; L-Low

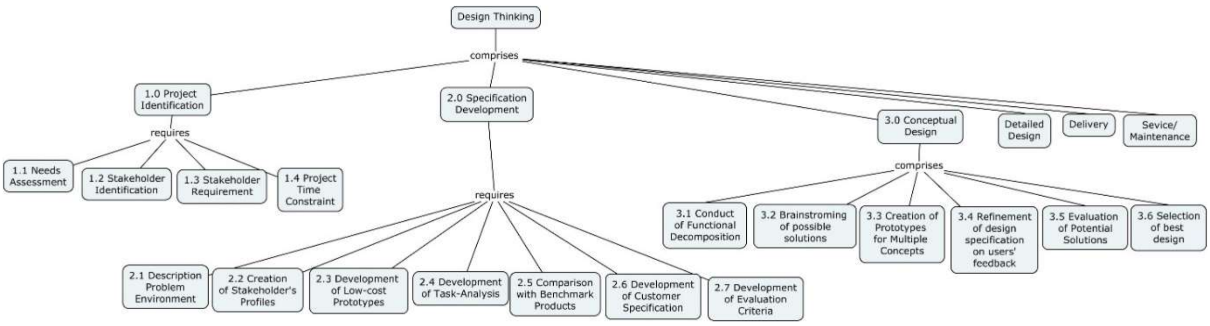
**Assessment Pattern: Cognitive Domain**

| **Phases** | **Deliverables** | **Marks** | **Course Outcomes** |
|---|---|---|---|
| **Continuous Assessment** | | | |
| | | | |
| Review 1 – Problem Identification | Technical Report | 10 | CO1 and CO2 |
| Review 2 – Specification Development | Technical Report | 20 | CO3 |

| | | | |
|---|---|---|---|
| Review 3 -Conceptual Design | Technical Report | 20 | CO4 and CO5 |
| | | | |
| **End-Semester Examination** | | | |
| Demonstration | Prototype | 60 | CO1, CO2, CO3, CO4 and CO5 |
| Poster Presentation | Poster | 40 | |

- Reports are to be submitted at each review. The report and presentation will be evaluated based on Rubrics
- Demonstration and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

## Concept Map




## Syllabus

**1.0 Project Identification:** Needs Assessment, Stakeholder Identification, Stakeholder Requirement Project Time Constraint.

**2.0 Specification Development:** Description Problem Environment, Creation of Stakeholder's Profiles Development of Low-cost Prototypes, Development of Task-Analysis, Comparison with Benchmark Products, Development of Customer Specification, Development of Evaluation Criteria,

**3.0 Conceptual Design:** Conduct of Functional Decomposition, Brainstorming of possible solutions, Creation of Prototypes for Multiple Concepts, Refinement of Design Specification on users' feedback, Evaluation of Potential Solutions, Selection of best design

## Learning Resources

1. Learning Material prepared by TCE faculty members
2. https://www.ideo.com/
3. https://engineering.purdue.edu/EPICS

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | | Course Outcome |
|---|---|---|---|---|
| | | In-Class | Hands-on | |
| 1. | **Project Identification**: Introduction to Human-Centered Design | 1 | - | CO1 |
| 1.1 | Needs Assessment | 1 | 2 | CO1 |
| 1.2 | Identification of Stakeholders | 1 | 2 | CO2 |
| 1.3 | Identification of Stakeholder Requirements | | 2 | CO2 |
| 1.4 | Project Time Constraint | 1 | 2 | CO2 |
| 2. | **Specification Development** | | | |
| 2.1 | Description Problem Environment | 1 | 2 | CO3 |
| 2.2 | Creation of Stakeholder's Profiles | | 2 | CO3 |
| 2.3 | Development of Low-cost Prototypes | 1 | 2 | CO3 |
| 2.4 | Development of Task-Analysis | 1 | 2 | CO3 |
| 2.5 | Comparison with Benchmark Products | 1 | 2 | CO3 |
| 2.6 | Development of Customer Specification | | 2 | CO3 |
| 2.7 | Development of Evaluation Criteria | 1 | 2 | CO3 |
| 3. | **Conceptual Design** | | | |
| 3.1 | Conduct of Functional Decomposition | 1 | 2 | CO4 |
| 3.2 | Brainstroming of possible solutions | 1 | 2 | CO5 |
| 3.3 | Creation of Prototypes for Multiple Concepts | 1 | 2 | CO5 |
| 3.4 | Refinement of design Specification on users' feedback | | 2 | CO6 |
| 3.5 | Evaluation of Potential Solutions | 1 | 2 | CO6 |
| 3.6 | Selection of best design | | 2 | CO6 |
| | Total | 12 | 34 | |

**Course Designers:**

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| 18EE410 | PROBABILITY AND RANDOM PROCESSES |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| BS | 3 | 0 | 0 | 3 |

## Preamble

An electrical engineering student needs to have some basic statistical tools and techniques to apply in diverse applications in digital signal processing (voice, image, video, etc.), communications systems and networks, radar systems, power systems. that requires an understanding of Probability distributions, and Testing of Hypotheses and random process. Also the Mathematical tool Curve Fitting is very much essential to find the statistical averages that occur in the above areas. The course is designed to impart the knowledge and understanding of the above concepts to Electrical Engineers and apply them in their areas of specialization.

## Prerequisite

Course Code : 18 MA110 Course Name: Engineering Calculus

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage in % |
|---|---|---|
| CO1 | Calculate expectation, variance and Standard deviation, Moments for discrete and continuous (univariate) random variables | 15% |
| CO2 | Use standard distributions to find the expected life time of electrical components | 20% |
| CO3 | Apply the concept of testing the hypotheses for large samples by using various tests for difference of proportions, means and variances, Apply the concept of testing the hypotheses for small samples by using various tests like t-test F test and Chi Square test. | 25% |
| CO4 | Explain about pseudo random number generation for a given probability distribution. | 10% |
| CO5 | Use Least square method to fit a Straight line, Parabola and exponential curves. | 10% |
| CO6 | Estimate the auto correlation function, power spectral density of random processes. | 20% |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.5,4.3.3,4.4.1 |
| CO2 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.5,4.3.3,4.4.1 |
| CO3 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.5,4.3.3,4.4.1 |
| CO4 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.5,2.2.1,2.2.4,4.3.3,4.4.1 |
| CO5 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.5,2.2.1,2.2.4,4.3.3,4.4.1 |
| CO6 | TPS3 | Apply | Value | | 1.1.1,2.1.1,2.1.2,2.1.4,2.1.5,4.3.3,4.4.1 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO2 | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO3 | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO4 | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO5 | S | M | L | L | - | - | - | M | M | M | - | M | S | S |
| CO6 | S | M | L | L | - | - | - | M | M | M | - | M | S | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | | | | - |
| Understand | 20 | 20 | 20 | | | | 30 |
| Apply | 70 | 70 | 70 | 100 | 100 | 100 | 70 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

## Sample Questions for Course Outcome Assessment

**Course Outcome (CO 1):**

1. An automobile service facility specializing in engine tune-ups knows that 45% of all tune-ups are done on four cylinder automobiles, 40% on six-cylinder automobiles, and 15% on eight-cylinder automobiles. Let X be the number of cylinders on the next car to be tuned. a)What is the pmf of *X*? b)What is the probability that the next car tuned has at least six cylinders? More than six cylinders?

2. The actual tracking weight of a stereo cartridge that is set to track at 3 g on a particular changer can be regarded as a continuous rv *X* with pdf. Compute k and the expected value of X.
3. In a test on 2000 electric bulbs, it was found that bulbs of a particular make, was normally distributed with an average life of 2040 hours and S.D of 60 hours. Estimate the number of bulbs likely to bourn for more than 2150 hours, less than 1950 hours, more 1920 hours but less than 2100 hours.

**Course Outcome (CO 2):**

1. The life (in hours) of a magnetic resonance imaging machine (MRI) is modeled by a Weibull distribution with parameters $\alpha = 4.5$ and $\beta = 500$ hours. Determine the following: (a) Mean life of the MRI (b) Variance of the life of the MRI(c) Probability that the MRI fails before 250 hours.
2. A sample of eleven electric bulbs is drawn every day from those manufactured at a plant. The eleven bulbs are tested before shipment to the customer. An analysis of the test data collected over a number of years reveals that the probability of finding no defective bulb in a sample of eleven bulbs is 0.6. Probabilities of defective bulbs are random and independent of previous results. a) What is the probability of finding exactly three defective bulbs in a sample? b) What is the probability of finding three or more defective bulbs in a sample?
3. Of the Type A electrical resistors produced by a factory, 85.0% have resistance greater than 41 ohms, and 3.7% of them have resistance greater than 45 ohms. The resistances follow a normal distribution. What percentage of these resistors have resistance greater than 44 ohms?

**Course Outcome (CO 3):**

1. A manufacture of light bulbs claims that on the average 2% of the bulbs manufactured by him are defective. A random sample of 400 bulbs contained 13 defectives.on the basis of this sample can you support the manufacturer's claim at 5% LOS.
2. A study shows that 16 out of 200 submersible pumps produced on one assembly line required extensive adjustments before they could be shipped, while the same was true for 14 of 400 pumps produced on another assembly line. At 0.01 LOS,does this support the claim that the second production line does superior work?
3. The output of a power supply is assumed to be normally distributed. Sixteen observations taken on voltages are as follows: 10.35, 9.3, 10.0, 9.96, 11.65, 12.00, 11.25, 9.58, 11.54, 9.95, 10.28, 8.37, 10.44, 9.25, 9.38, and 10.85. Test the hypothesis that mean voltage is equal to 12 V against a two sided alternative using 5% l.o.s.
4. A manufacturer of fluorescent lamps claims that his lamps have an average luminous flux of 3,600 lm at rated voltage and frequency and that 90% of all lamps produced by an automatic process have a luminous flux higher than 3,300 lm. The luminous flux of the lamps follows a normal distribution. What standard deviation is implied by the manufacturer's claim? Assume that this standard deviation does not change. A random sample of l0 lamps is tested and gives a sample mean of 3,470 lm. At the 5% level of significance can we conclude that the mean luminous flux is significantly less than what the manufacturer claims? State your null hypothesis and alternative hypothesis

**Course Outcome (CO 4):**

1. Buses arrive at the bus stop at a bus stand according to a Poisson process with a mean of one bus per 15 minutes. Generate a random variate, N, which represents the number of arriving buses during a 1-hour time slot. Now, N is Poisson distributed with a mean of four buses per hour. Using random number table generate a poisson variate.
2. Downtimes for a high-production candy-making machine have been found to be gamma distributed with mean 2.2 minutes and variance 2.10 minutes$^2$ Generate a gamma variate using the random numbers R1 = 0.832, R2 = 0.021; R3 = 0.434, R4 = 0.716;
3. Using the multiplicative congruential method, find the period of the generator for a = 13, m = 26 = 64 and X0 = 1,2,3,4.

**Course Outcome (CO5)**

1. Fit a straight line to the following data. Also estimate the value of y at X=70

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| X; | 71 | 68 | 73 | 69 | 67 | 65 | 66 | 67 |
| Y: | 69 | 72 | 70 | 70 | 68 | 67 | 68 | 64 |

2. Fit a parabola , by the method of least squares , to the following data, also estimate y at x =6

| | | | | | |
|---|---|---|---|---|---|
| X: | 1 | 2 | 3 | 4 | 5 |
| Y: | 5 | 12 | 26 | 60 | 97 |

3. From the table given below, find the best values of a and b in the law $y = a\ e^{bx}$ by the method of least squares.

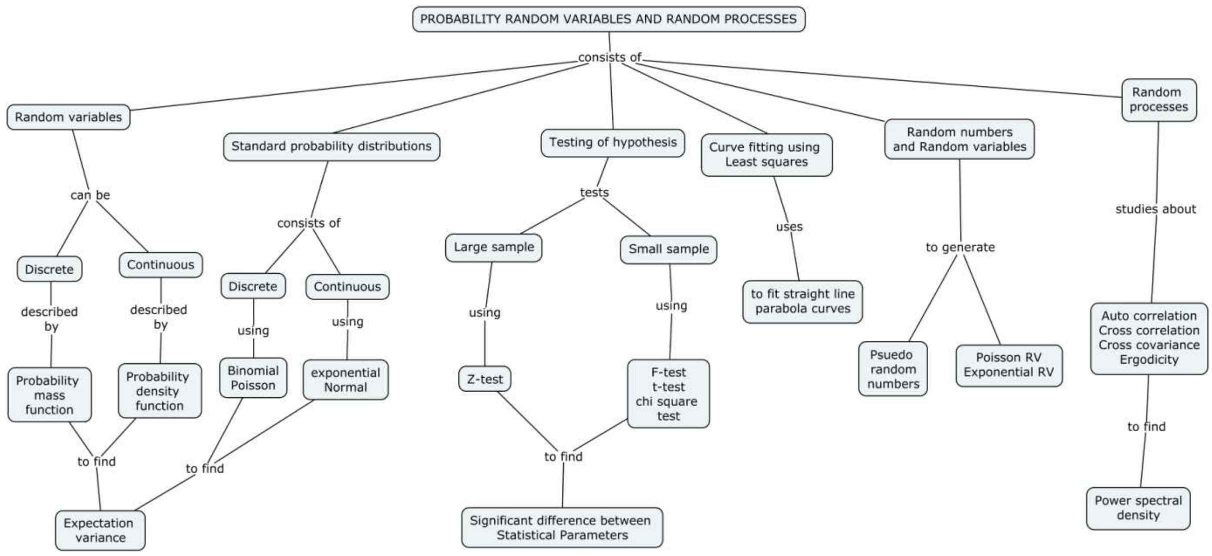
| | | | | | |
|---|---|---|---|---|---|
| X: | 0 | 5 | 8 | 12 | 20 |
| Y: | 3.0 | 1.5 | 1.0 | 0.55 | 0.18 |

**Course Outcome (CO6):**

1. A random process is defined by $X(t) = K\,Cos\,\omega t\ ;\ t > 0$ where $\omega$ is a constant and K is uniformly distributed between 0 and 2. Determine the following i) E{X(t)} ii) The auto correlation function of X(t)} iii) The auto covariance function of X(t)}
2. A random process has the sample functions of the form $X(t) = A\,Cos(\omega t + \theta)$ where $\omega$ is a constant and A is a random variable and has a magnitude of +1 and -1with equal probability , and $\theta$ is a random variable that is uniformly distributed between 0 and $2\pi$ .Assume that the random variables A and $\theta$ are independent , i) Is X(t) a wide sense stationary process
3. A random process Y(t) has a power spectral density $S_{YY}(\omega) = \dfrac{9}{\omega^2 + 64}$ , find

   i) the average power in the process and ii) the auto correlation function.

## Concept Map




## Syllabus

**Random variables and Probability distributions (5 hours)**

Random variables – Probability distributions for discrete and continuous random variables – Probability mass function, Probability density functions – Cumulative distribution functions and expected values

**Standard Probability Distributions (7 hours)**

The Binomial probability distribution –The Poisson Distribution - The exponential, and Normal Distributions

**Testing of Hypothesis (11 hours)**

Hypotheses and Test Procedures – Tests concerning a population mean – Tests concerning a Population proportion – Tests concerning population variance –inferences concerning difference between two population Means – inferences concerning difference between Population proportions - Inferences concerning two population variances

**Random Numbers and Variables (3 hours)**

Definition – Properties of Random numbers – Random Number Generation by Linear Congruential Method and Mixed Congruential Method – Random variable generator for Poisson and exponential probability distributions.

**Curve Fitting using Least Squares (3 hours)**

Using least square method to fit a Straight Line, Parabola and exponential curves

**Random Processes (7 Hours)**

Introduction - Classification of random process - characterizing a random process - cross correlation and cross covariance of a functions - stationary random processes - - power spectral density.

## Learning Resources

1. Jay L. Devore ,Probability and Statistics for Engineering and the Sciences (English) 8th Edition, Cengage Learning India Pvt Ltd, New Delhi, 2012. (For Modules 1,2,3).
2. Oliver C. Ibe, Fundamentals of Applied Probability and Random Processes, Elsevier, 2015.(For Modules4&5 4.1, 4.2, 4.3.)

3. Jerry Banks, John S.Curson Bary I Nelson, Discrete Event System Simulation - PHI, 2009. (Module 4.4, 4.5)

## Course Contents and Lecture Schedule

| Module No. | Topic | No. Of Hours | Course Outcome |
|---|---|---|---|
| 1. | **Random variables and Probability distributions** | | |
| 1.1 | Random variables | 1 | CO 1 |
| 1.2 | Probability distributions for Discrete and Continuous random variables | 1 | CO 1 |
| 1.3 | Probability density functions – Cumulative Distribution functions | 1 | CO 1 |
| 1.4 | Expected values | 2 | CO 1 |
| 2 | **Standard Probability Distributions** | | |
| 2.1 | The Binomial distribution, Poisson distribution | 3 | CO 2 |
| 2.2 | The exponential Distribution. | 2 | CO 2 |
| 2.3 | The Normal Distribution. | 2 | CO 2 |
| 3 | **Testing of Hypothesis** | | |
| 3.1 | Hypotheses and Test Procedures | 3 | CO3 |
| 3.2 | Test on Large Samples | 4 | CO 3 |
| 3.3 | Test on small Samples | 4 | CO 3 |
| 4 | **Random Numbers and Variables** | | |
| 4.1 | Introduction, random number generation using linear congruential methods, mixed congruential method | 2 | CO 4 |
| 4.2 | Random variate generation for Poisson, exponential distribution | 1 | CO4 |
| 5 | **Curve Fitting using Least Squares** | | |
| 5.1 | Straight Line fit | 1 | CO 5 |
| 5.2 | Parabolic fit | 1 | CO 5 |
| 5.3 | Fitting of exponential curves | 1 | CO 5 |
| 6 | **Random Processes** | | |
| 6.1 | Introduction , Classification of random process, characterizing a random process | 2 | CO6 |
| 6.2 | Cross correlation and cross covariance of a functions | 1 | CO6 |
| 6.3 | Stationary random processes | 2 | CO6 |
| 6.4 | Power spectral density | 2 | CO6 |
| | TOTAL No. of Hours | 36 | |

## Course Designers

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| 18EE420 | AC MACHINES |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 3 | 0 | 0 | 3 |

## Preamble

Rotating electrical machines are widely used for the purpose of converting energy from one form to another. AC machines are becoming more and more attractive in many applications such as those requiring variable speed and flexible control. Alternating Current (AC) machines are the most preferred for generation of electric power. AC motors are the commonly used in industry for motive power for applications. Electrical drive is superior to other forms of prime movers in terms of efficiency, control and pollution. There are three families of rotating machines one of which is the synchronous machine commonly in the form of the AC synchronous generator such machines are widely used in power stations for electric power generation. The synchronous motor has limited application. However an asynchronous machine, the induction motor has wide spread industrial and domestic application such that about 85 % of electric power consumption is due to induction motor loads. Single phase motor has wide spread small power application for example in the home. Due to their low cost and economical advantages, AC motors are widely used in applications requiring a wide range of speeds or precise control of output.

## Prerequisite

18EE240 Electromagnetic Fields
18EE230 Electric Circuits Analysis

## Course Outcomes

On the successful completion of the course, students will be able to:

| COs No. | Course Outcomes | Weightage % |
|---|---|---|
| CO1. | Explain the Fundamentals and laws governing motoring and Generating Action of AC Machines | 10 |
| CO2 | Explain the construction of AC Machines and role of its parts | 10 |
| CO3 | Obtain the performance of AC Generators | 25 |
| CO4 | Obtain the performance of AC Motors using equivalent circuit | 25 |
| CO5 | Explain the Operation and Control of AC Machines | 15 |
| CO6 | Apply the testing procedures for AC Machines as per the standard practice | 15 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |

| | Scale | | | | |
|---|---|---|---|---|---|
| | | | | | |
| CO1 | TPS2 | Understand | Respond | | 1.2.8, |
| CO2 | TPS2 | Understand | Respond | | 1.2.8, 2.3.1, |
| CO3 | TPS3 | Apply | Value | | 1.2.8, 2.1.1, |
| CO4 | TPS3 | Apply | Value | | 1.2.8, 2.1.1, 2.1.2, |
| CO5 | TPS2 | Understand | Respond | | 1.2.8, 2.1.1, |
| CO6 | TPS3 | Apply | Value | | 1.2.8, 2.1.1,2.2.4 |

**Mapping with Programme Outcomes**

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO1 0 | PO1 1 | PO1 2 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | |
| CO2 | M | L | | | | | | M | | M | | | M | |
| CO3 | S | M | L | L | | | | M | | M | | | S | |
| CO4 | S | M | L | L | | | | M | | M | | | S | |
| CO5 | M | L | | | | | | M | | M | | | M | |
| CO6 | S | M | L | L | | | | M | | M | | | S | |

**S**- Strong; **M**-Medium; **L**-Low

**Assessment Pattern**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 10 | - | - | - | 10 |
| Understand | 40 | 40 | 30 | - | - | - | 30 |
| Apply | 40 | 40 | 60 | 100 | 100 | 100 | 60 |
| Analyze | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Distinguish between rotating armature and rotating field types.
2. State Flemings Right and Left hand rule.

**Course Outcome 2 (CO2):**

1. Specify the role of damper winding in Alternator?
2. What does skewing means in squirrel cage Induction motor?
3. Specify the purpose of connecting a capacitor in the auxiliary winding of a single-phase induction motor?

**Course Outcome 3 (CO3)**.

1. Define the term voltage regulation in Alternator?
2. Specify the need of parallel operation of alternators.
3. Explain the method of finding voltage regulation using synchronous impedance method for alternator?
4. Find the synchronous impedance and reactance of an alternator in which a given field current produces an armature current of 200 amperes on short circuit and a generated EMF of 50 volts on open circuit. The armature resistance is 0.1 Ohms. Calculate the induced voltage of armature, if it is deliver a load of 100 amperes at a power factor of 0.8 lagging with terminal voltage of 200 Volts?

**Course Outcome 4 (CO4)**

1. Draw the v curve of Synchronous motor and specify its axis parameters?
2. Discuss the effect of rotor resistance and reactance with the help of speed torque curve of induction motor?
3. Find the percentage of tapping required on an auto-transformer required for a squirrel cage induction motor to start the motor against $1/3^{rd}$ of full load torque? The short circuit current on nominal voltage is 7 times of the full load current and the full load slip is 2%.
4. A Three phase induction motor has a 4 pole Delta connected stator winding and runs on a 415 Volts, 50Hz supply. The rotor resistance per phase is 0.18 ohms and reactance 1.2 ohms. The ratio of stator to rotor turns is 1.8. The full load slip is 3%. Calculate the load torque in kg-m and speed at maximum torque?

**Course Outcome 5 (CO5)**

1. Two alternators A and B are operating in Parallel and supply a load of 10MW at 0.8p.f. lagging. Suggest with justification, the possible way to carry out the following and hence determine the reactive and active power share by each alternator.

i) Is the real power shared by alternator A is increased to 6 MW.
ii) If the p.f. of alternator B is increased to 0.94.

2. With neat sketch explain the various speed control techniques applied for three phase induction motor.
3. Design a five step rotor resistance starter for a three phase induction motor. The slip at the maximum starting current is 2% with slip – ring short circuited and the resistance per rotor phase 0.02 Ohm.

**Course Outcome 6 (CO6)**

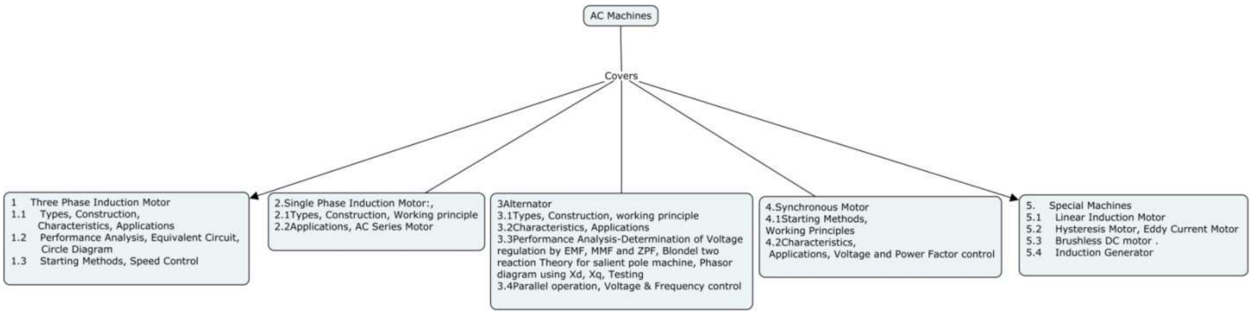
1. A three phase, 6600V, 50 Hz, star – connected alternator gave the following test results.

| | | | | | |
|---|---|---|---|---|---|
| $V_{OC}$ | 3100 | 4900 | 6600 | 7500 | 8300 |
| $I_f$ | 16 | 25 | 37.5 | 50 | 70 |

A field current of 22A is required to circulate full load current on short circuit test. Calculate the full load voltage regulation for, 0.8 p.f. lagging using EMF and MMF method. Give your interpretation for difference in the regulation calculated.

2. With neat sketch explain the slip test on a salient pole alternator.

## Concept Map




## Syllabus

**ASYNCHRONOUS MACHINE**

**Three Phase Induction Motor** : Types, Construction, Working Principle, Characteristics, Applications, Performance Analysis, Equivalent Circuit, Circle Diagram, Starting Methods and Speed Control.

**Single Phase Induction Motor**: Types, Construction, Working principle, Applications, AC Series Motor.

**SYNCHRONOUS MACHINE**

**Alternator**: Types, Construction, working principle, Characteristics, Applications, Performance Analysis, Testing, Parallel operation, Voltage & Frequency control

**Synchronous Motor**: Starting Methods, Working Principles, Characteristics, Applications, Voltage and Power Factor control.

**Special Machines:** Linear Induction Motor, Hysteresis Motor, Eddy Current Motor, Brushless DC motor, Induction Generator.

## Learning Resources

1. H.Wayne Beaty & Jame. L.Kirtley.Jr " Electric Motor Handbook", McGraw-Hill, USA, 1st Edition, 1998.
2. A.K.Sawhney and A.Chakrabarti, "A course in Electrical Machine Design",6th Edition, Dhanpat Rai & Co (P) Ltd., 2006.
3. Gupta.J.B,"Theory of Performances of Electrical Machines' Katson, 7th Edition, 1987
4. Vincent Deldoro ," Electromechanical Energy Conversion " PHI III edition,
5. M.G.Say, The Performance and Design of Alternating Current machines, Tata-McGraw Hill.

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| | **ASYNCHRONOUS MACHINE** | | |
| 1 | **Three Phase Induction Motor** | | |
| 1.1 | Types, working Principle | 2 | CO1 |
| 1.2 | Construction, Characteristics, Applications | 2 | CO2 |
| 1.3 | Performance Analysis, Equivalent Circuit | 3 | CO4 |
| 1.4 | Starting Methods, Speed Control | 2 | CO5 |
| | Linear Induction Motor, Testing, Standards, Specifications | 2 | CO6 |
| 2. | **Single Phase Induction Motor**:, | | |
| 2.1 | Types, Construction, Working principle | 2 | CO1 |
| 2.2 | Applications, AC Series Motor | 2 | CO3 |
| | **SYNCHRONOUS MACHINE** | | |
| 3 | **Alternator** | | |
| 3.1 | Types, , working principle | 2 | CO1 |
| 3.2 | Construction, Characteristics, Applications | 2 | CO2 |
| 3.3 | Performance Analysis-Determination of Voltage regulation by EMF, MMF and ZPF, Blondel two reaction Theory for salient pole machine, Phasor diagram using Xd, Xq, Testing | 5 | CO3 |
| 3.4 | Parallel operation, Voltage & Frequency control | 3 | CO5 |
| 4. | **Synchronous Motor** | | |
| 4.1 | Starting Methods, Working Principles | 2 | CO1 |
| 4.2 | Characteristics, Applications, Voltage and Power Factor control | 4 | CO4 |
| 5.0 | **Special Machines:** | | |
| 5.1 | Linear Induction Motor , Hysteresis Motor | 1 | CO3 |
| 5.2 | Eddy Current Motor, Stepper Motor | 1 | CO3 |
| 5.3 | Brushless DC motor, Induction Generator | 1 | CO3 |
| | **Total** | **36** | |

## Course Designers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3. Dr.R.Rajan Prakash r_rajanprakash@tce.edu

| 18EE430 | MEASUREMENTS AND INSTRUMENTATION | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PC | 3 | 0 | 0 | 3 |

## Preamble

The rapid development of new and exciting means of measurement using new technologies, the adoption of new standards give us a path way to the state of "Classic Electrical Measurements". However knowledge of these subjects is important to understand the principles of modern measuring instruments. Instrumentation systems helps to create, construct and maintain measuring devices and systems found in manufacturing plants and research institutions. Its main objective is to ensure that systems and processes operate safely and efficiently. This course is designed to impart fundamental knowledge of analog and digital measuring instruments characteristics. This course exposes the knowledge about the construction, principle and applications of analog and digital measuring instruments. Students will get the fundamental knowledge of DC and AC null measurement methods along with its behaviours on it's various applications. Also this course will provide an adequate exposure to various sensors, and usage of suitable sensing elements for the vital parameters like pressure, temperature, Flow, Current & Voltage.

## Prerequisite

- 18EE250 Electronic Devices and Circuits
- 18EE230: Electric Circuit Analysis
- 18EE240: Electromagnetic Fields
- 18EE340: Digital Systems

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the static & dynamic characteristics, calibration, errors and standards of measuring instruments. | 8 |
| CO2 | Explain the construction, working principle and applications of various Analog measuring Instruments | 15 |
| CO3 | Explain the construction, working principle and applications of instrument transformers. | 7 |
| CO4 | Explain the principle of operation and applications of various Digital instruments. | 15 |

| | | |
|---|---|---|
| CO5 | Explain the concepts of Smart Meters, Automatic Meter Reading(AMR) and PMU | 5 |
| CO6 | Apply suitable AC and DC bridge for measuring R, L,C and frequency for the given specifications | 20 |
| CO7 | Explain the working of smart sensors, MEMS and Nano sensors. | 10 |
| CO8 | Apply suitable transducers for the measurement of pressure, temperature, speed, flow, current & voltage for the required precision | 20 |

*** Weightage depends on Bloom's Level, number of contact hours,

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | - | 1.2.9, 2.3.1,2.3.2, |
| CO2 | TPS2 | Understand | Respond | - | 1.2.9,2.1.1,2.1.5,2.3.1,2.3.2,2.4.2 |
| CO3 | TPS2 | Understand | Respond | - | 1.2.9,2.1.1,2.1.5,2.3.1,2.3.2,2.4.2 |
| CO4 | TPS2 | Understand | Respond | - | 1.2.9,2.1.1,2.1.5,2.3.1,2.3.2,2.4.2 |
| CO5 | TPS2 | Understand | Respond | - | 1.2.9,2.1.1,2.1.5,2.3.1,2.3.2,2.4.2 |
| CO6 | TPS3 | Apply | Value | - | 1.2.9,2.1.1,2.1.5,2.3.1,2.3.2,2.4.2,2.2.3 |
| CO7 | TPS2 | Understand | Respond | | 1.2.9,2.1.1,2.1.5,2.3.1,2.3.2,2.4.2 |
| CO8 | TPS3 | Apply | Value | | 1.2.9,2.1.1,2.1.5,2.3.1,2.3.2,2.4.2,2.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | | | | | M | M | M | | M | | | M | M |
| CO2 | M | L | | | | | | M | | M | L | | M | M |
| CO3 | M | L | | | | M | S | M | | M | | | M | M |
| CO4 | M | L | | | | | | M | | M | | | M | M |
| CO5 | M | L | | | M | | S | M | | M | | | M | M |
| CO6 | S | M | L | L | | | | M | | M | L | | S | S |
| CO7 | M | L | | | | | | M | | M | | | M | M |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 8 | S | M | L | L | | | | M | | M | L | | S | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 10 | 10 | - | - | - | 10 |
| Understand | 80 | 50 | 50 | - | - | - | 50 |
| Apply | - | 40 | 40 | 100 | 100 | 100 | 40 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO1):**

1. State the meaning for 'International Standard' in measurements.
2. Name the few static performance characteristics of a measuring instrument.
3. Explain the significance of the dynamic characteristics.

**Course Outcome 2(CO2):**

1. Describe the various forces/torques required in the measuring instruments.
2. Derive the expression for equation of motion for permanent magnet moving coil instrument.
3. Demonstrate the construction features of a repulsion type MI instruments.

**Course Outcome 3(CO3):**

1. What is a potential transformer?
2. What is a current transformer?
3. Explain how power measurement is done using CT and PT.

**Course Outcome 4 (CO4):**

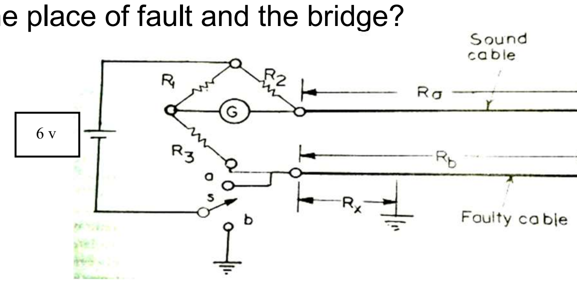
1. Explain the working principle of digital voltmeter.
2. Explain the operation of digital energy meter.
3. Summarize the advantages of Digital Instruments.

**Course Outcome 5 (CO5):**

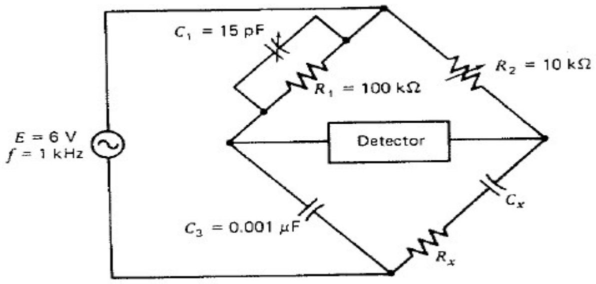
1. Demonstrate the significance of smart meters.
2. Explain the concept of smart Grid.
3. Summarize about the Automatic Meter Reading (AMR).
4. Explain the concept of PMU.

**Course Outcome 6(CO6):**

1. A Wheatstone bridge is connected for identify the cable fault as shown in Figure 3. When the switch is in position a, the bridge is balanced with R1=1000Ω, R2=100 Ω, R3=53 Ω. When switch S is in position b, the bridge is balanced with R1=1000 Ω, R2=100 Ω, R3=52.9 Ω. if the resistance of the shorted wire is 0.015 Ω /m. What is the distance between the place of fault and the bridge?




2. The Schering bridge shown in Figure 2 is operated at balance. Find the equivalent series resistance and capacitance of Rx and Cx. Also find the Q factor of the capacitor Cx.




**Course Outcome 7(CO7):**

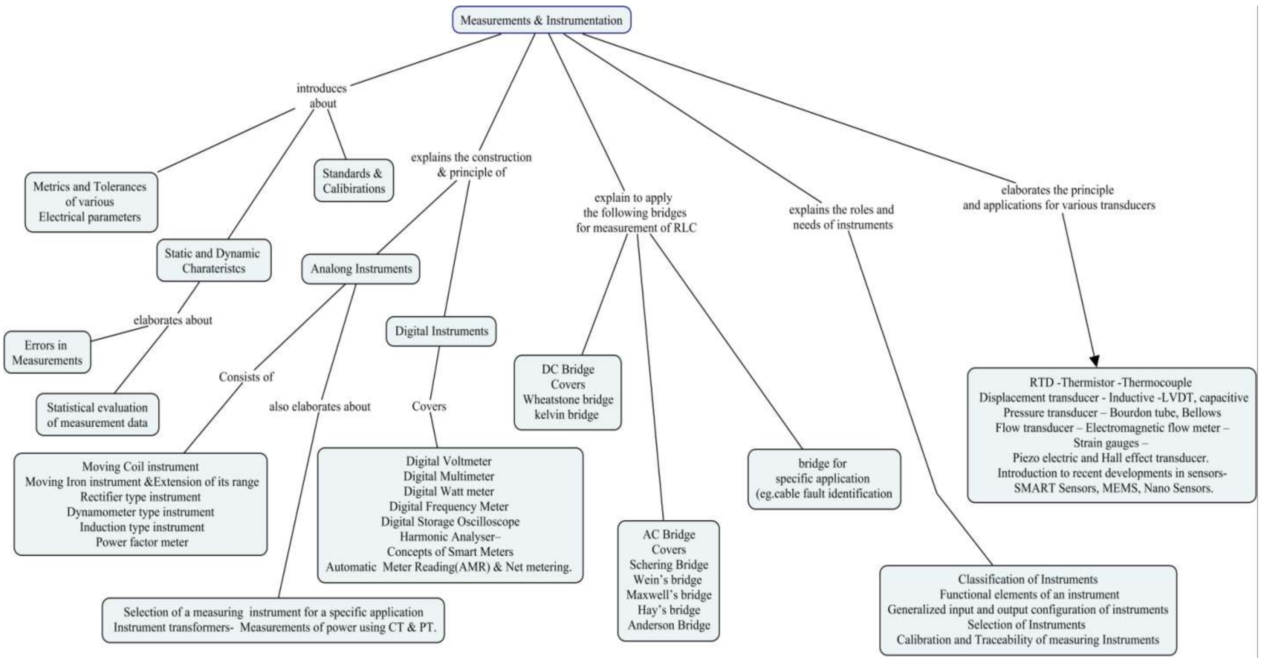
1. Explain the traceability hierarchy with respect to the traceability of measurement
2. Define SMART SENSOR.
3. Explain a smart sensor with block diagram.
4. What is mean by MEMS?

**Course Outcome 8 (CO8):**

1. A pressure gage is to be used in an LVDT – diaphragm combination. The LVDT has sensitivity of 1V/mm, and the diaphragm is to be constructed of steel (E=200GPa, v=0.3 and density 7800kg/m3) with a diameter of 20cm. Calculate the diaphragm thickness in accordance with the restriction that the maximum deflection does not exceed one fourth of this thickness. The maximum pressure is 2MPa. If a milli voltmeter capable of measuring a minimum of 1mV and that can be measure in steps of 1mV, is used for measurement, What is the lowest pressure in kPa which may be sensed by this instrument, resolution and the natural frequency of the diaphragm?
2. An experiment is conducted to calibrate a copper –constant thermocouple. With cold junction at 0°C, emf obtained at boiling point of water (100°C) and boiling point of sulphur (445°C) are 5 mV and 25 mV, respectively. If the relation is assumed to be $e_{t1-t2=a(t_1-t_2)+b\,(t_1^2-t_2^2)}$. Determine constants a and b.

A resistance thermometer is to be constructed of nickel wire. Thermometer resistance at 20°C is 100Ω. What length of 0.4mm-diameter wire should be used. What would be the length if 2mm diameter wire is used? (Resistivity =0.8 Ωm). If resistance varies linearly with temperature then what would be the resistance at t = -50°C and 100°C? (Sensitivity = 0.2 Ω /°C).

## Concept Map




## Syllabus

### Introduction to measurement

Metrics and Tolerances of various Electrical parameter (V,I, f, Power)- – Static and dynamic characteristics – Errors in measurement – Statistical evaluation of measurement data – Standards and calibration.-

### Analog and Digital Instruments

**Analog Instruments**: Introduction to analog measuring instruments-Construction, principle and applications of - Moving Coil instrument- Moving Iron instrument - Extension of range. Rectifier type instrument - Dynamometer type instrument - Induction type instrument, Power factor meter, Selection of a measuring instrument for a specific application, - Instrument transformers- Measurements of power using CT & PT.

**Digital Instruments :** (Working Principle and it's applications) – True- RMS Meter-Average type Instruments-Digital Voltmeter -Digital Multimeter - Digital Watt meter - Digital Frequency

Meter - Digital Storage Oscilloscope - Harmonic Analyser– Concepts of Smart Meters – Automatic Meter Reading(AMR) – Net metering- Introduction to PMU.

**DC and AC null measurements and it's applications** -Wheatstone bridge, kelvin bridge - Schering Bridge, Wein's bridge -Maxwell's bridge, Hay's bridge, Anderson Bridge- Blumliens Bridge-Selection of a suitable bridge for specific application (eg. cable fault identification).

**Role & Needs of instrumentation** – Classification of Instruments – Functional elements of an instrument-Generalized input and output configuration of instruments– Selection of Instruments – Calibration and Traceability of measuring Instruments.

**Transducers: Temperature transducers**- RTD, thermistor, Thermocouple - **Displacement transducer** - Inductive, capacitive, LVDT, **Pressure transducer** – Bourdon tube, Bellows- **Speed transducers**- Encoders – **Flow transducer** – Electromagnetic flow meter – Strain gauges – Piezo electric and Hall effect transducer. Introduction to recent developments in sensors- SMART Sensors, MEMS, Nano Sensors.

**Learning Resources**

1. A.K. Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai & Co, 2012.
2. E.O. Doebelin, Measurement Systems – Application and Design, Tata McGraw Hill publishing company, 2003.
3. Robert.B.Northrop, Introduction to instrumentation and measurements, Allied Publishers, 2002.
4. Patranabis,D, Principles of Industrial Instrumentation, 3rd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2010.
5. B. E. Jones, Instrumentation measurement and Feedback, Tata McGraw-Hill, 2000.
6. Kalsi H.S, Electronic Instrumentation , Tata McGraw-Hill 2003
7. Alan S. Morris, Principles of Measurement and Instrumentation, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003
8. http://www.nist.gov/pml/mercury_traceability.cfm (Module 1.5)
9. http://www.european-accreditation.org/publication/ea-4-07-m (Module 1.5)
10. Lecture series: https://nptel.ac.in/syllabus/108106070/

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1. | **Introduction to measurement** | | |
| 1.1 | Metrics and Tolerances of various Electrical parameters (V,I, f, Power) | 1 | CO1 |
| 1.2 | Static and dynamic characteristics | 1 | CO1 |
| 1.3 | Errors in measurement | 1 | CO1 |
| 1.4 | Statistical evaluation of measurement data | 1 | CO1 |
| 1.5 | Standards and calibration | 1 | CO1 |
| 2. | **Analog and Digital Instruments** | | |
| 2.1 | ***Analog Instruments**:* Introduction to analog measuring instruments | 1 | CO2 |
| 2.2 | Construction, principle and applications of - Moving | 1 | CO2 |

| | | | |
|---|---|---|---|
| | Coil instrument | | |
| 2.3 | Construction, principle and applications of - Moving Iron instrument, Extension of range | 2 | CO2 |
| 2.4 | Rectifier type instrument | 1 | CO2 |
| 2.5 | Dynamometer type instrument | 1 | CO2 |
| 2.6 | Induction type instrument | 1 | CO2 |
| 2.7 | Power factor meter, Selection of a measuring instrument for a specific application | 1 | CO2 |
| 2.8 | Instrument transformers- Measurements of power using CT & PT. | 2 | CO3 |
| | ***Digital Instruments*** | | |
| 2.9 | True- RMS Meter-Average type Instruments | 1 | CO4 |
| 2.10 | Digital Voltmeter -Digital Multimeter | 1 | CO4 |
| 2.11 | Digital Watt meter - Digital Frequency Meter | 1 | CO4 |
| 2.12 | Digital Storage Oscilloscope, Harmonic Analyser | 2 | CO4 |
| 2.13 | Concepts of Smart Meters – Automatic Meter Reading(AMR) – Net metering – Introduction to PMU | 2 | CO5 |
| 3. | **DC and AC null measurements and it's applications** | | |
| 3.1 | Wheatstone bridge | 1 | CO6 |
| 3.2 | kelvin bridge | 1 | CO6 |
| 3.3 | Schering Bridge | 1 | CO6 |
| 3.4 | Wein's bridge | 1 | CO6 |
| 3.5 | Maxwell's bridge, Blumliens Bridge | 1 | CO6 |
| 3.6 | Hay's bridge, Anderson Bridge | 1 | CO6 |
| 3.7 | Selection of a suitable bridge for specific application | 1 | CO6 |
| 4. | **Role & Needs of instrumentation** | | |
| 4.1 | Classification of Instruments | 1 | CO7 |
| 4.2 | Functional elements of an instrument | 1 | CO7 |
| 4.3 | Generalized input and output configuration of instruments | 1 | CO7 |
| 4.4 | Selection of Instruments – Calibration and Traceability of measuring Instruments. | 1 | CO7 |
| 5. | **Transducers** | | |
| 5.1 | **Temperature transducers-** RTD, thermistor, Thermocouple | 1 | CO8 |
| 5.2 | **Displacement transducer** – Inductive, capacitive, LVDT | 1 | CO8 |
| 5.3 | **Pressure transducer** – Bourdon tube, Bellows | 1 | CO8 |
| 5.4 | **Speed transducer -** Encoder | 1 | CO8 |
| 5.5 | **Flow transducer** – Electromagnetic flow meter – Strain gauges | 1 | CO8 |
| 5.6 | Piezo electric and Hall effect transducer. | 1 | CO8 |
| 5.7 | Introduction to recent developments in sensors- SMART Sensors, MEMS, Nano Sensors. | 1 | CO8 |
| **Total hours** | | **40** | |

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| 18EE440 | CONTROL SYSTEMS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 2 | 1 | - | 3 |

## Preamble

This course is to impart students a good understanding of fundamental principles in control engineering. The course includes: Mathematical Modelling of Linear Continuous Time Invariant Single Input - Single Output Dynamical Systems, Transfer Functions and State Space Models, Performance Specifications, Analysis and Design of Closed Loop Control Systems.

## Prerequisite

- 18MA110 Engineering Calculus
- 18MA210 Matrices and Ordinary Differential Equations
- 18EE230 Electric Circuit Analysis
- 18EE350 Signals & Systems

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Determine the transfer function and state space model of given electrical, mechanical and electro-mechanical system | 20 |
| CO2 | Analyse the time response characteristics of a given transfer function model | 25 |
| CO3 | Analyse the frequency response characteristics of a given transfer function model | 25 |
| CO4 | Analyse the closed loop characteristics of a given transfer function using root locus | 20 |
| CO5 | Explain the effects of compensators in improving the performance of the system | 5 |
| CO6 | Determine the controllability and observability of given LTI system | 5 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psycho | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | motor | |
| CO1 | TPS3 | Apply | Value | | 1.2.10,2.1.1, 2.1.2, 2.3.1,2.3.2 |
| CO2 | TPS4 | Analyse | Organise | | 1.2.10,2.1.1, 2.1.4, 2.3.1, 2.3.2, 2.3.3 |
| CO3 | TPS4 | Analyse | Organise | | 1.2.10,2.1.1, 2.1.4, 2.3.1, 2.3.4, 3.2.3 |
| CO4 | TPS4 | Analyse | Organise | | 1.2.10,2.1.1, 2.1.4, 2.4.4, 3.2.3 |
| CO5 | TPS3 | Understand | Respond | | 1.2.10,2.1.1, 2.1.4, 2.3.1, 2.3.4, 2.4.4 |
| CO6 | TPS3 | Apply | Value | | 1.2.10,2.1.1, 2.1.4,2.3.1,2.3.2, 2.3.3 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | M | L | | | | M | | M | | | S | S |
| CO2 | S | S | M | M | | | | M | | M | | | S | S |
| CO3 | S | S | M | M | M | | | M | | M | | | S | S |
| CO4 | S | S | M | M | M | | | M | | M | | | S | S |
| CO5 | M | L | | | | | | M | | M | | | M | M |
| CO6 | S | M | M | M | | | | M | | M | | | S | S |

S- Strong; M-Medium; L-Low

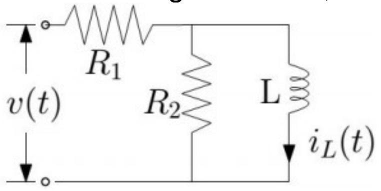
## Assessment Pattern: Cognitive Domain

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | - | - | - | 10 |
| Understand | 20 | 20 | 20 | - | - | - | 20 |
| Apply | 70 | 70 | 70 | 50 | 50 | 50 | 70 |
| Analyse | | | | 50 | 50 | 50 | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

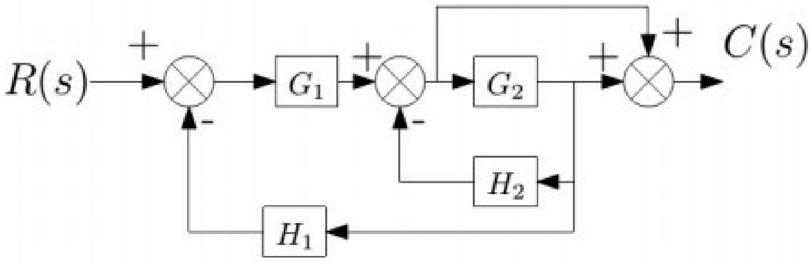
## Sample Questions for Course Outcome Assessment

**Course Outcome 1(CO1):**

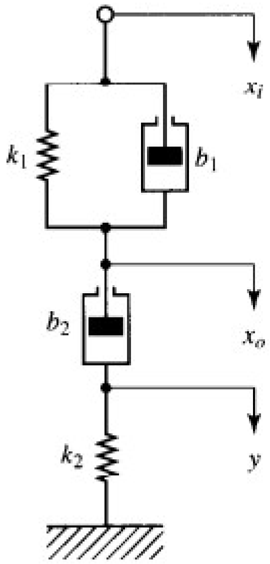
1. For the circuit given below, determine the transfer function IL(s)/V(s)




2. Reduce the block diagram given below and find C(s)/R(s)



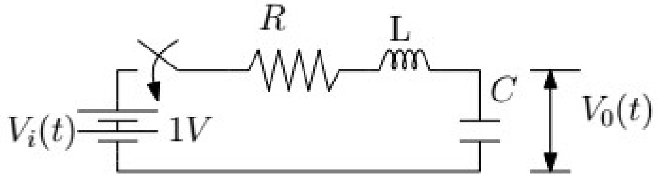

3. For the mechanical system shown below, determine the transfer function Y(s)/Xi(s) and also State space model.

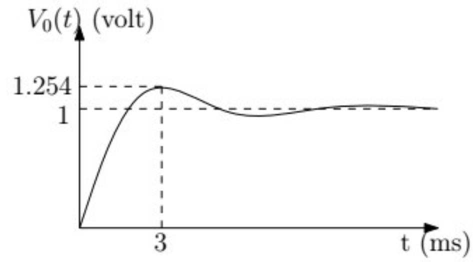



**Course Outcome 2(CO2):**

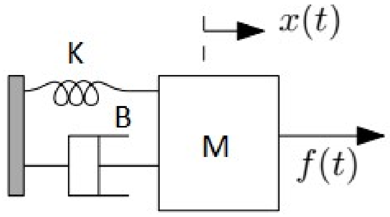
1. The open loop transfer function of a unity feedback control system is given by $G(s) = \dfrac{0.4s+1}{s(s+0.6)}$.
   a. Calculate the closed loop transfer function and calculate the response for unit step reference
   b. Calculate the maximum peak overshoot

2. Consider the RLC circuit. When the switch is closed at time t=0, the voltage across capacitor varies as shown below. If R=1Ω,
   a. Calculate the values of L and C
   b. Calculate peak time and maximum peak overshoot when the value R is doubled
   c. From the results of b, comment on the effect of resistance in damping of output.



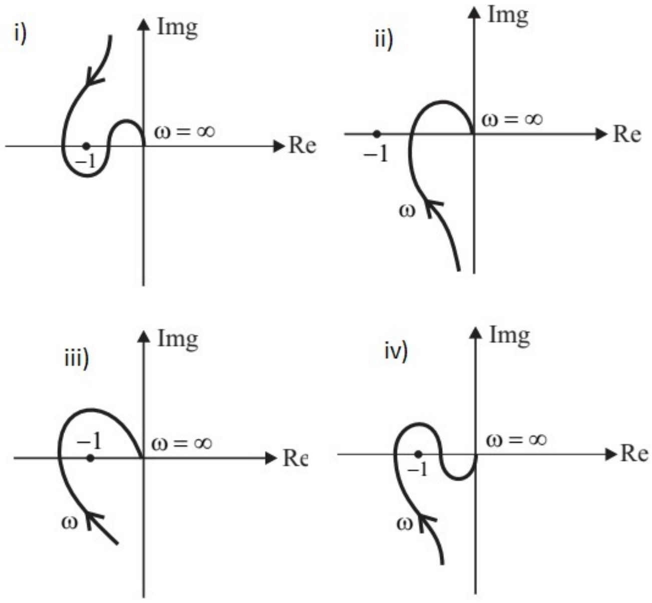




3. Consider the mechanical system shown below. When unit step force is applied, the steady state displacement is 2m, Maximum peak overshoot is 16%. Peak time is 2s. Determine the values of M, B and K




**Course Outcome 3(CO3):**

1. Sketch the Bode plot of the system G(s)H(s)=10(s+1)/s(s+10)(s+100) and calculate gain margin and phase margin
2. Choose the stable closed loop system from the polar plots shown below.




3. Consider unity feedback system with plant transfer function G(s) =K/s(s+1)(s+2). Using Nyquist stability criterion, determine the range of K for which the closed loop system is stable.

**Course Outcome 4 (CO4):**

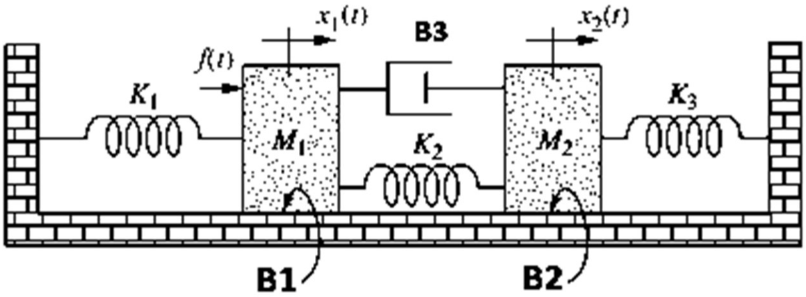
1. Sketch the root locus of the system G(s)H(s)=K/s(s+1)(s+2) and calculate the value of K for maximum peak overshoot =16%.
2. Consider a unity feedback system with plant transfer function $G(s) = k / s(s^2 + s + 1)(s + 2)$. Using Routh stability criterion find the range of K for the system to be stable
3. Sketch the root locus of the system $G(s)H(s) = \dfrac{K(s+3)}{s(s^2 + 2s + 2)}$ and calculate the value of K for maximum peak overshoot =16%.

**Course Outcome 5 (CO5):**

1. Explain the effect of adding a zero in forward path of a transfer function
2. Explain the frequency response of lead compensator.
3. Explain the design procedure for lag compensator.

**Course Outcome 6(CO6):**

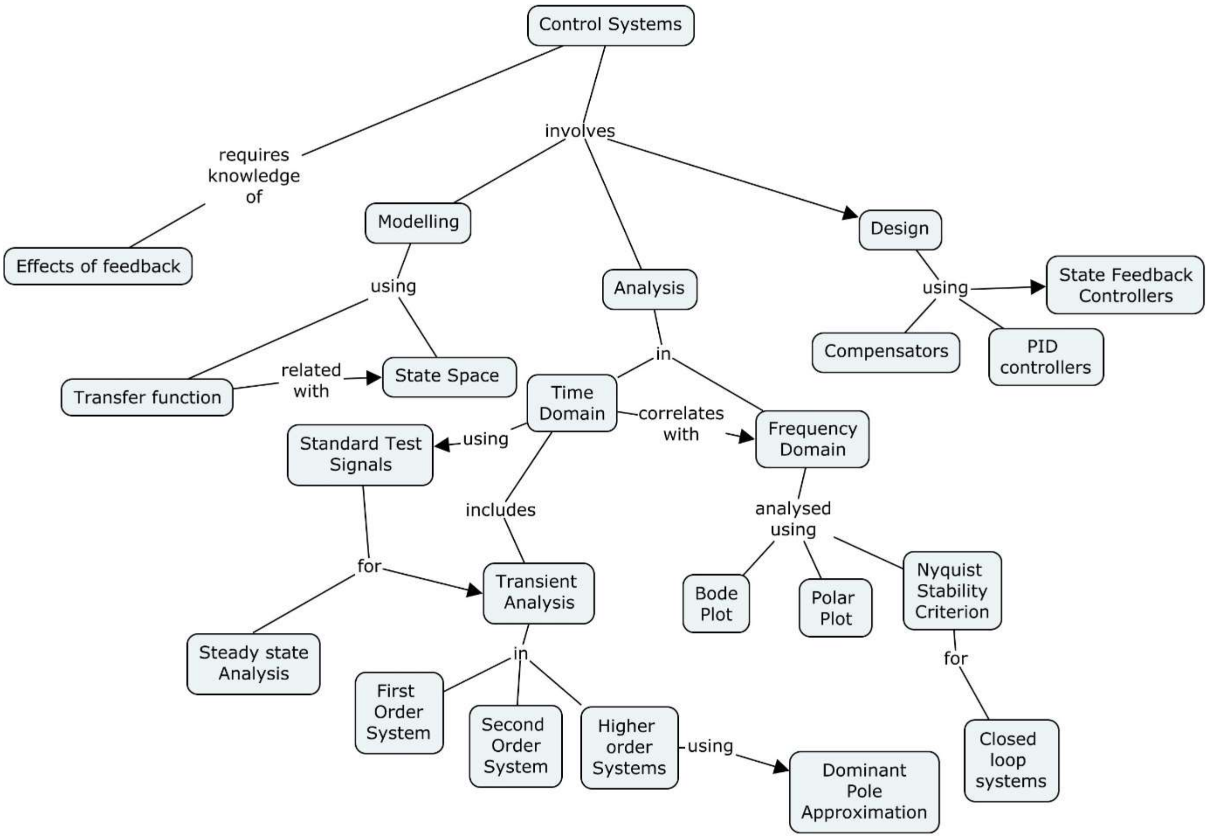
1. Determine the transfer function X2(s)/F(s) for the mechanical system shown below




2. Obtain controllable and observable canonical form of the system $G(s)=\dfrac{s^3+3s^2+4s+4}{s^3+2s^2+2s+2}$

3. Determine controllability and observability of the system
$$\dot{X}=\begin{bmatrix}0 & -2\\ -3 & -1\end{bmatrix}X+\begin{bmatrix}1\\1\end{bmatrix}u$$
$$Y=\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}X$$

## Concept Map




## Syllabus

**Basic concepts**: Industrial control examples, Feedback control: Open loop and Closed loop systems, Benefits of feedback, Transfer function models of linear time invariant systems. Concept of state variable, state space model. Mathematical models of electrical, mechanical and electromechanical systems, Block diagram reduction, signal flow graphs and Mason gain formula

**Time domain analysis and stability:** Test Signals, Steady state errors, Time response of First order and second order systems- Dominant pole approximation of higher order systems, Integral performance indices

Concept of Stability and Characteristic equation, Routh-Hurwitz criteria- Root-locus construction and interpretation, closed loop analysis using root locus, Time domain and root locus analysis using MATLAB

**Frequency-domain analysis:**

Frequency responses and Frequency domain specifications, Bode plot, polar plot, construction and interpretation, Nyquist stability criterion- Gain and phase margin, closed loop frequency response. Frequency domain analysis using MATLAB

**Compensation:**

Types of compensators, characteristics and effects of lead, lag, lag-lead compensators and P, PI and PID controllers

**State Variable Analysis:**

Relation between state space and transfer functions, canonical forms, solution of state equation, Eigen values and stability analysis, Controllability and observability, concept of state feedback control

## Learning Resources


1. Norman S. Nise, Control Systems Engineering, 6th edition, John Wiley, 2010. (Indian edition)
2. IJ Nagrath and M Gopal, Control Systems engineering, 5th Edition, New Age International, 2007
3. Robert H Bishop and Richard C Dorf, Modern Control Systems, 12th Edition, Pearson Education, 2010
4. John JD Azzo, Constantine H Houpis, and Stuart N Sheldon, Linear Control Systems: Analysis and Design with MATLAB, 5th Edition, Taylor and Francis, 2003
5. B.C. Kuo, and F.Golnaraghi, Automatic Control Systems, 9th Edition. Wiley India Pvt limited 2014. (Student edition)
6. Katsuhiko Ogata, Modern Control Engineering, 5th edition, PHI, 2010
7. M Gopal, Control Systems-Principles and Design, 4th Edition, McGraw Hill India, 2012
8. NPTEL Online Course: Control Systems, URL: https://nptel.ac.in/courses/107106081/72


## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| **1** | **Basic concepts** | | |
| 1.1 | Industrial control examples, Feedback control: Open loop and Closed loop systems, Benefits of feedback | 1 | CO1 |
| 1.2 | Transfer function models of linear time invariant systems | 1 | CO1 |
| 1.3 | Mathematical models of electrical, mechanical and | 3 | CO1 |

| | | | |
|---|---|---|---|
| | electromechanical systems | | |
| 1.4 | Block Diagram reduction | 2 | CO1 |
| 1.5 | Signal flow graph and mason gain formula | 2 | CO1 |
| 1.6 | Concept of state variable, state space model | 2 | CO1 |
| 1.7 | Relation between state space and transfer functions, canonical forms | 1 | CO1 |
| **2** | **Time domain analysis and stability:** | | |
| 2.1 | Test Signals, Steady state errors | 2 | CO2 |
| 2.2 | Time response of First order system | 1 | CO2 |
| 2.3 | Time response of second order systems | 2 | CO2 |
| 2.4 | Dominant pole approximation of higher order systems, Integral performance indices | 1 | CO2 |
| 2.5 | Concept of Stability and Characteristic equation | 1 | CO4 |
| 2.6 | Routh –Hurwitz criteria | 2 | CO4 |
| 2.7 | Root-locus construction and interpretation | 2 | CO4 |
| 2.8 | Closed loop analysis using root locus | 1 | CO4 |
| 2.9 | Time domain and root locus analysis using MATLAB | 1 | CO4 |
| **3** | **Frequency-domain analysis:** | | |
| 3.1 | Frequency responses and Frequency domain specifications | 1 | CO3 |
| 3.2 | Bode plot and interpretation | 2 | CO3 |
| 3.3 | Polar plot and interpretation | 1 | CO3 |
| 3.4 | Nyquist stability criterion | 1 | CO3 |
| 3.5 | Gain and phase margin | 1 | CO3 |
| 3.6 | Closed loop frequency response | 2 | CO3 |
| 3.7 | Frequency domain analysis using MATLAB | 1 | CO3 |
| **4** | **Compensation** | | |
| 4.1 | Types of compensators, Characteristics and effects of lead, lag, lag-lead compensators | 2 | CO5 |
| 4.2 | P, PI and PID controllers | 1 | CO5 |
| **5** | **State Variable Analysis** | | |
| 5.1 | Solution of state equation | 1 | CO6 |
| 5.2 | Controllability and observability | 1 | CO6 |
| 5.3 | Concept of state feedback control | 1 | CO6 |
| | Total | 40 | |

**Course Designers:**

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| 18EE470 | MEASUREMENTS AND INSTRUMENTATION LAB | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PC | - | - | 2 | 1 |

## Preamble

This course familiarizes the students in three basic aspects of measurements and instrumentation such as (i) measurement of non electric parameters, (ii) measurement of electric parameters and (iii) basic aspects data acquisition. Student can able to demonstrate the measurement of common industrial control parameters such as temperature & displacement. Also the students will get experience in utilizing the various parameters such as range, resolution & sampling frequency for selection of instruments. This course will also provide the experiences about measurement of current, voltage and power with the help of Transducers as well as with CT & PT. Finally this course also provides some exposures to basics of data acquisition.

## Prerequisite

14EE250 Analog Devices and Circuits

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Analyse the influence of range, resolution and maximum sampling frequency on instrumentation performance | 15 |
| CO2 | Measure electrical parameters using Sensors/Meters by Direct Data Acquisition | 30 |
| CO3 | Produce the electricity consumption charges using the concept of Net metering | 10 |
| CO4 | Obtain the static and dynamic characteristics of Sensors/Transducers | 25 |
| CO5 | Acquire data using Networked measurement | 10 |
| CO6 | Acquire Data using Instrument Control | 10 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | Mechanism | 1.2.9,2.1.1,2.1.5,2.2.3,2.3.1,2.3.2,3.1.1,3.1.2,3.1.5,3.1.4,3.2.1,3.2.2,3.2.3,3.2.4,3.2.5,3.2.6,3.3.1,4.4.14.4.3.4.5.1 |
| CO2 | TPS3 | Apply | Value | Mechanism | 1.2.9,2.1.1,2.1.5,2.2.3,2.3.1,2.3.2,3.1.1,3.1.2,3.1.5,3.1.4,3.2.1,3.2.2,3.2.3,3.2.4,3.2.5,3.2.6,3.3.1,4.4.14.4.3.4.5.1 |

| | | | | | |
|---|---|---|---|---|---|
| CO3 | TPS3 | Apply | Value | Mechanism | 1.2.9,2.1.1,2.1.5,2.2.3,2.3.1,2.3.2,3.1.1,3.1.2,3.1.5,3.1.4,3.2.1,3.2.2,3.2.3,3.2.4,3.2.5,3.2.6,3.3.1,4.4.14.4.3.4.5.1 |
| CO4 | TPS3 | Apply | Value | Mechanism | 1.2.9,2.1.1,2.1.5,2.2.3,2.3.1,2.3.2,3.1.1,3.1.2,3.1.5,3.1.4,3.2.1,3.2.2,3.2.3,3.2.4,3.2.5,3.2.6,3.3.1,4.4.14.4.3.4.5.1 |
| CO5 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.2.9,2.1.1,2.1.5,2.2.3,2.3.1,2.3.2,3.1.1,3.1.2,3.1.5,3.1.4,3.2.1,3.2.2,3.2.3,3.2.4,3.2.5,3.2.6,3.3.1,4.4.14.4.3.4.5.1 |
| CO6 | TPS3 | Apply | Value | Mechanism | 1.2.9,2.1.1,2.1.5,2.2.3,2.3.1,2.3.2,3.1.1,3.1.2,3.1.5,3.1.4,3.2.1,3.2.2,3.2.3,3.2.4,3.2.5,3.2.6,3.3.1,4.4.14.4.3.4.5.1 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | S | | | M | | M | | | S | S |
| CO2 | S | M | L | L | S | | | M | | M | | | S | S |
| CO3 | S | M | L | L | M | | | M | | M | | | S | S |
| CO4 | S | M | L | L | | | | M | | M | | | S | S |
| CO5 | S | S | M | M | S | | | M | | M | | | S | S |
| CO6 | S | M | L | L | | | | M | | M | | | S | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Model Examination | Terminal Examination |
|---|---|---|
| Remember | - | - |
| Understand | - | - |
| Apply | 50 | 50 |
| Analyse | 20 | 20 |
| Evaluate | - | - |
| Create | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Miniproject /Practical Component/Observation |
|---|---|

| | |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 30 |
| Complex Overt Responses | - |
| Adaptation | -- |
| Origination | - |

## List of Experiments/Activities with CO Mapping

| E.No | Name of the experiment | CO | No. of sessions |
|---|---|---|---|
| **1.** | Choice of sampling frequency and Aliasing phenomenon | CO1 | 1 |
| 2. | Choice of range and its impact on Accuracy of measurement | CO1 | 1 |
| 3. | Choice of Resolution and its impact on Accuracy of measurement | CO1 | 1 |
| 4. | True RMS measurement vs Average quantity based measurement of AC quantities | CO2 | 1 |
| 5. | Current Measurement using Current Transducer, Current Transformer | CO2 | 1 |
| 6. | Voltage Measurement using Voltage Transducer, Voltage Transformer | CO2 | 1 |
| 7. | Power measurement by data acquisition of voltage and current | CO2 | 1 |
| 8. | Power measurement from Wattage transducer using 4-20mA data transmission | CO2 | 1 |
| 9. | Measure the Net utilised energy | CO3 | 1 |
| 10. | Cold junction compensation of Thermocouple | CO4 | 1 |
| 11. | Time constant of TC/Thermistor | CO4 | 1 |
| 12. | Measurement of Temperature using RTD and Wheatstone’s bridge | CO4 | 1 |
| 13. | Dynamic Characteristics of LVDT | CO4 | 1 |
| 14. | Speed Measurement using Digital Encoder | CO4 | 1 |
| 15. | Networked Measurement of Power | CO5 | 1 |
| 16. | Data Acquisition from DSO using Instrument control | CO6 | 1 |

## Learning Resources

1. A.K. Sawhney, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai & Co, 2012.
2. E.O. Doebelin, Measurement Systems – Application and Design, Tata McGraw Hill publishing company, 2003.
3. Kalsi H.S, Electronic Instrumentation , Tata McGraw-Hill 2003

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| 18EE480 | AC MACHINES LAB |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 0 | 0 | 2 | 1 |

## Preamble

This laboratory gives a practical exposure to the students to fundamental concepts regarding AC Machines that are currently used in Electrical Systems. The students also learn to select the suitable AC Electrical Machines for an application based on its characteristics, perform suitable capacitor additions to improve power factor and to familiarize the standard testing procedures of AC Machines. The students can also perform evaluation of efficiency improvement by switching over to Adjustable speed drives and also can know about the various harmonic components that arise due to Adjustable speed drives.

## Prerequisite

18EE280 – Electrical Workshop
18EE320 - DC Machines and Transformers

## Course outcomes

| COs No. | Course outcomes | Weightage % |
|---|---|---|
| CO1 | Obtain the load characteristics of AC Generator (Salient Pole & Cylindrical Rotor type) experimentally | 20 |
| CO2 | Obtain the load characteristics of AC Motor (Squirrel Cage, Slip ring, Single Phase & Synchronous) experimentally | 20 |
| CO3 | Demonstrate predetermination efficiency of AC Motor experimentally | 20 |
| CO4 | Obtain the voltage regulation of AC Generators using EMF, MMF and ZPF methods | 20 |
| CO5 | Obtain the characteristics of Synchronous motor experimentally | 10 |
| CO6 | Demonstrate experimentally a generative action of induction machine | 10 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | Mechanism | 1.2., 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.5.1, 3.1.1, 3.1.2. 3.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO2 | TPS3 | Apply | Value | Mechanism | 1.2., 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.4.3, 2.5.1, 3.1.2, 3.1.1, 3.2.3 |
| CO3 | TPS3 | Apply | Value | Mechanism | 1.2., 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.4.3,2.5.1, 3.1.2, 3.1.1, 3.2.3 |
| CO4 | TPS3 | Apply | Value | Mechanism | 1.2., 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.4.3,2.5.1, 3.1.2, 3.1.1, 3.2.3 |
| CO5 | TPS3 | Apply | Value | Mechanism | 1.2., 2.2.3, 2.2.4,2.3.1, 2.4.1, 2.5.1, 3.1.2 3.1.1, 3.2.3 |
| CO6 | TPS2 | Understand | Respond | Guided Response | 1.2., 2.2.3, 2.2.4,2.3.1, 2.5.1, 3.1.2, 3.1.1, 3.2.3 |

**Mapping with Programme Outcomes**

| **Cos** | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO1 0** | **PO1 1** | **PO1 2** | **PSO 1** | **PSO 2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | | | | M | S | M | | | S | |
| CO2 | S | M | L | L | | M | M | M | S | M | | | S | |
| CO3 | S | M | L | L | | | | M | S | M | | | S | |
| CO4 | S | M | L | L | | M | M | M | S | M | | | S | |
| CO5 | S | M | L | L | | | | M | S | M | | | S | |
| CO6 | M | L | | | | M | S | M | S | M | | | M | |

**S**- Strong; **M**-Medium; **L**-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Model Examination** | **Terminal Examination** |
|---|---|---|
| Remember | | |
| Understand | 10 | 10 |
| Apply | 40 | 40 |
| Analyse | 20 | 20 |
| Evaluate | | |
| Create | | |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **Miniproject /Practical Component/Observation** |
|---|---|

| | |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 30 |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**List of Experiments/Activities with CO Mapping**

| E.No | Name of the experiment | CO | No. of sessions |
|---|---|---|---|
| **Asynchronous Machines** | | | |
| **1.** | Determination of Induction Motor efficiency using circuit model | CO3 | 1 |
| 2. | Performance Characteristics of Induction Motor | CO2 | 1 |
| 3. | Performance Characteristics of Induction Motor using VFD | CO2 | 1 |
| **Single Phase Induction Motor** | | | |
| 4. | Performance Characteristics of Single Phase Induction Motor | CO2 | 1 |
| **Induction Generator** | | | |
| 5. | Load Characteristics of Induction Generator | CO6 | 1 |
| **Synchronous Machines** | | | |
| 6. | V and inverted V curves of Synchronous Motor | CO5 | 1 |
| 7. | Slip test on Salient Pole Synchronous generator | CO1 | 1 |
| 8. | Regulation characteristics of Cylindrical pole Alternator | CO1 | 1 |
| 9. | Synchronization of Alternators | CO4 | 1 |
| 10. | Load Characteristics of Alternators | CO1 | 1 |

**Learning Resources**

1. H.Wayne Beaty & Jame. L.Kirtley.Jr " Electric Motor Handbook", McGraw-Hill, USA, 1st Edition, 1998.
2. A.K.Sawhney and A.Chakrabarti, "A course in Electrical Machine Design",6th Edition, Dhanpat Rai & Co (P) Ltd., 2006.
3. Gupta.J.B,"Theory of Performances of Electrical Machines' Katson, 7th Edition, 1987
4. Vincent Deldoro ," Electromechanical Energy Conversion " PHI III edition,

5. M.G.Say, The Performance and Design of Alternating Current machines, Tata-McGraw Hill.

**Course Designers**

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| 18EE490 | PROJECT MANAGEMENT |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| HSS | 3 | 0 | 0 | 3 |

## Preamble

Project management has been proven to be the most effective method of delivering products within cost, schedule, and resource constraints. It provides the skills to ensure that the projects are completed on time and on budget while giving the user the product, they expect. This course gives strong working knowledge of the basics of project management and be able to immediately use that knowledge to effectively manage work projects.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course, students will be able to

| **Cos** | **Course outcomes** | Weightage (%) |
|---|---|---|
| CO1 | Explain the importance of project management and methodologies | 15% |
| CO2 | Prepare a project proposal and apply methods for project planning and analysis | 20% |
| CO3 | Apply methods to examine the risk and social cost benefit while implementing a project | 15% |
| CO4 | Identify the critical path and time in scheduling a set of project-activities | 20% |
| CO5 | Explain resource allocation and levelling and the use of PM software | 15% |
| CO6 | Outline the importance and various activities during project closure and prepare a project report | 15% |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 2.3.1, 2.5.2, 4.2.1,4.3.4 |
| CO2 | TPS3 | Apply | Value | | 2.3.2, 2.4.3, 2.5.4, 3.2.3, 3.2.4,4.3.4 |
| CO3 | TPS3 | Apply | Value | | 2.1.4, 2.4.4, 4.1.5,4.3.4 |
| CO4 | TPS3 | Apply | Value | | 2.4.3, 2.4.4,4.3.4 |
| CO5 | TPS2 | Understand | Respond | | 3.2.4,4.3.4 |
| CO6 | TPS3 | Understand | Respond | | 2.1.5, 3.2.3, 3.2.4, 4.3.4 |

## Mapping with Programme Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1. | | | | | | | | M | | M | S | | | |
| CO2. | | | | | | | | M | | M | S | | | |
| CO 3 | | | | | | | | M | | M | S | | | |
| CO 4 | | | | | | | | M | | M | S | | | |
| CO 5. | | | | | | | | M | | M | S | | | |
| CO 6. | | | | | | | | M | | M | S | | | |

S- Strong; M-Medium; L-Low

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | | Assignments | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | - | - | - | 10 |
| Understand | 60 | 40 | 40 | - | - | - | 40 |
| Apply | 30 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | 0 | 0 | 0 | | | | 0 |
| Evaluate | 0 | 0 | 0 | | | | 0 |
| Create | 0 | 0 | 0 | | | | 0 |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. Identify the suitable project management methodology for an organization change in an Engineering college.
2. Explain the necessity of project management.
3. Explain in detail about any two project management methodologies with examples.

**Course Outcome 2 (CO2):**

1. Prepare a project proposal for the new technical function to be organized by you.
2. The sales of a certain product during a fourteen year period have been as follows:Find the least squares regression line for the data given.

| Period | Sales | Period | Sales |
|---|---|---|---|
| 1 | 2000 | 8 | 4000 |
| 2 | 2200 | 9 | 3900 |

| | | | |
|---|---|---|---|
| 3 | 2100 | 10 | 4000 |
| 4 | 2300 | 11 | 4200 |
| 5 | 2500 | 12 | 4300 |
| 6 | 3200 | 13 | 4900 |
| 7 | 3600 | 14 | 5300 |

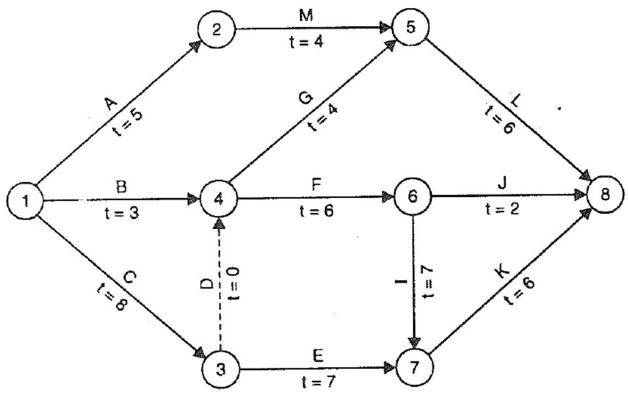
3. Consider a scenario that you are organizing an Electrical Association event on software contest. Do SWOT analysis for this assignment. Explain the outcome of the analysis.

**Course Outcome 3 (CO3)**

1. Prepare a work breakdown structure for a shifting a software company from one location to another and illustrate the need of WBS
2. Do the UNIDO-SCBA analysis for the new government road projects.
3. Demonstrate the risks associated in a electronics project implementation.

**Course Outcome 4 (CO4)**

1. Create a customer database for the Modesto league baseball team. Draw a project network Complete the forward and backward pass, compute activity slack, and identify the critical path. How long will this project take? How sensitive is the network schedule? Calculate the free slack and total slack for all noncritical activities.
2. The following nework shows information related to a project that involves merging two marketing firms. Determine the Earliest start time, Earliest finish time, Latest start time and latest completion time for each activity. List the critical activities and determine the project completion duration.



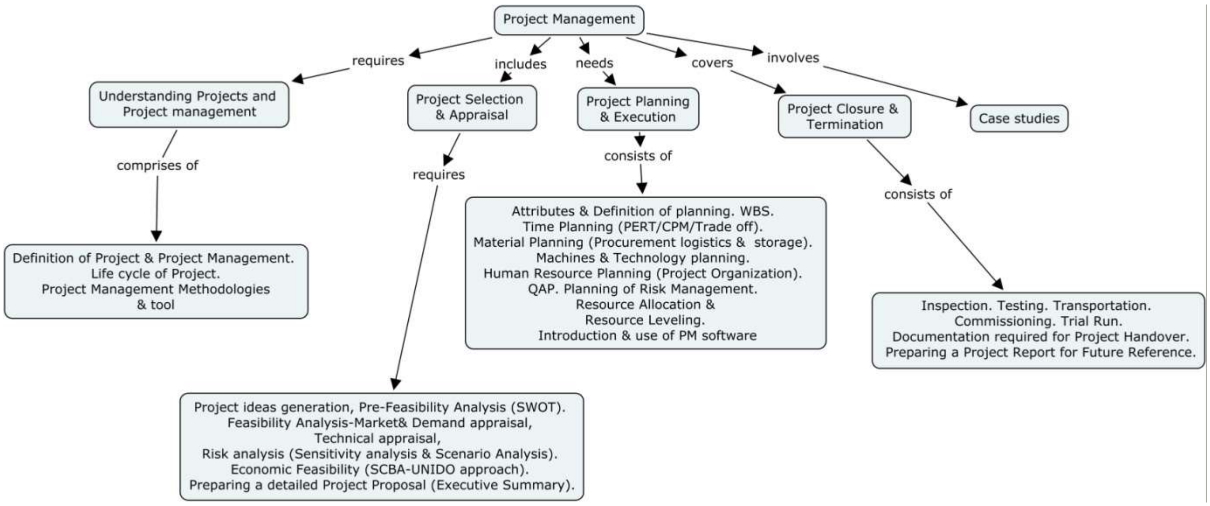

**Course Outcome 5 (CO5)**

1. Explain resource allocation in detail
2. Discuss various PM software that are being used widely.
3. Explain about the resource levelling

**Course Outcome 6 (CO6)**

1. Discuss the key elements to be included in project report.
2. Develop a project report for the given problem scenario.
3. List out the various activities to be considered in project closure.

## Concept Map




## Syllabus

**Understanding Projects and Project management**: Definition of Project & Project Management. Life cycle of Project. Project Management Methodologies and tools.

**Project Selection & Appraisal:** Project ideas generation, Pre-Feasibility Analysis -SWOT Feasibility Analysis-Market& Demand appraisal, Technical appraisal, Risk analysis-Sensitivity analysis & Scenario Analysis. Economic Feasibility -SCBA-UNIDO approach. Preparing a detailed Project Proposal (Executive Summary).

**Project Planning& Execution**: Attributes & Definition of planning. WBS. Time Planning - PERT/CPM/Trade off. Material Planning - Procurement logistics & storage. Machines & Technology planning. Human Resource Planning in Project Organization. Quality Assurance Plan. Planning of Risk Management. Resource Allocation & Resource Levelling. Introduction & use of PM software.

**Project Closure & Termination:** Inspection. Testing. Transportation. Commissioning. Trial Run. Documentation required for Project Handover. Preparing a Project Report for Future Reference, Templates.

**Case Studies**

## Learning Resources

1. Prasanna Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review,Mc Graw Hill, 8th edition, 2015
2. Project planning and control using PERT and CPM, Dr.P.C.Punmia, Lakshmi publications, 2006
3. Project Management- A Managerial Approach to Planning, Scheduling, and Controlling Harold Kerzner, 10th edition John Wiley & Sons, Inc.
4. Project Management Institute (PMBOK) Guide, 5th Edition

**Lecture Schedule**

| S.No. | Topic | No. of Lectures | COs |
|---|---|---|---|
| 1 | **Understanding Projects and Project management**: | | |
| 1.1 | Definition of Project & Project Management. | 1 | CO1 |
| 1.2 | Life cycle of Project. | 1 | CO1 |
| 1.3 | Project Management Methodologies | 2 | CO1 |
| 1.4 | Project Management tools | 1 | CO1 |
| 2 | **Project Selection & Appraisal:** | | |
| 2.1 | Project ideas generation, Pre-Feasibility Analysis -SWOT. | 2 | CO2 |
| 2.2 | Feasibility Analysis-Market& Demand appraisal, | 2 | CO2 |
| 2.3 | Technical appraisal | 1 | CO2 |
| 2.4 | Risk analysis (Sensitivity analysis & Scenario Analysis). | 2 | CO3 |
| 2.5 | Economic Feasibility (SCBA-UNIDO approach). | 2 | CO3 |
| 2.6 | Preparing a detailed Project Proposal (Executive Summary). | 1 | CO2 |
| **3** | **Project Planning& Execution**: | | |
| 3.1 | Attributes & Definition of planning. WBS. | 1 | CO2 |
| 3.2 | Time Planning (PERT). | 3 | CO4 |
| 3.3 | CPM/Trade off | 3 | CO4 |
| 3.4 | Material Planning (Procurement logistics & storage), Machines & Technology planning. | 1 | CO5 |
| 3.5 | Human Resource Planning (Project Organization). | 1 | CO5 |
| 3.6 | QAP. | 1 | CO5 |
| 3.7 | Planning of Risk Management. | 1 | CO3 |
| 3.8 | Resource Allocation & Resource Leveling. | 1 | CO5 |
| 3.9 | Introduction & use of PM software. | 2 | CO5 |
| **4** | **Project Closure & Termination:** | | |
| 4.1 | Inspection. Testing. Transportation. | 1 | CO6 |
| 4.2 | Commissioning. Trial Run. | 1 | CO6 |
| 4.3 | Documentation required for Project Handover. | 1 | CO6 |
| 4.4 | Preparing a Project Report for Future Reference. | 1 | CO6 |
| **5** | **Case Studies** | 3 | CO6 |

| | | | |
|---|---|---|---|
| | Total | 36 | |

## Course Designers

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| 18CHAB0 | CONSTITUTION OF INDIA |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| AC | 2 | 0 | 0 | 0 |

**Preamble**

On the successful completion of the course, the students will be able to explain the basic features and fundamental principles of Constitution of India. The Constitution of India is the supreme law of India. Parliament of India cannot make any law which violates the Fundamental Rights enumerated under the Part III of the Constitution. The Parliament of India has been empowered to amend the Constitution under Article 368, however, it cannot use this power to change the "basic structure" of the constitution, which has been ruled and explained by the Supreme Court of India in its historical judgments. The Constitution of India reflects the idea of "Constitutionalism" – a modern and progressive concept historically developed by the thinkers of "liberalism" – an ideology which has been recognized as one of the most popular political ideology and result of historical struggles against arbitrary use of sovereign power by state. The historic revolutions in France, England, America and particularly European Renaissance and Reformation movement have resulted into progressive legal reforms in the form of "constitutionalism" in many countries. The Constitution of India was made by borrowing models and principles from many countries including United Kingdom and America.

The Constitution of India is not only a legal document but it also reflects social, political and economic perspectives of the Indian Society. It reflects India's legacy of "diversity". It has been said that Indian constitution reflects ideals of its freedom movement; however, few critics have argued that it does not truly incorporate our own AICTE Model Curriculum for Mandatory Courses & Activities (Non-Credit) for Undergraduate Degree in Engineering & Technology ancient legal heritage and cultural values. No law can be "static" and therefore the Constitution of India has also been amended more than one hundred times. These amendments reflect political, social and economic developments since the year 1950. The Indian judiciary and particularly the Supreme Court of India has played an historic role as the guardian of people. It has been protecting not only basic ideals of the Constitution but also strengthened the same through progressive interpretations of the text of the Constitution. The judicial activism of the Supreme Court of India and its historic contributions has been recognized throughout the world and it gradually made it "as one of the strongest court in the world"

**Course Outcome:**

On the successful completion of the course students will be able to

| | | |
|---|---|---|
| CO1 | Explain the meaning of the constitution law and constitutionalism and | Understand |

| | | |
|---|---|---|
| | Historical perspective of the Constitution of India | |
| CO2 | Explain the salient features and characteristics of the Constitution of India, scheme of the fundamental rights and the scheme of the Fundamental Duties and its legal status | Understand |
| CO3 | Explain the Directive Principles of State Policy, Federal structure and distribution of legislative and financial powers between the Union and the States, and Parliamentary Form of Government in India | Understand |
| CO4 | Explain the amendment of the Constitutional Powers and Procedure, the historical perspectives of the constitutional amendments in India, and Emergency Provisions. | Understand |
| CO5 | Explain the Local Self Government – Constitutional Scheme in India, Scheme of the Fundamental Right to Equality, | Understand |
| CO6 | Explain the scheme of the Fundamental Right to certain Freedom under Article 19, and Scope of the Right to Life and Personal Liberty under Article 21 | Understand |

**Mapping with Programme Outcomes**

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

S- Strong; M-Medium; L-Low

**Syllabus**

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the fundamental rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy – Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India
9. Amendment of the Constitutional Powers and Procedure
10. The historical perspectives of the constitutional amendments in India
11. Emergency Provisions : National Emergency, President Rule, Financial Emergency
12. Local Self Government – Constitutional Scheme in India
13. Scheme of the Fundamental Right to Equality
14. Scheme of the Fundamental Right to certain Freedom under Article 19
15. Scope of the Right to Life and Personal Liberty under Article 21

**Assessment Pattern**

| **Bloom's category** | **Continuous Assessment Tests** | | **Seminar** |
|---|---|---|---|
| | **1** | **2** | **-** |
| Remember | 40 | 40 | 0 |
| Understand | 60 | 60 | 100 |
| Apply | 0 | 0 | 0 |
| Analyze | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 |
| Create | 0 | 0 | 0 |

**References**

1. Durga Das Basu, 'Introduction to The Constitution of India', LexisNexis Butterworths Wadhwa, 20th Edition, Reprint 2011.
2. Constitution of India, National Portal of India, Web link: https://www.india.gov.in/my-government/constitution-india

**Course Designers:**

1. Adapted from AICTE Model Curriculum for Undergraduate Degree Courses in Engineering & Technology, Volume-II, January 2018.

**CURRICULUM AND DETAILED SYLLABI**

**FOR**

**B.E. EEE DEGREE PROGRAMME**

**FIFTH TO EIGHTH SEMESTER**

**FOR THE STUDENTS ADMITTED IN THE**

**ACADEMIC YEAR 2018-19 ONWARDS**

**THIAGARAJAR COLLEGE OF ENGINEERING**
(A Government Aided Autonomous Institution affiliated to Anna University)
**MADURAI – 625 015, TAMILNADU**

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**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**
**B.E. EEE Degree Programme**
**COURSES OF STUDY**
(For the candidates admitted from 2018-19)

**FIFTH SEMESTER**

| Course Code | Name of the Course | Category | No. of Hours / Week | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| 18EE510 | Generation, Transmission and Distribution | PC | 2 | 1 | - | 3 |
| 18EE520 | Microcontrollers | PC | 3 | - | - | 3 |
| 18EE530 | Power Electronics | PC | 3 | - | - | 3 |
| 18EE540 | Accounting and Finance | HSS | 3 | - | - | 3 |
| 18YYGX0 | General Elective | GE | 3 | - | - | 3 |
| 18EEPX0 | Programme Elective | PE | | | | 3 |
| **THEORY CUM PRACTICAL** | | | | | | |
| 18ES590 | System Thinking | ES | 1 | - | 2 | 2 |
| **PRACTICAL** | | | | | | |
| 18EE570 | Microcontrollers Lab | PC | - | - | 2 | 1 |
| 18EE580 | Control and Automation Lab | PC | - | - | 2 | 1 |
| **MANDATORY AUDIT COURSE** | | | | | | |
| 18CHAC0 | Essence of Indian Knowledge | AC | 2 | - | - | 0 |
| **Total** | | | | | | **22** |

**SIXTH SEMESTER**

| Course Code | Name of the Course | Category | No. of Hours / Week | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| 18EE610 | Power System Analysis | PC | 3 | - | - | 3 |
| 18EE620 | Data Structures | ES | 3 | - | - | 3 |
| 18EEPX0 | Programme Elective | PE | | | | 3 |
| 18XXXX0 | Elective | PE/GE/FE | | | | 3 |
| 18XXXX0 | Elective | ES | | | | 3 |
| **PRACTICAL** | | | | | | |
| 18EE670 | Energy Management System Laboratory | PC | - | - | 2 | 1 |
| 18EE680 | Power Electronics and Drives Lab | PC | - | - | 2 | 1 |
| 18ES690 | Engineering Design Project | Project | - | - | 6 | 3 |
| **Total** | | | | | | **20** |

**SEVENTH SEMESTER**

| Course Code | Name of the Course | Category | No. of Hours / Week | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| 18EE710 | Electric Power Utilization | PC | 3 | - | - | 3 |
| 18EEPX0 | Programme Elective | PE | | | | 3 |
| 18EEPX0 | Programme Elective | PE | | | | 3 |
| 18EEPX0 | Programme Elective | PE | | | | 3 |
| 18XXXX0 | Elective | PE/GE/FE | | | | 3 |
| **PRACTICAL** | | | | | | |
| 18EE770 | Electric Power Systems Laboratory | PC | - | - | 2 | 1 |
| 18ES790 | Capstone Design Project | Project | - | - | 6 | 3 |
| **Total** | | | | | | **19** |

**EIGHTH SEMESTER**

| Course Code | Name of the Course | Category | No. of Hours / Week | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| 18EEPX0 | Programme Elective | PE | | | | 3 |
| 18XXXX0 | Elective | PE/GE/FE | | | | 3 |
| **PRACTICAL** | | | | | | |
| 18EE890 | Project | Project | - | - | 18 | 9 |
| **Total** | | | | | | **15** |

BS : Basic Science
ES : Engineering Science
PC : Programme Core
PE : Programme Elective ; GE: General Elective; FE: Foundation Elective
L : Lecture
T : Tutorial
P : Practical

**Note**:

1 Hour Lecture/week is equivalent to 1 credit
1 Hours Tutorial/week is equivalent to 1 credit
2 Hours Practical/week is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015**
**B.E. EEE Degree Programme**

**SCHEME OF EXAMINATIONS**
(For the candidates admitted from 2018-19onwards)

**FIFTH SEMESTER**

| S.No. | Course Code | Name of the Course | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | 18EE510 | Generation, Transmission and Distribution | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | 18EE520 | Microcontrollers | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | 18EE530 | Power Electronics | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | 18EE540 | Accounting and Finance | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | 18YYGX0 | General Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| 6 | 18EEPX0 | Programme Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| **THEORY CUM PRACTICAL** | | | | | | | | |
| 7 | 18ES590 | System Thinking | - | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 8 | 18EE570 | Microcontrollers Lab | 3 | 50 | 50 | 100 | 25 | 50 |
| 9 | 18EE580 | Control and Automation Lab | 3 | 50 | 50 | 100 | 25 | 50 |

## SIXTH SEMESTER

| S.No. | Course Code | Name of the Course | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | 18EE610 | Power System Analysis | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | 18EE620 | Data Structures | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | 18EEPX0 | Programme Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | 18XXXX0 | Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | 18XXXX0 | Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 6 | 18EE670 | Energy Management System Laboratory | 3 | 50 | 50 | 100 | 25 | 50 |
| 7 | 18EE680 | Power Electronics and Drives Lab | 3 | 50 | 50 | 100 | 25 | 50 |
| 8 | 18ES690 | Engineering Design Project | - | 50 | 50 | 100 | 25 | 50 |

## SEVENTH SEMESTER

| S.No. | Course Code | Name of the Course | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | 18EE710 | Electric Power Utilization | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | 18EEPX0 | Programme Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | 18EEPX0 | Programme Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | 18EEPX0 | Programme Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | 18XXXX0 | Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 6 | 18EE770 | Electric Power Systems Laboratory | 3 | 50 | 50 | 100 | 25 | 50 |
| 7 | 18ES790 | Capstone Design Project | - | 50 | 50 | 100 | 25 | 50 |

## EIGHTH SEMESTER

| S.No. | Course Code | Name of the Course | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | 18EEPX0 | Programme Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | 18XXXX0 | Elective | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 3 | 18EE890 | Project | - | 50 | 50 | 100 | 25 | 50 |

* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

| 18EE510 | GENERATION, TRANSMISSION AND DISTRIBUTION |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 2 | 1 | 0 | 3 |

## Preamble

The objective of any power system is to generate electrical energy in sufficient quantity at various locations, to transmit it as a bulk to various load centers and to distribute it with different voltage levels to various consumers with good quality and reliability. To maintain the quality and reliability of supply, the voltage and frequency are to be maintained at specified values, with minimum voltage drop and power loss at an economic price. This course introduces the technical aspects of power generation from non-renewable and renewable energy sources. The calculation of network parameters and performance indices of transmission lines, voltage and current calculation in distribution lines and study of insulators and underground cables are also included.

## Prerequisite

18EE230 : Electric Circuit Analysis
18EE240 : Electromagnetic Fields
18EE320 : DC Machines & Transformers
18EE420: AC Machines

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | **Explain** the methods of electric power generation using conventional and non-conventional energy sources. | 20 |
| CO2 | **Compute** the transmission network parameters for various configurations. | 15 |
| CO3 | **Compute** the performance indices of transmission lines using nominal-T, $\pi$, rigorous methods and Power circle diagram. | 20 |
| CO4 | **Explain** the construction of various types of insulators and underground cables. | 5 |
| CO5 | **Compute** the string efficiency of suspension insulators. | 10 |
| CO6 | **Compute** the grading parameter (thickness and location of different insulating materials and inter-sheaths) for uniform dielectric stress in UG cables. | 10 |
| CO7 | **Compute** the voltages and currents for a given distribution System. | 20 |

*** Weightage depends on Bloom's Level and number of contact hours.

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.2, 2.3.1,3.2.3 |
| CO2 | TPS3 | Apply | Value | | 1.2, 2.1.5,3.2.3 |
| CO3 | TPS3 | Apply | Value | | 1.2, 2.1.5,3.2.3 |
| CO4 | TPS2 | Understand | Respond | | 1.2, 2.3.1,3.2.3 |
| CO5 | TPS3 | Apply | Value | | 1.2, 2.1.5,3.2.3 |
| CO6 | TPS3 | Apply | Value | | 1.2, 2.1.5,3.2.3 |
| CO7 | TPS3 | Apply | Value | | 1.2, 2.1.5,3.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | **M** | **L** | | | | | | **M** | | **M** | | | **M** | |
| CO2 | **S** | **M** | **L** | | | | | **M** | | **M** | | | **S** | |
| CO3 | **S** | **M** | **L** | | | | | **M** | | **M** | | | **S** | |
| CO4 | **M** | **L** | | | | | | **M** | | **M** | | | **M** | |
| CO5 | **S** | **M** | **L** | | | | | **M** | | **M** | | | **S** | |
| CO6 | **S** | **M** | **L** | | | | | **M** | | **M** | | | **S** | |
| CO7 | **S** | **M** | **L** | | | | | **M** | | **M** | | | **S** | |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 10 | 10 | | | | 10 |
| Understand | 40 | 40 | 40 | | | | 40 |
| Apply | 40 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | 0 | 0 | 0 | | | | 0 |
| Evaluate | 0 | 0 | 0 | | | | 0 |
| Create | 0 | 0 | 0 | | | | 0 |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **~~Miniproject~~ /Assignment/~~Practical Component~~** |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Explain the basic thermal power plant with the help of suitable diagrams.
2. Describe (i) Basic components of wind electric system (ii) Standalone Solar PV systems.
3. Discuss the merits and demerits of Nuclear power plant.

**Course Outcome 2 (CO2):**

1. The six conductors of a double circuit three phase line are arranged as shown in Fig.1 The dia of each conductor is 1.5cm. Find the inductive and capacitive reactance to neutral and the charging current per km per phase at 66 KV and 50Hz, assuming that the line is transposed.

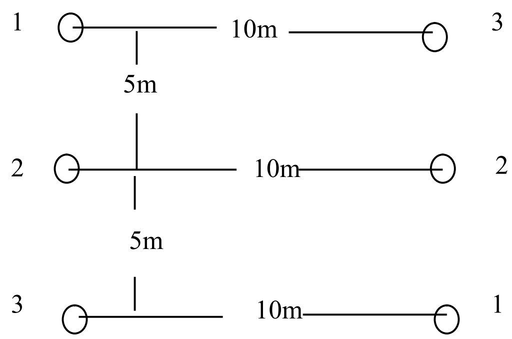



Fig.1

2. A single-phase overhead transmission line consists of two solid aluminum conductors having a radius of 2.5 cm, with a spacing 3.6 m between centers. (a) Determine the total line inductance in mH/m. (b) Given the operating frequency to be 60 Hz, find the total inductive reactance of the line in Ω/km. (c) If the spacing is doubled to 7.2 m, how does the reactance change?
3. Fig. 2 shows the conductor configuration of a completely transposed three-phase overhead transmission line with bundled phase conductors. All conductors have a radius of 0.74 cm with a 30-cm bundle spacing. (a) Determine the inductance per phase in mH/km (b) Find the inductive line reactance per phase in Ω/km at 60 Hz.

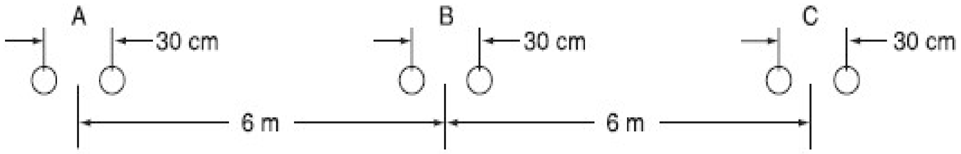



Fig. 2

**Course Outcome 3 (CO3):**

1. A balanced 3 phase load of 40MW is supplied at 132KV, 50 Hz and 0.8 p.f lagging by means of transmission line. The series impedance of a single conductor is (20+j50) ohms and the total phase-neutral admittance is 315 x $10^{-6}$ mho. Using nominal-T and -π methods, determine: (a)the A,B,C, and D constants (b)receiving end voltage and (c)regulation of the line.

2. A 132kV, 3-phase, 50Hz transmission line 200km long delivers a load of 50MW at 0.9 PF lagging 110kV has the following distributed parameters: L =1.3x$10^{-3}$ H/km , C = 9 x$10^{-9}$ F/km R = 0.2 Ω/km. Find the generalized constants. Find the maximum power transfer capacity of the line.

**Course Outcome 4 (CO4):**

1. Discuss the various types of insulators and their applications.
2. Consider a three-core, three-phase, 50 Hz, 11 kV cable whose conductors are denoted as, RY and B in the Fig.3 The inter-phase capacitance(C1) between each line conductor and the sheath is 0.4 F m . Find the per-phase charging current.

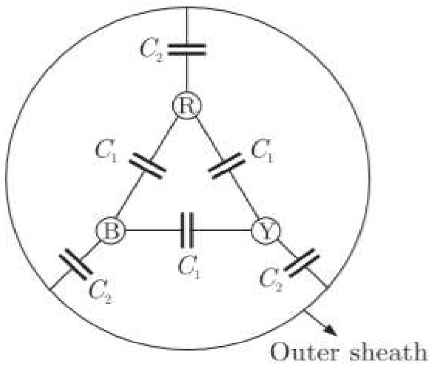



Fig.3

**Course Outcome 5 (CO5):**

1. Calculate the string efficiency of a 3 unit suspension insulator if the capacitance of the link pins to earth and the line are respectively 25% and 10% of self capacitance of each unit. What should be the values of link pins to the line C for 100% string efficiency?
2. Each of the three insulators forming a string has a self-capacitance of C Farads. The shunting capacitance of the connecting network of each insulator is 0.2C to earth and 0.15C to the line. A guard ring increases the capacitance to the line of the network of the lowest insulator to 03C. Calculate the string efficiency of the arrangement with guard ring.

**Course Outcome 6 (CO6):**

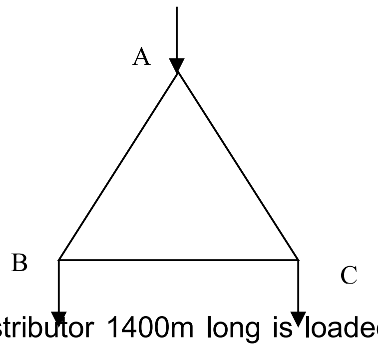
1. A single core lead sheathed cable has a diameter of 3 cm: the diameter of the cable being 9 cm. The cable is graded by using two dielectrics of relative permittivity 5 and 4 respectively with corresponding safe working stress of 30 kV/cm and 20 kV/cm. Calculate the radial thickness of each insulation and the safe working voltage of the cable.
2. A single core cable for 66kV, 3phase system as a conductor of 2cm diameter and sheath of inside diameter 5.3cm. It is required to have two intersheaths so that the

stress varies between the same maximum and minimum values in the three layers of dielectric. Find the positions of intersheaths, maximum and minimum stress and voltages on the intersheaths

**Course Outcome 7 (CO7):**

1. 3-phase distribution system is as shown in Figure 4. Power is supplied at A at 11kV(line voltage) and balanced loads of 50A per phase at 0.8 lagging power factor and 70A at 0.9 power factor are taken at B and C respectively. The impedance of the feeders are AB = (5 +j9) Ω, BC = (6+j10) Ω and CA = (4 +j8) Ω. Calculate the voltage at B and C and the currents in each branch. Power factors are assumed with respect to voltage at A.

Figure 4.




2. A 2 wire distributor 1400m long is loaded as shown in Fig.5. B is the midpoint. The Power factors at the two load points refer to the voltage at C. The impedance of each line is (0.15 + j 0.2) ohms. Calculate the sending end voltage and current. The voltage at C is 240V.

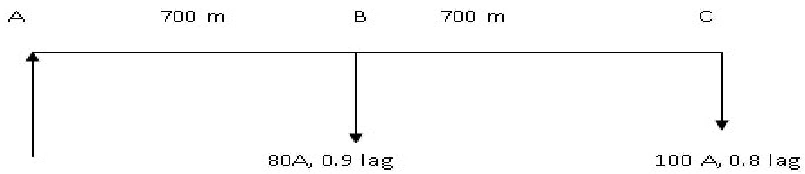
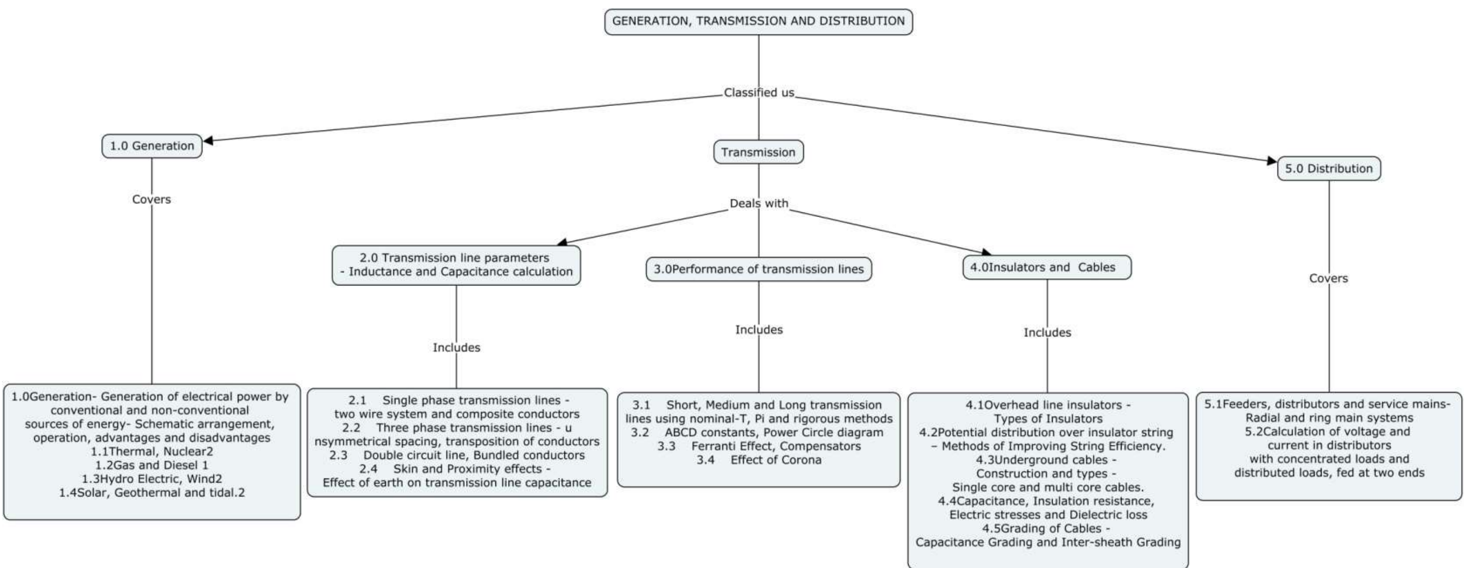



Fig.5

## Concept Map



## Syllabus

**Generation -** Generation of electrical power by conventional and non-conventional sources of energy- Schematic arrangement, operation, advantages and disadvantages-Thermal, Nuclear, Gas and Diesel - Hydro Electric, Wind, Solar, Geothermal and tidal.

**Transmission line parameters -** Inductance and Capacitance calculation - Single phase transmission lines - two wire system and composite conductors - Three phase transmission lines - unsymmetrical spacing, transposition of conductors, double circuit line – Bundled conductors - Skin and Proximity effects - Effect of earth on transmission line capacitance.

**Performance of transmission lines –** Performance characteristics of Short, Medium and Long transmission lines - nominal-T, $\pi$ and rigorous methods – ABCD constants – Power Circle diagram, Ferranti Effect, Compensators, Effect of Corona.

**Insulators and Cables -** Overhead line insulators -Types of Insulators – Potential distribution over insulator string – Methods of Improving String Efficiency .

Underground cables - Construction and types - Single core and multi core cables - Capacitance, Insulation resistance, Electric stresses and Dielectric loss – Grading of Cables - Capacitance Grading and Inter-sheath Grading.

**Distribution systems** - AC Distribution Systems – Feeders, distributors and service mains- Radial and ring main systems- Calculation of voltage and current in distributors with concentrated and distributed loads -fed at both ends.

## Learning Resources

1. C.L. Wadwa - "Electrical Power system", New Age International-6th Edition – 2010.
2. C.L. Wadhwa, "Generation, Distribution and Utilization of Electrical Energy", New Age International Publishers, Second Edition, 2006.
3. S.N. Singh, Electric Power Generation, Transmission and Distribution, Prentice Hall of India, ISBN – (978-81-203-36508), Second edition 2008.
4. Chetan Singh Solanki, Renewable Energy Technologies, PHI Learning Private Limited, New Delhi, 5th Printing, 2013.
5. B.R.Gupta, "Power System Analysis and Design", S.Chand& Co. pvt.ltd.,2015 Edition.
6. H. Cotton and H. Barber - Transmission and distribution of electrical energy – BI, NewDelhi -1992.
7. S.L. Uppal - Electrical power, Khanna Publishers, 1996.

8. Soni ML and Gupta PV - A Textbook on Power Systems Engineering – Dhanpath Rai 1st Edition-1998.
9. IS 12360:1988 - Voltage Bands For Electrical Installations Including Preferred Voltages And Frequency
10. T.S.M. Rao - Principles and practice of electric power transfer systems, 1994.
11. 141-1993 - IEEE Recommended Practice for Electric Power Distribution for Industrial Plants.
12. http://nptel.ac.in/courses

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| **1.0** | **Generation-** Generation of electrical power by conventional and non-conventional sources of energy- Schematic arrangement, operation, advantages and disadvantages | | |
| 1.1 | Thermal, Nuclear | 2 | CO1 |
| 1.2 | Gas and Diesel | 1 | CO1 |
| 1.3 | Hydro Electric, Wind | 2 | CO1 |
| 1.4 | Solar, Geothermal and tidal. | 2 | CO1 |
| **2.0** | **Transmission line parameters -** Inductance and Capacitance calculation | | |
| 2.1 | Single phase transmission lines - two wire system and composite conductors | 3 | CO2 |
| 2.2 | Three phase transmission lines - unsymmetrical spacing, transposition of conductors | 3 | CO2 |
| 2.3 | Double circuit line, Bundled conductors | 2 | CO2 |
| 2.4 | Skin and Proximity effects - Effect of earth on transmission line capacitance | 1 | CO2 |
| **3.0** | **Performance of transmission lines -** Performance characteristics | | |
| 3.1 | Short, Medium and Long transmission lines using nominal-T, $\pi$ and rigorous methods | 3 | CO3 |
| 3.2 | ABCD constants, Power Circle diagram | 2 | CO3 |
| 3.3 | Ferranti Effect, Compensators | 1 | CO3 |
| 3.4 | Effect of Corona | 1 | CO3 |
| **4.0** | **Insulators and Cables** | | |
| 4.1 | Overhead line insulators -Types of Insulators | 1 | CO4 |
| 4.2 | Potential distribution over insulator string – Methods of Improving String Efficiency. | 2 | CO5 |
| 4.3 | Underground cables - Construction and types - Single core and multi core cables. | 2 | CO4 |
| 4.4 | Capacitance, Insulation resistance, Electric stresses and Dielectric loss | 1 | CO4 |
| 4.5 | Grading of Cables - Capacitance Grading and Inter- | 2 | CO6 |

| | | | |
|---|---|---|---|
| | sheath Grading | | |
| **5.0** | **Distribution systems** - AC Distribution Systems | | |
| 5.1 | Feeders, distributors and service mains- Radial and ring main systems | 2 | CO7 |
| 5.2 | Calculation of voltage and current in distributors with concentrated loads and distributed loads, fed at two ends | 3 | CO7 |
| | TOTAL | 36 | |

**Course Designers:**

1.Prof. S.Sivakumar siva@tce.edu

2. Dr.N.Shanmuga Vadivoo nsveee@tce.edu

3.Dr.R.Rajan Prakash r_rajanprakash@tce.edu

| | | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| **18EE520** | **MICROCONTROLLERS** | PC | 3 | 0 | 0 | 3 |

## Preamble

Microprocessors are the predecessors to microcontrollers and they are mainly used as CPU in the desktop computers and laptops nowadays and they are also used for measurement and control applications in the past few decades. Due to the development in VLSI technology, microcontrollers evolve which function similar to microprocessors but they have most of the peripherals built on-chip. Microcontroller is used as the main controller in most of the embedded systems nowadays. This course makes the students to be familiar with the architecture and programming of Microcontrollers. Introduction to Microprocessors and their evolution is also given. This course provides a detailed study of architecture and assembly language & embedded 'C' language programming of Intel 8051 and ATmega328p microcontroller and interfacing various peripherals with them.

## Prerequisite

18EE340 – Digital Systems

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the evolution and architecture of microprocessors and microcontrollers. | 15 |
| CO2 | Explain the architecture and the function of on-chip hardware units in 8051 microcontroller. | 15 |
| CO3 | Develop 8051 Assembly Language programs for data manipulations and accessing on-chip hardware units. | 15 |
| CO4 | Explain the architecture and hardware features of ATmega328p | 15 |
| CO5 | Develop 8051 based embedded C programs for interfacing LED, Matrix Keyboard, LCD, DAC, ADC, 7 segment LED Display and Stepper/DC Motors. | 25 |
| CO6 | Develop ATmega328p based embedded C programs for Capture/Compare/PWM generation and signal acquisition using on-chip ADC | 15 |

*** Weightage depends on Bloom's Level, number of contact hours.

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psycho motor | |
| CO1 | TPS2 | Understand | Respond | | 1.2, ,3.2.3 |
| CO2 | TPS2 | Understand | Respond | | 1.2, 2.3.1, 2.3.2,3.2.3 |
| CO3 | TPS3 | Apply | Value | | 1.2, 2.1.1, 2.3.2 , 2.1.5,3.2.3 |
| CO4 | TPS3 | Understand | Respond | | 1.2, 2.3.1, 2.3.2,3.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO5 | TPS4 | Apply | Value | | 1.2, 2.3.1, 2.3.2, ,3.2.3, 2.1.5 |
| CO6 | TPS2 | Apply | Value | | 1.2,2.3.1, 2.3.2, ,3.2.3, 2.1.5 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | M | L | | | | | | M | | M | | | | M |
| CO3 | S | M | L | | | | | M | | M | | | | S |
| CO4 | M | L | | | | | | M | | M | | | | M |
| CO5 | S | M | L | | | | | M | | M | | | | S |
| CO6 | S | M | L | | | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 40 | 20 | 20 | - | - | - | 20 |
| Understand | 40 | 30 | 30 | - | - | - | 30 |
| Apply | 20 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | 0 | 0 | 0 | | | | 0 |
| Evaluate | 0 | 0 | 0 | | | | 0 |
| Create | 0 | 0 | 0 | | | | 0 |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO1):**

1. Compare microprocessors and microcontrollers.
2. Distinguish Harvard and Von Neuman architectures.

3. Give examples for RISC machines.

**Course Outcome 2(CO2):**

1. If a 12 MHz crystal is connected to 8051, how much is the time duration for one state and one machine cycle?
2. How to program the external interrupts of 8051 as falling edge or low level triggered interrupt?
3. Why external pull-up resistor is required for port-0 in 8051?

**Course Outcome 3(CO3):**

1. Write the 8051 ALP to find the largest byte in an array, stored in the external data memory from the address 2000H and store the result in the address 3000H. The array contains one hundred bytes of data.
2. Write 8051 ALP to convert the given 8-bit binary number into BCD number.
3. Write 8051 assembly language program to generate a square wave of 1 KHz using timer 0 of 8051. The crystal frequency is 12 MHz.

**Course Outcome 4 (CO4):**

1. List the on-chip hardware units available in ATmega328p microcontroller.
2. Explain the working of on-chip ADC module in ATmega328p.
3. Specify the function of CCP module in ATmega328p microcontroller.

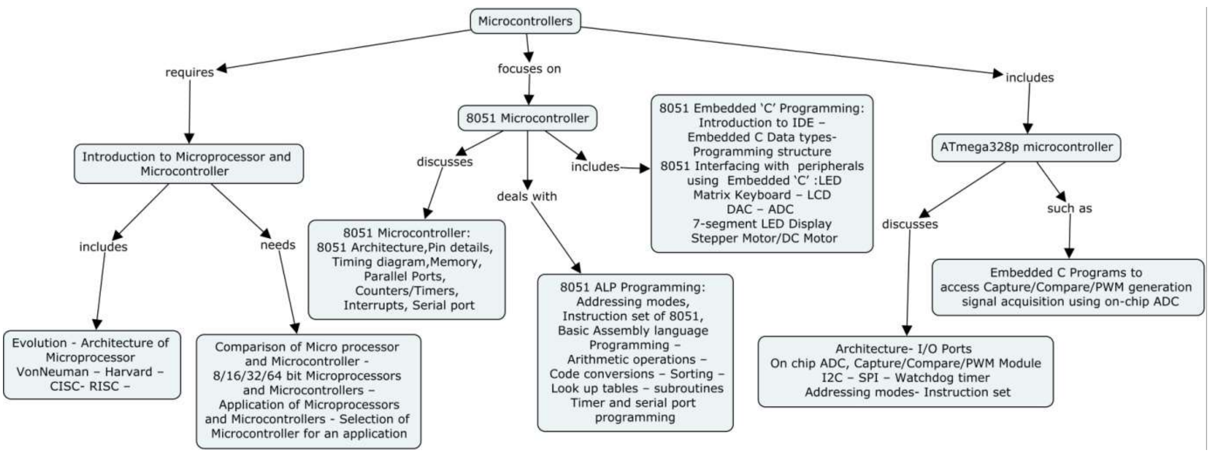
**Course Outcome 5 (CO5):**

1. Interface an 2*16 LCD with 8051 and write embedded ‘C’ program to display the name of the Department and College in the middle portion of the LCD.
2. Interface an 8-bit ADC with 8051 and write embedded ‘C’ program to get 100 samples of input data each taken at a time interval of 100 micro seconds and store the result in external data memory from the address 2000H. The crystal frequency is 12 MHz.
3. Write 8051 based embedded C program to identify the key pressed in the matrix keyboard interfaced with 8051 and send the ASCII code of the key pressed in Port 0.

**Course Outcome 6(CO6):**

1. Develop an embedded C program to access on-chip ADC of ATmega328p and to convert the given analog signal to digital.
2. Configure the Capture unit of ATmega328p controller to capture the external event
3. Generate PWM signals using ATmega328p microcontroller to provide gate pulses of a single phase inverter.

## Concept Map



## Syllabus

**Introduction:** Introduction to Microprocessor and Microcontroller – Evolution – Architecture of Microprocessor -Von Neumann and Harvard architecture – CISC and RISC –– Comparison of Microprocessor and Microcontroller – Overview of 8/16/32/64 bit Microprocessors and Microcontrollers – Applications of Microprocessors and Microcontrollers - Selection of Microcontroller for an application.
**8051 Microcontroller:** 8051 Architecture – Pin details- Timing Diagram - Memory - Parallel Ports - Counters/Timers – Interrupts - Serial port.
**8051 Assembly Language Programming:** Addressing modes, Instruction set of 8051, Basic Assembly language Programming – Arithmetic operations – Code conversions – Sorting – Look up tables – subroutines – Timer/Counter, Interrupt and serial port programming. Introduction to simulators.
**ATmega328p microcontroller**: Architecture- I/O Ports - On chip ADC, Capture/Compare/PWM Module - $I^2C$ – SPI – Watchdog timer - Addressing modes- Instruction set
**Embedded 'C' Programming:** Introduction to IDE – Embedded C Data types-Programming structure
**8051 Interfacing with peripherals using Embedded 'C'**: LED - Matrix Keyboard – LCD – DAC – ADC – 7-segment LED Display – Stepper Motor/DC Motor.
**ATmega328p based embedded C programs:** Programs to access Capture/Compare/PWM generation - signal acquisition using on-chip ADC

## Learning Resources


1. Muhammad Ali Mazidi, Janice Gillispie Mazidi, and Rolin D. McKinlay, The 8051 Microcontroller and Embedded Systems, (second edition), 2005 Pearson Education, Inc
2. Ajay V.Deshmukh, Microcontrollers- Theory and applications, Tata McGraw-Hill, publisher,2005.
3. N.Senthil kumar, M.Saravanan, S.Jeevanandhan, Microprocessors and Microcontrollers, Oxford university press, 2010.
4. P.S.Manoharan, P.S.Kannan, Microcontroller based system design, Scitech Publications Pvt. Ltd., Chennai, 2007.
5. Kenneth .J. Ayala, The 8051 Microcontroller, Architecture, Programming & Applications (third edition), Penram International, India (2004).
6. http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf
7. Rao B. Kanta, Embedded Systems, PHI Learning Pvt. Ltd., 2011.
8. https://nptel.ac.in/courses/108105102/ (Microprocessors and Microcontrollers)


## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| **1.** | **Introduction** | | |
| 1.1 | Introduction to Microprocessor and Microcontroller– Evolution - Architecture of Microprocessor | 1 | CO1 |
| 1.2 | VonNeuman and Harvard architecture – CISC- RISC | 1 | CO1 |
| 1.3 | Comparison of Micro processor and Microcontroller | 1 | CO1 |
| 1.4 | Overview of 8/16/32/64 bit Microprocessors and Microcontrollers | 1 | CO1 |
| 1.5 | Application of Microprocessors and Microcontrollers - Selection of Microprocessors for an application | 1 | CO1 |

| | | | |
|---|---|---|---|
| **2.** | **8051 Microcontroller** | | |
| 2.1 | 8051 Architecture, Pin details | 1 | CO2 |
| 2.2 | Timing diagram, Memory | 1 | CO2 |
| 2.3 | Parallel Ports | 1 | CO2 |
| 2.4 | Counters/Timers | 1 | CO2 |
| 2.5 | Interrupts | 1 | CO2 |
| 2.6 | Serial port | 1 | CO2 |
| **3.** | **8051 ALP Programming** | | |
| 3.1 | Addressing modes | 1 | CO3 |
| 3.2 | Instruction set of 8051 | 2 | CO3 |
| 3.3 | Basic Assembly language Programming – Arithmetic operations | 1 | CO3 |
| 3.4 | Code conversions - Sorting | 1 | CO3 |
| 3.5 | Look up tables – subroutines – Timer/Counter, interrupt and serial port programming | 1 | CO3 |
| 3.6 | Introduction to simulators | 1 | CO3 |
| **4.** | **ATmega328p microcontroller** | | |
| 4.1 | Architecture | 1 | CO4 |
| 4.2 | I/O Ports - On chip ADC | 1 | CO4 |
| 4.3 | Capture/Compare/PWM Module | 1 | CO4 |
| 4.4 | $I^2C$ – SPI – Watchdog timer | 1 | CO4 |
| 4.5 | Addressing modes- Instruction set | 1 | CO4 |
| **5** | **Embedded 'C' Programming** | | |
| 5.1 | Introduction to IDE | 1 | CO5/CO6 |
| 5.2 | Embedded C Data types-Programming structure | 1 | CO5/CO6 |
| 6 | **8051 Interfacing with peripherals using Embedded 'C'** | | |
| 6.1 | LED, Matrix Keyboard | 2 | CO5 |
| 6.2 | Liquid Crystal Display | 1 | CO5 |
| 6.3 | DAC | 1 | CO5 |
| 6.4 | ADC | 1 | CO5 |
| 6.5 | 7 segment LED Display | 1 | CO5 |
| 6.6 | Stepper Motor/DC Motor. | 2 | CO5 |
| 7 | **ATmega328p based embedded C programs** | | |
| 7.1 | Programs to access Capture/Compare/PWM generation | 2 | CO6 |
| 7.2 | Signal acquisition using on-chip ADC | 1 | CO6 |
| | **Total** | **36** | |

**Course Designers:**

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2.Dr.P.S.Manoharan psmeee@tce.edu
3 Dr.D.Kavitha dkavitha@tce.edu

| 18EE530 | POWER ELECTRONICS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 3 | 0 | 0 | 3 |

## Preamble

Power Electronics can be defined as the application of solid state electronics for the control, conversion and transmission of electric power. Power electronic circuits convert electrical energy in one form from source to the form required by load in an efficient and effective way. They find applications in industrial motor control, power supplies, vehicle propulsion systems, high voltage direct current (HVDC) systems, flexible AC transmissions (FACTs), heat controls and light controls.

## Prerequisite

18EE250 Electronic Devices and Circuits
18EE230 Electric Circuit Analysis

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the steady state characteristics and applications of Power diode, Power transistor, Power MOSFET, IGBT, SCR, Triac and Silicon carbide devices. | 10 |
| CO2 | Design SCR triggering circuits, protection circuits and commutation circuits for the given requirements. | 10 |
| CO3 | Design uncontrolled and controlled single phase and three phase rectifiers for the given specifications | 20 |
| CO4 | Design single phase and three phase voltage source and current source inverters for the given specifications | 20 |
| CO5 | Design step-up, step-down chopper, buck, boost and buck-boost switching regulator for the given specifications | 20 |
| CO6 | Explain the SMPS topologies, single phase, three phase AC voltage controllers. | 10 |
| CO7 | Analyze the performance of the given power converter and gate drive circuits using PLECS /PSPICE / MATLAB /PSIM software. | 10 |

*** Weightage depends on Bloom's Level and number of contact hours

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| | | | | | |
| CO1 | TPS2 | Understand | Respond | | 1.2.13, 2.3.1 |
| CO2 | TPS3 | Apply | Value | | 1.2.13, 2.3.2 |

| | | | | | |
|---|---|---|---|---|---|
| CO3 | TPS3 | Apply | Value | | 1.2.13, 2.3.1,2.3.2 |
| CO4 | TPS3 | Apply | Value | | 1.2.13, 2.3.1,2.3.2 |
| CO5 | TPS3 | Apply | Value | | 1.2.13, 2.3.1,2.3.2 |
| CO6 | TPS2 | Understand | Respond | | 1.2.13, 2.3.1 |
| CO7 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.13, 2.1.2, 2.1.5,2.2.2 ,3.2.3,3.2.5 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | M |
| CO2 | S | M | L | | | | | M | | M | | | S | S |
| CO3 | S | M | L | | | | | M | | M | | | S | S |
| CO4 | S | M | L | | | | | M | | M | | | S | S |
| CO5 | S | M | L | | | | | M | | M | | | S | S |
| CO6 | M | L | | | | | | M | | M | | | M | M |
| CO7 | S | S | M | L | M | | | M | | M | | | S | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | 0 | 0 | 0 | 20 |
| Understand | 40 | 40 | 40 | 0 | 0 | 0 | 40 |
| Apply | 40 | 40 | 40 | 50 | 50 | 50 | 40 |
| Analyse | 0 | 0 | 0 | 50 | 50 | 50 | 0 |
| Evaluate | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Create | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Note:** Simulation of power converters as per CO7 will be given as assignments.

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Mini project /Assignment/Practical Component |
|---|---|
| Perception | 0 |
| Set | 0 |
| Guided Response | 0 |
| Mechanism | 0 |
| Complex Overt Responses | 0 |
| Adaptation | 0 |
| Origination | 0 |

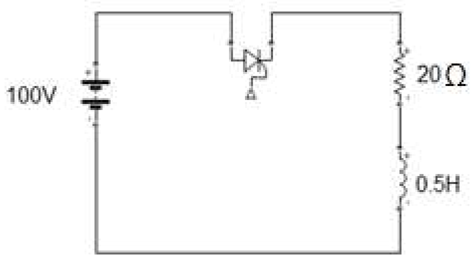
## Sample Questions for Course Outcome Assessment

**Course Outcome 1(CO1)**

1. Draw the symbol of NPN Power Transistor.
2. Explain the transfer characteristics of MOSFET.
3. Compare On-line and Off-line UPS.

**Course Outcome 2(CO2)**

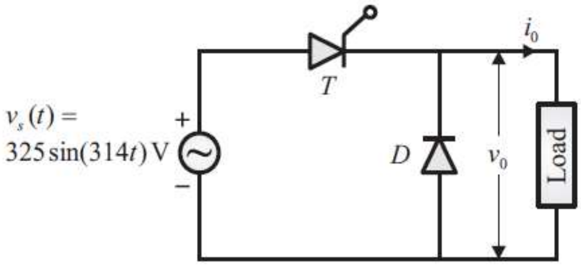
1. What is natural commutation?
2. In the given Chopper circuit, the latching current of SCR is 50mA,the firing pulse width is 50μs.Comment on the state of SCR whether it is turned-on.




3. Design a snubber circuit to meet the following data:
   (i) Supply transformer rating is 5kVA with secondary voltage of 120V rms.
   (ii)Switching frequency=400Hz.
   (iii) Circuit inductance=100μH.
   (iv)Peak transient voltage limit=200V.
   (v)Damping factor=0.75.

**Course Outcome 3(CO3)**

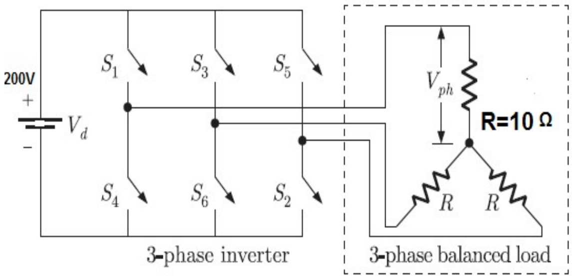
1. Write the applications of rectifier circuits.
2. Find the firing angle of the SCR shown in figure to get an average output voltage of 70V with RL load having R=10Ω and L=0.05H.Assume ideal devices.



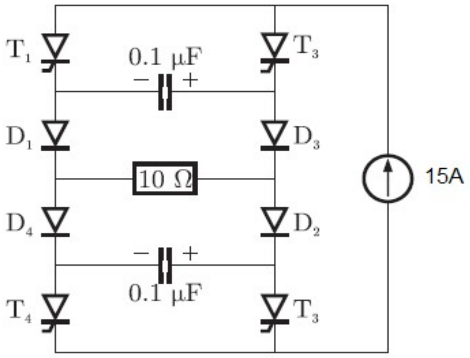

3. A single phase full wave controlled rectifier is operated from 200V, 50Hz supply. The load is RL with R=100Ω and the average output voltage is 50V. Assume continuous conduction mode: Determine (i) firing angle (ii) rms output voltage and current (iii) form factor (iv) ripple factor and (v) transformer utilization factor.

**Course Outcome 4 (CO4)**

1. What are the various voltage control methods in inverter?
2. Find the rms value of load line voltage and the power consumed by the three phase load.

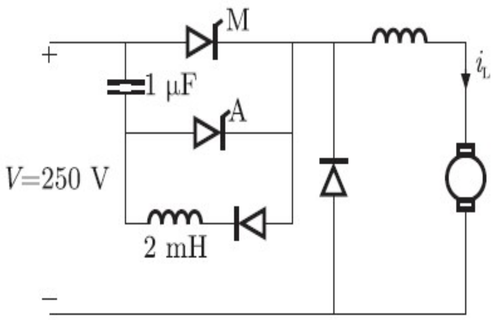



3. Calculate the maximum theoretical output frequency of the given CSI circuit with R load:




**Course Outcome 5 (CO5)**

1. What are the various voltage control methods in DC choppers?
2. A voltage commutated Chopper, shown in figure is operated at f=1kHz and the load current is constant at 10A.Find the following: (i) The minimum time for which the main SCR(M) should be on (ii)The average output voltage of the Chopper circuit.

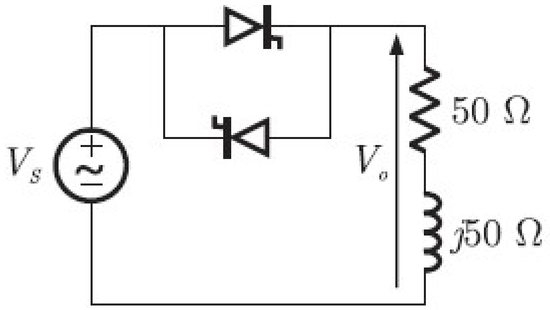



3. A buck-boost regulator has an input voltage, Vs=10V.The duty cycle k=0.25,the average load current, Ia=1A and the switching frequency is 25kHz.If L=150μH and C=220μF,calculate (i)the average output voltage, (ii)the ripple current of L, (iii)the ripple voltage of C, and (iv)the critical values of L & C. .

**Course Outcome 6(CO6)**

1. Explain the different topologies of DC-DC power converter of SMPS.

2. In the given single phase AC voltage controller circuit, for what range of firing angle the output voltage is not controllable.

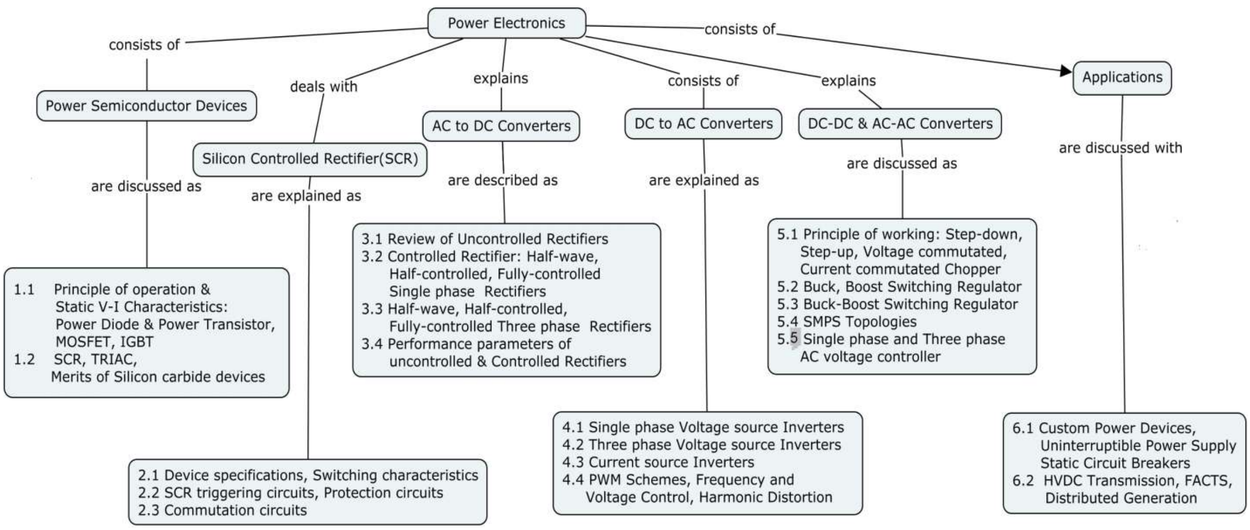



3. Discuss the operation of the bidirectional converter circuit that converts 50Hz, three phase AC to variable magnitude 50Hz, three phase AC.

**Course Outcome 7(CO7)**

1. Simulate 3-phase semi converter and analyse the performance parameters using PLECS /PSPICE software.
2. Design and simulate 1-phase voltage source inverter and current source inverter with RLE load and compare the performance using PSIM software.
3. Design suitable converters for wind energy conversion and analyze the performance using MATLAB software.

## Concept Map




## Syllabus

**Power Semiconductor Devices**

Principle of operation & static V-I Characteristics of power diode, power transistor, MOSFET, IGBT, SCR and TRIAC, merits of silicon carbide devices, **SCR:** Triggering circuits, protection circuits and commutation circuits.

**AC to DC Converters**

Review of uncontrolled rectifiers, Controlled Rectifiers: Half wave, half controlled, fully controlled single phase and three phase controlled rectifiers, performance parameters.

**DC to AC Converters**

Single phase and three phase voltage source inverter, current source inverter, frequency and voltage control, PWM schemes, harmonic distortion.

**DC-DC & AC-AC Converters**

Principle of working: Step-down, step-up, voltage commutated, current commutated chopper, switching regulators: buck, boost & buck-boost, SMPS topologies, single phase and three phase ac voltage controller.

**Applications**

Electric Drives, Custom power devices, uninterruptible power supply, HVDC transmission, FACTS, distributed generation.

**Simulation of Power Converers**

Performance analysis of the power converters and gate drive circuits using PLECS /PSPICE / MATLAB /PSIM software.

**Learning Resources**

1. Muhammad H.Rashid, Power Electronics Devices, Circuits & Applications, Fourth Edition, Pearson Education India Publication, New Delhi, 7th Impression, 2019.
2. M.D.Singh & K.B.Khanchandani, Power Electronics – Tata Mc Graw Hill publishing company Ltd, New Delhi, 2008.
3. Ned Mohan, Tore Undeland & William Robbins, Power Electronics:Converters, Applications and Design-John Willey and sons, 3rd Edition, 2003.
4. P.S. Bimbhra, Power Electronics- Khanna Publishers, Sixth Edition, 2018.
5. John G.Kassakian, Martin F.Schlecht, George C.Verghese, Principles of Power Electronics, Pearson Education, 12th Impression, 2014.
6. Daniel W.Hart, Introduction to Power Electronics, First Edition, Prentice Hall International Inc.,1996.
7. L. Umanand, Power Electronics: Essentials and Applications- Wiley India, 2009.
8. Marty Brown, Power Sources and Supplies, ELSEVIER, 2008.
9. https://ocw.mit.edu/courses/electrical-engineering.

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| **1.** | **Power Semiconductor Devices** | | |
| 1.1 | Principle of operation & Static V-I Characteristics: Power Diode & Power Transistor, MOSFET, IGBT | 2 | CO1 |
| 1.2 | SCR, TRIAC, Merits of Silicon carbide devices | 2 | CO1 |
| 1.3 | Device specifications, Switching characteristics | 2 | CO1 |
| 1.4 | SCR triggering circuits, Protection circuits | 2 | CO2 |
| 1.5 | Commutation circuits | 2 | CO2 |
| **2.** | **AC to DC Converters** | | |
| 2.1 | Review of Uncontrolled Rectifiers | 1 | CO3 |
| 2.2 | Controlled Rectifier: Half-wave, Half-controlled, Fully-controlled Single phase Rectifiers | 2 | CO3 |
| 2.3 | Half-wave, Half-controlled, Fully-controlled Three phase Rectifiers | 2 | CO3 |
| 2.4 | Performance parameters of uncontrolled& Controlled Rectifiers | 2 | CO3 |
| **3.** | **DC to AC Converters** | | |
| 3.1 | Single phase Voltage source Inverters | 1 | CO4 |
| 3.2 | Three phase Voltage source Inverters | 2 | CO4 |

| | | | |
|---|---|---|---|
| 3.3 | Current source Inverters | 1 | CO4 |
| 3.4 | Frequency and Voltage Control, PWM Schemes | 2 | CO4 |
| 3.5 | Harmonic Distortion | 1 | CO4 |
| **4.** | **DC-DC & AC-AC Converters** | | |
| 4.1 | Principle of working: Step-down, Step-up, Voltage commutated, Current commutated Chopper | 2 | CO5 |
| 4.2 | Buck, Boost Switching Regulator | 2 | CO5 |
| 4.3 | Buck-Boost Switching Regulator | 1 | CO5 |
| 4.4 | SMPS Topologies | 1 | CO6 |
| 4.5 | Single phase and Three phase AC voltage controller | 2 | CO6 |
| **5.** | **Applications** | | |
| 5.1 | Electric Drives, Custom Power Devices, Uninterruptible Power Supply | 1 | CO1 |
| 5.2 | HVDC Transmission, FACTS, Distributed Generation | 1 | CO1 |
| 5.3 | Performance analysis of the power converters and gate drive circuits using PLECS /PSPICE / MATLAB /PSIM software | 2 | CO7 |
| | **Total** | 36 | |

**Course Designers:**

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| 18EE540 | ACCOUNTING AND FINANCE |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| HSS | 3 | - | - | 3 |

**Preamble**

Engineering profession involves lots of decision making. The decisions may range from operation to non-operation. For taking decisions of these kinds, an engineer needs among other data about the organization routine operations and non-routine operations. Accounting is a science which provides all the data by recording, classifying, summarizing and interpreting the various transactions taking place in an organization and thereby helps an engineer in taking vital decisions in an effective manner. Finance is an allied but a separate field relying on accounting and enables engineers in taking useful financial and cost related decisions by providing well defined concepts, tools and techniques

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Prepare financial statements of accounting, common size statements and comparative statements. | 20 |
| CO2 | Perform cost sheet, depreciation and its applications in business. | 15 |
| CO3 | Compute various types of budgets in an organization | 15 |
| CO4 | Obtain break even analysis and activity based costing systems for a business applications.. | 15 |
| CO5 | Compute working capital requirements and long term investment decisions. | 20 |
| CO6 | Apply the appropriate sources of finance and mobilize the right quantum of finance and use them in most profitable investment avenues | 15 |

*** Weightage depends on Bloom's Level, number of contact hours.

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.1,1.2,2.1.3, 2.1.4, 2.1.5, 2.3, 2.4.3, 2.4.6, 2.4.7, 2.4.6 |
| CO2 | TPS3 | Apply | Value | | 1.1, 1.2, 2.1.3, 2.1.5, 2.4.6, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.1.1, 4.1.2 |
| CO3 | TPS3 | Apply | Value | | 1.1, 1.2, 2.1.3, 2.1.4, 2.1.5, 2.3.4, 2.4.6, 2.4.5, 2.4.7, 2.5.1, 3.1.1, 3.1.2, 3.1.5, 3.2, 4.1.1, |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 4.1.2 |
| CO4 | TPS3 | Apply | Value | | 1.1,1.2, 2.3.3, 2.3.4, 2.4.6, 2.4.7, 2.5.1, 3.2.3. 3.2.4, 4.1.1 |
| CO5 | TPS3 | Apply | Value | | 1.1, 1.2, 2.1.4, 2.1.5, 2.4.6, 2.4.7, 2.5.1, 3.1, 3.2, 4.1.1, 4.1.2 |
| CO6 | TPS3 | Apply | Value | | 1.1, 1.2, 2.1.5, 2.3.1, 2.3.3, 2.4.1, 2.4.3, 2.4.4, 2.4.6, 2.4.7, 2.5.1, 2.5.3, 3.1.4, 3.2, 4.1.1, 4.1, 4.2, 4.6.6 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | M | S | M | S | S | S | S | L | L |
| CO2 | | | | | | - | M | M | S | S | S | M | L | L |
| CO3 | | | | | | - | - | S | S | S | S | S | L | L |
| CO4 | | | | | | M | L | S | S | S | S | M | L | L |
| CO5 | | | | | | M | M | S | S | S | M | M | L | L |
| CO6 | | | | | | M | M | S | S | M | M | S | L | L |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 30 | 30 | 30 | - | - | - | 20 |
| Apply | 50 | 50 | 50 | 100 | 100 | 100 | 60 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Mini project/Assignment/Practical Component |
|---|---|
| | |

| | |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO1):**

1. Explain in detail about accounting concepts and conventions.
2. Prepare Trading Account, Profit and Loss Account and Balance Sheet from the following

| S.NO | PARTICULARS | Debit balances (in Rs) | Credit balances(in Rs) |
|---|---|---|---|
| 1 | Capital | | 300000 |
| 2 | Bank | 15000 | |
| 3 | Plant and machinery | 40000 | |
| 4 | Land and building | 60000 | |
| 5 | Debtors | 20000 | |
| 6 | Creditors | | 40000 |
| 7 | Cash | 70000 | |
| 8 | Purchases and sales | 35000 | 50000 |
| 9 | Purchase returns and sales returns | 7000 | 4000 |
| 10 | Bills receivable | 3000 | |
| 11 | Bills payable | | 5000 |
| 12 | Wages | 40000 | |
| 13 | Salaries | 30000 | |
| 14 | Discount | | 4000 |
| 15 | Stock on Jan 2017 | 10000 | |
| 16 | Furniture | 7000 | |
| 17 | Carriage inwards | 5000 | |
| 18 | Carriage outwards | 6000 | |
| 19 | Advertising | 10000 | |
| 20 | Travelling expense | 3000 | |
| 21 | Loans | | 60000 |
| 22 | Vans | 100000 | |
| 23 | Telephone | 2000 | |
| | **Total** | **463000** | **463000** |
| | | | |

3. From the following particulars, prepare comparative balance sheet of Malar Ltd as on 31st March 2017 and 31st March 2018.

| Particulars | 31st March 2017 | 31st March 2018 |
|---|---|---|
| **I EQUITY AND LIABILITIES** | | |

| | | |
|---|---|---|
| 1. Shareholders' fund<br>a) Share capital<br>b) Reserves and surplus<br>2. Non-current liabilities<br>Long-term borrowings<br>3. Current liabilities<br>Trade payables | <br><br>2,00,000<br>50,000<br><br>30,000<br><br>20,000 | <br><br>2,50,000<br>50,000<br><br>60,000<br><br>60,000 |
| **Total** | **3,00,000** | **4,20,000** |
| **II ASSETS**<br>1. Non-current assets<br>a) Fixed assets<br>b) Non - current investments<br>2. Current assets<br>a)Inventories<br>b) Cash and cash equivalents | <br><br>1,00,000<br>50,000<br><br>75,000<br>75,000 | <br><br>1,50,000<br>75,000<br><br>1,50,000<br>45,000 |
| **Total** | **3,00,000** | **4,20,000** |

**Course Outcome 2(CO2):**

1. Classify the cost according to function.
2. Prepare cost sheet in the book of Vimi from the following particulars.

Opening stock: - Raw material = Rs 5,000
Finished goods = Rs 4,000
Closing stock: Raw material = Rs 4,000
Finished goods = Rs 5,000

Raw material purchased = Rs 50,000
Wages paid to laboures = Rs 20,000
Chargeable expenses = Rs 2,000
Rent and Taxes = Rs 7,400
Power = Rs 3,000
Experimental expenses = Rs 600
Sale of wastage of material = Rs 200
Office management salary = Rs 4,000
Office printing & stationery = Rs 200
Salaries to salesman = Rs 2,000
Commission to traveling agents = Rs 1,000
Sales = Rs 1, 00,000

**Course Outcome 3(CO3):**

1. Classify the budget based on function.
2. Explain the advantages and applications of budgetary control.

3. From the forecast of income and expenditure prepare a cash budget for the months from April to June 2019.

| Month | Sales Rs | Purchases Rs | Wages Rs | Office expenses Rs | Selling expenses Rs |
|---|---|---|---|---|---|
| Feb | 70,000 | 45,000 | 4,500 | 2,700 | 1,800 |
| Mar | 72,000 | 43,000 | 4,700 | 3,000 | 2,000 |
| Apr | 75,000 | 44,000 | 4,900 | 2,900 | 2,200 |
| May | 71,000 | 40,000 | 5,000 | 3,000 | 2,100 |
| Jun | 70,000 | 42,000 | 5,000 | 2,800 | 1,900 |

- Plant worth Rs25, 000 purchased in June. 40% payable immediately and the remaining in two equal instalments in subsequent months.
- Advance tax payable in April Rs 4500
- Period of credit allowed
    - By suppliers 2 months
    - To customer 1 month
- Dividend payable Rs 7000 in June
- Delay in payment of wages and office expenses 1 month and selling expenses 1 month. Expected cash balance on 1st April Rs 30,000

Machinery expected to sell on May is Rs 20,000

**Course Outcome 4 (CO4):**

1. From the following information calculate the Breakeven point in terms of units and breakeven point in terms of sales.Sales....Rs.10,000, Variable costs Rs.6,000,fixed costs Rs.2000:profit Rs.2,000;No. Ofunits produced 1,000 units.
2. Calculate the breakeven point and margin of safety from the following information Fixed cost ...Rs.10,000, sales in Rs.25,000,selling price per unit Rs.30; variable cost per unit Rs.10

**Course Outcome 5(CO5):**

1. Classify capital budgeting decisions.
2. From the following information extracted from the books of a manufacturing company, compute the operating cycle in days and the amount of working capital required:

Period Covered 365 days

| | |
|---|---|
| Average period of credit allowed by suppliers | 16 days |
| Average Total of Debtors Outstanding | 480 |
| Raw Material Consumption | 4,400 |
| Total Production Cost | 10,000 |
| Total Cost of Sales | 10,500 |
| Sales for the year | 16,000 |
| **Value of Average Stock maintained:** | |
| Raw Material | 320 |
| Work-in-progress | 350 |
| Finished Goods | 260 |

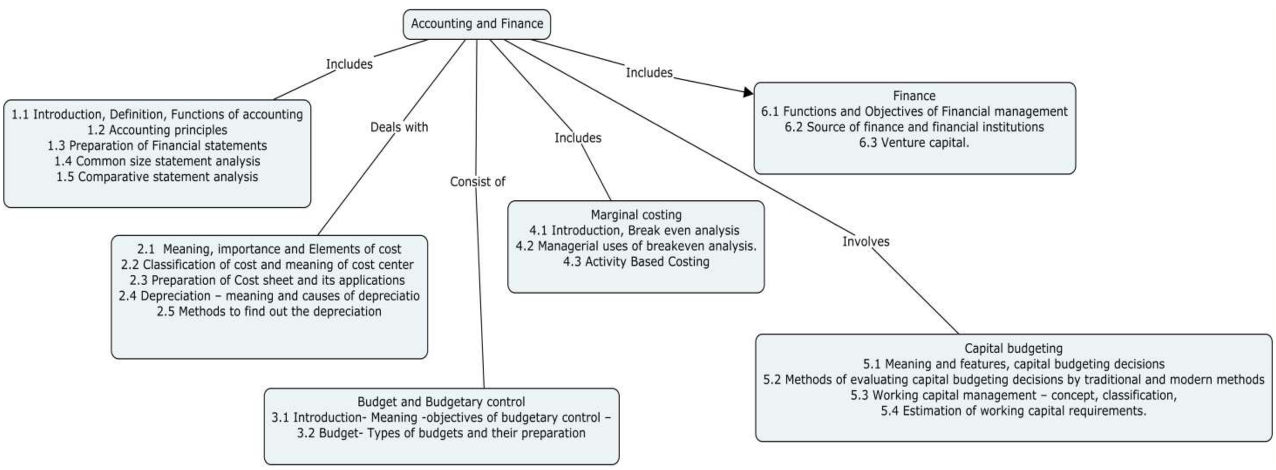
3. From the following data of a project, Calculate IRR and suggest whether the project is to be undertaken or not if the cut off rate is 9%.

| **Cash Out flow (Rs.)** | | 1,50,000 |
|---|---|---|
| **Cash Inflow(Rs.)** | **Year 1** | 41,000 |
| | **Year 2** | 50,000 |
| | **Year 3** | 50,000 |
| | **Year 4** | 42,000 |

**Course Outcome 6(CO6):**

1. List the sources of finance.
2. Suggest suitable sources of finance to start a business with a capital of 60 crores.

## ConceptMap




## Syllabus

**Accounting** Introduction definition, functions of accounting, Accounting principles-. Preparation of financial statements and their analysis with common size and comparative statements.

**Cost Accounting** - Meaning and importance -Elements of cost- classification of cost- Cost centre, Preparation of cost sheet and its applications .Depreciation – meaning and causes of depreciation, Methods to find out the depreciation
**Budget** and Budgetary control- Introduction-Meaning -objectives of budgetary control – Budget-Types of budgets and their preparation.
**Marginal costing**- Introduction, Break even analysis –Managerial of breakeven analysis.
**Activity based Costing**
**Capital budgeting**- Meaning and features, capital budgeting decisions, Methods of evaluating capital budgeting decisions by traditional and modern methods. Working capital management - concept, classification, Estimation of working capital requirements.
**Finance**: Functions, Objectives of financial management and Source of finance and financial institutions, Venture capital.

## Learning Resources


1. M.C.Shukla,T.S.Grewal,“AdvancedAccounts-Volume-I,2010 Reprint, S. Chand & company Ltd.,2010.
2. Prasanna Chandra, “Financial Management-Theory and practice” seventh Reprint,Tata McGraw-Hill publishing company Limited,2010.
3. P.S.BoopathiManickam “Financial and Management Accounting” PSG publications 2009.
4. Don R. Hansen and Maryanne M. Mowen “Cost Management: Accounting and Control, Fifth Edition” Thomson, 2006.
5. Michael C . Ehrhardt and Eugene F . Brigham, “Financial Management: Theory and Practice -thirteenth edition” South-Western cengage learning, 2011
6. Pandey, “Financial Management”, Vikas Publishing House Pvt. Ltd., 2007
7. Paramasivan.C, Subramanian.T, “Financial management” New Age international Publishers, 2014.
8. https://nptel.ac.in/courses/110/106/110106135/: Decision making using financial accounting, Prof. G Arun Kumar, IIT Madras
9. https://nptel.ac.in/courses/110/101/110101131/ : Financial Accounting, Dr. Varadraj Bapat, IIT Bombay.
10. https://nptel.ac.in/courses/110/107/110107127/: Management Accounting, Prof. Anil K. Sharma, IIT Roorkee.
11. https://nptel.ac.in/courses/105104178/: Introduction to Accounting and Finance for Civil Engineers, Dr. Sudhir Misra, IIT Kanpur.
12. https://www.youtube.com/watch?v=P9JIBbZas3w: Introduction to accounting, Dr.S.Vaidhyasubramanian, Adjunct professor, Sastra University.


## Course Contents and Lecture Schedule

| Module No | Topic | No. of Lectures | Cos |
|---|---|---|---|
| 1 | **Accounting** | | CO1 |
| 1.1 | Introduction, Definition, Functions of accounting | 1 | |
| 1.2 | Accounting principles | 1 | |
| 1.3 | Preparation of Financial statements | 3 | |
| 1.4 | Common size statement analysis | 1 | |
| 1.5 | Comparative statement analysis | 1 | |
| 2 | **Cost Accounting** | | CO2 |
| 2.1 | Meaning, importance and Elements of cost | 1 | |

| | | | |
|---|---|---|---|
| 2.2 | classification of cost and meaning of Cost centre, | 1 | |
| 2.3 | Preparation of Cost sheet and its applications | 3 | |
| 2.4 | Depreciation – meaning and causes of depreciation | 1 | |
| 2.5 | Methods to find out the depreciation | 2 | |
| 3 | **Budget and Budgetary control** | | CO3 |
| 3.1 | Introduction- Meaning -objectives of budgetary control – | 1 | |
| 3.2 | Budget- Types of budgets and their preparation | 4 | |
| 4 | **Marginal costing** | | CO4 |
| 4.1 | Introduction, Break even analysis | 2 | |
| 4.2 | Managerial uses of breakeven analysis. | 1 | |
| 4.3 | Activity Based Costing | 2 | |
| 5 | **Capital budgeting** | | CO5 |
| 5.1 | Meaning and features, capital budgeting decisions | 1 | |
| 5.2 | Methods of evaluating capital budgeting decisions by traditional and modern methods | 4 | |
| 5.3 | Working capital management – concept, classification, | 1 | |
| 5.4 | Estimation of working capital requirements. | 1 | |
| 6 | **Finance** | | CO6 |
| 6.1 | Function sand Objectives of Financial management | 1 | |
| 6.2 | Source of finance and financial institutions | 3 | |
| 6.3 | Venture capital. | 1 | |
| | **Total** | **36 hrs** | |

**Course Designers:**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3. Mr.S Rajkumar srmech@tce.edu

| | | | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|---|
| **18EE570** | **MICROCONTROLLERS LAB** | | PC | 0 | 0 | 2 | 1 |

## Preamble

Microcontroller is used as the main controller in most of the embedded systems nowadays. This course makes the students to be familiar with the assembly language and Embedded 'C' language programming of 8051 and ATmega328P microcontroller for interfacing various peripherals and also performing them through simulation using software tools.

## Prerequisite

18EE340-Digital Systems

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Analyze 8051 microcontroller based assembly language programs and embedded 'C' programs to implement basic operations by software tools. | 10 |
| CO2 | Analyze 8051/ ATmega328P embedded 'C' programs for accessing on-chip hardware units such as timer/counter, interrupts and serial communication. | 15 |
| CO3 | Analyze 8051/ ATmega328P microcontroller based embedded 'C' programs for Key board and display interface. | 15 |
| CO4 | Analyze 8051/ ATmega328P based embedded 'C' programs for ADC and DAC interfacing and Motor control, | 15 |
| CO5 | Analyze 8051/ ATmega328P microcontroller based embedded 'C' programs to implement the given application through simulation by software tools. | 20 |
| CO6 | Develop 8051/ ATmega328P microcontroller based system for real world applications. | 25 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.12, 2.1.1, 2.1.5,2.2.2, 2.4.2, 2.4.3, 2.4.7, 3.1.1 |
| CO2 | TPS4 | Analyze | Organise | Complex | 1.2.12, 2.1.1, 2.1.5,2.2.2, 2.4.2, |

| | | | | | |
|---|---|---|---|---|---|
| | | | | Overt Responses | 2.4.3, 2.4.7, 3.1.1 |
| CO3 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.12, 2.1.1, 2.1.5,2.2.2, 2.4.2, 2.4.3, 2.4.7, 3.1.1 |
| CO4 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.12, 2.1.1, 2.1.5,2.2.2, 2.4.2, 2.4.3, 2.4.7, 3.1.1 |
| CO5 | TPS4 | Analyze | Organise | Complex Overt Responses | 1.2.12, 2.1.1, 2.1.5,2.2.2, 2.4.2, 2.4.3, 2.4.7, 3.1.1 |
| CO6 | TPS5 | Evaluate | Organise | Adaptation | 1.2.12, 2.1.1, 2.1.5,2.2.2, 2.4.2, 2.4.3, 2.4.7, 3.1.1 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | | | | | M | | M | | | | S |
| CO2 | S | M | L | | | | | M | | M | | | | S |
| CO3 | S | M | L | | | | | M | | M | | | | S |
| CO4 | S | M | L | | | | | M | | M | | | | S |
| CO5 | S | S | M | L | S | | | M | | M | | | | S |
| CO6 | S | S | M | L | S | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Model Examination** | **Terminal Examination** |
|---|---|---|
| Remember | | |
| Understand | | |
| Apply | 45 | 45 |
| Analyse | 30 | 30 |
| Evaluate | | |
| Create | | |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **~~Miniproject~~ /Practical Component/~~Observation~~** |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 25 |
| Complex Overt Responses | |
| Adaptation | |

| Origination | |
|---|---|

**CO5 & CO6 are evaluated through mini project separately for 20 marks out of 50 marks accounted for continuous assessment.**

## List of Experiments/Activities with CO Mapping

**List of Experiments:**

**Module – 1 (CO1)**

- Use of software simulation tools
- Evaluation of arithmetic expressions

**Module -2 (CO2)**

- Timer/Counter applications with and without interrupts: (i) square wave generation (ii) Frequency measurement
- Serial communication ($I^2C$, UART) and Parallel communication.

**Module - 3 (CO3 &CO4)**

- Control of illumination of LED string / Traffic light
- Keyboard and Seven segment LED interfacing
- ADC and DAC interfacing
- Speed control of DC motor / Stepper motor

**Module - 4 (Applications/Product ) (CO5 & CO6)**

Automatic Toll gate
Smart Energy meter
PWM generator
Smart Voltmeter/ Power meter /Power factor meter
IoT applications such as Smart grid, Smart city, Agriculture, Health care, Security applications

## Learning Resources


1. Ajay V.Deshmukh, "Microcontrollers- Theory and applications", Tata McGraw-Hill, publisher,2005.
2. The 8051 Microcontroller and Embedded Systems, (second edition). By Muhammad Ali Mazidi, Janice Gillispie Mazidi, and Rolin D. McKinlay © 2005 Pearson Education, Inc
3. N.Senthil kumar, M.Saravanan, S.Jeevanandhan, "Microprocessors and Microcontrollers", Oxford university press, 2010.
4. P.S.Manoharan, P.S.Kannan, "Microcontroller based system design", Scitech Publications Pvt. Ltd., Chennai, 2007.
5. http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf
6. https://nptel.ac.in/courses/108105102/ (Microprocessors and Microcontrollers)
7. UNIVERSAL EMBEDDED TRAINER (VUET-REV0) - Manual


## Course Designers:


| | | |
|---|---|---|
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| 18EE580 | CONTROL AND AUTOMATION LAB |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 0 | 0 | 2 | 1 |

## Preamble

Control and Automation systems are backbone of modern day industries. Exposure to computer based design and practical implementation of control and automation systems are mandate for electrical engineering students. This course is framed in such a way to introduce computer aided analysis & design of control systems, implementation of designed controller in real world system. Exposure to PLC based automation system design and implementation for sequential processes is also provided.

## Prerequisite

18EE440 Control Systems

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Analyze time and frequency domain characteristics of the given system using simulation tools | 20 |
| CO2 | Analyze the effect of cascade compensators on the closed performance of the given system using simulation tools | 20 |
| CO3 | Analyze the performance of LabVIEW based PID control system for the given specifications | 10 |
| CO4 | Analyze the performance of *the* Ziegler Nichols and Cohen-Coon methods based PID controller for the given closed loop PC based system | 10 |
| CO5 | Develop a PLC based software to perform the given sequential tasks experimentally | 30 |
| CO6 | Analyze the performance of the discrete-time PID controller implemented using micro controller for controlling the servo system | 10 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |

| | | | | | |
|---|---|---|---|---|---|
| CO1 | TPS4 | Analyze | Organize | Complex Overt Responses | 2.1.1, 2.1.2, 2.1.3, 2.2.3 |
| CO2 | TPS4 | Analyze | Organize | Complex Overt Responses | 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.2.3. |
| CO3 | TPS3 | Apply | Value | Mechanism | 2.1.1, 2.1.2, 2.1.3 |
| CO4 | TPS3 | Apply | Value | Mechanism | 2.1.1, 2.1.2, 2.1.3, 2.1.4 |
| CO5 | TPS3 | Apply | Value | Mechanism | 2.1.1, 2.1.4, 2.1.5, 4.5.3, |
| CO6 | TPS3 | Apply | Value | Mechanism | 2.1.1, 2.1.2, 2.1.4 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | M | L | M | | | M | | M | | | S | S |
| CO2 | S | S | M | L | M | | | M | | M | | | S | S |
| CO3 | S | M | L | | M | | | M | | M | | | S | S |
| CO4 | S | M | L | | M | | | M | | M | | | S | S |
| CO5 | S | M | L | | M | | | M | | M | | | S | S |
| CO6 | S | M | L | | M | | | M | | M | | | S | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Model Examination | Terminal Examination |
|---|---|---|
| Remember | - | |
| Understand | - | |
| Apply | 50 | 50 |
| Analyse | 40 | 40 |
| Evaluate | | |
| Create | | |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | ~~Miniproject~~ /Practical Component/~~Observation~~ |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 10 |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**List of Experiments/Activities with CO Mapping**

CO1:

- Time response Analysis using MATLAB
- Frequency response Analysis using MATLAB

CO2:

- Compensator Design using MATLAB
- Design and implementation of compensator closed loop control of Quanser Servo mechanism

CO3

- Development of LabVIEW based control system for tank level control process

CO4

- Tuning of PID controllers using MATLAB

CO5:

- Study of PLC modules and I/O connection
- Sequential control of processes using Ladder logics and PLC
    - Elevator Control Systems
    - Dozing pump control system
- Hardwired and PLC based start delta starter
- PLC based control of Batch process

CO6:

- Discrete PID control of servo mechanism – Simulation
- Discrete PID control of Servo mechanism – Practical implementation

**Learning Resources**


1. Nagarath, I.J. and Gopal, M., "Control Systems Engineering", New Age InternationalPublishers, 2017.
2. Richard C.Dorf and Bishop, R.H., "Modern Control Systems", Pearson Education,2009.
3. MATLAB based control system analysis: http://ctms.engin.umich.edu/CTMS/index.php?aux=Home
4. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publication
5. Limited, 2008
6. Frank D Petruzella, Programmable logic controllers, Third Edition, Tata McGraw-Hill, 2010
7. Logix Pro: PLC Simulator: http://www.thelearningpit.com/lp/logixpro.html


**Course designers**


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| | | | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|---|
| **18EE610** | **POWER SYSTEM ANALYSIS** | | PC | 3 | 0 | 0 | 3 |

## Preamble

Mathematical modeling and solutions on digital computers constitute an extremely viable approach to system analysis and planning studies for a modern-day power system with its large size, complex and integrated nature. A stage has, therefore, been reached where an under-graduate must be trained in the latest techniques of analysis of large scale power systems. This course has been designed to fulfill this need by integrating the basic principles of power system analysis illustrated through a simplest system structure with analysis techniques. This course provides an exposure of representation of power system, formulation of network matrices, power flow analysis, symmetrical fault analysis, and symmetrical component method of unsymmetrical fault analysis and stability studies.

## Prerequisite

- 18EE230: Electric Circuit Analysis
- 18EE420: AC Machines

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Develop a mathematical model of a power system under steady state operating condition using single line diagram and per unit notations. | 20 |
| CO2 | Apply direct inspection and singular transformation methods to determine Y-bus matrix of the given system. | 20 |
| CO3 | Describe the concept of load flow problem formulation and the various numerical methods of solution. | 20 |
| CO4 | Calculate the fault current for various types of symmetrical faults on the given power system. | 10 |
| CO5 | Calculate the fault current for various types of unsymmetrical faults on the given power system. | 10 |
| CO6 | Explain the role of swing equation and equal area criterion in stability studies | 20 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.2, 2.1.1, 2.1.5, 2.3.1, 3.2.3 |
| CO2 | TPS3 | Apply | Value | | 1.2, 2.1.1, 2.1.2,2.1.5, 3.2.3 |
| CO3 | TPS2 | Understand | Respond | | 1.2, 2.3.1, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.2, 2.1.1,2.1.5, 3.2.3 |
| CO5 | TPS3 | Apply | Value | | 1.2, 2.1.1, 2.1.5, 3.2.3 |

| 18ES590 | SYSTEM THINKING |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| ES | 1 | - | 2 | 2 |

## Preamble

Systems thinking is the integrated paradigm for systems science and system approaches to practice. It is concerned with understanding or intervening in problem situations, based on the principles and concepts of the system model. It can help to provide a common language and an intellectual foundation and make practical system concepts, principles, patterns and tools accessible to systems engineering. System thinking considers the similarities between systems from different domains in terms of a set of common systems concepts, principles, and patterns. The scope of systems thinking is a starting point for dealing with real-world situations using a set of related systems concept. The system thinking is viewed as both a set of founding ideas for the development of systems theories and practices and also as a pervasive way of thinking need by those developing and applying them. This systems approach is a way of tackling real-world problems and making use of the concepts, principle, patterns of systems thinking to enable the systems to be engineered and used.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage in % |
|---|---|---|
| CO1 | Explain the concepts of systems thinking, System engineering and Systems Life Cycle | 10 |
| CO2 | Identify system elements, interactions, boundary and environment for the given system descriptions | 10 |
| CO3 | Develop a functional architecture with appropriate primary function(s) and sub-functions of the identified system | 15 |
| CO4 | Develop a physical architecture with appropriate sub-systems and components of the identified system | 15 |
| CO5 | Prepare a system requirement specification review documents for the various stages of acquisition phase of the identified system | 20 |
| CO6 | Develop a system model with logical and physical architecture using system modelling tool like SysML | 30 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | - | 1.1, 2.3.1, 2.3.2 |
| CO2 | TPS3 | Apply | Value | - | 1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 4.3.1, |
| CO3 | TPS3 | Apply | Value | Mechanism | 1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1 |
| CO4 | TPS3 | Apply | Value | Mechanism | 1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1 |
| CO5 | TPS3 | Apply | Value | Mechanism | 1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, |

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| | | | | | 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1 |
| CO6 | TPS3 | Apply | Value | Mechanism | 1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | - | - | - | - | - | - | - | - | - | - |
| CO2 | S | M | L | - | - | L | L | L | L | L | - | M |
| CO3 | S | M | L | - | - | M | M | M | L | M | M | S |
| CO4 | S | M | L | - | - | M | M | M | L | M | M | S |
| CO5 | S | M | L | - | - | M | M | M | L | M | M | S |
| CO6 | S | M | L | - | S | M | M | M | L | M | M | S |

S- Strong; M-Medium; L-Low

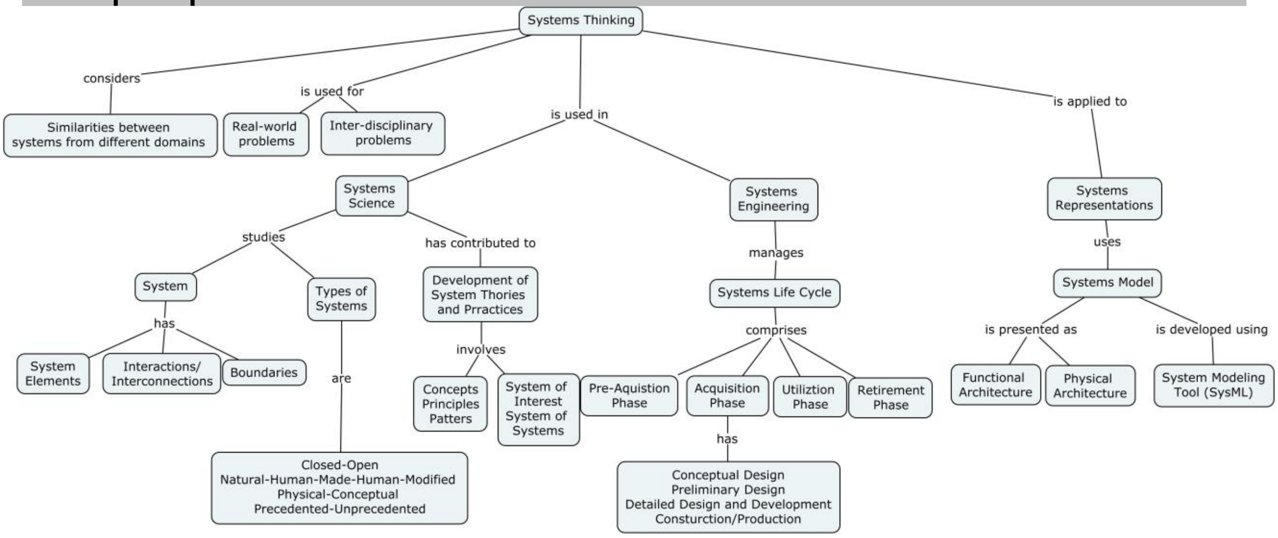
**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Test -2 |
|---|---|
| Remember | 20 |
| Understand | 40 |
| Apply | 40 |
| Analyse | - |
| Evaluate | - |
| Create | - |

| Phases | Deliverables | Marks | Course Outcomes |
|---|---|---|---|
| **Continuous Assessment** | | | |
| Continuous Assessment Test-1 | | 10 | CO1 and CO2 |
| Review 1 – Functional & Physical Architecture and System Requirement Specification | Technical Report | 25 | CO3, CO4 and CO5 |
| Review 2 – Systems Modeling | Technical Report | 15 | CO6 |
| **End-Semester Examination** | | | |
| Demonstration | Virtual Prototype with simulation | 60 | CO1, CO2, CO3, CO4 CO5 and CO6 |
| Poster Presentation | Poster | 40 | |

- Reports are to be submitted at each review. The report and presentation will be evaluated based on Rubrics.
- Demonstration of Virtual Prototype with simulation and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

## Concept Map




## Syllabus

**1.0 Systems Fundamentals:** System - Definition, System Elements, Interactions, System Boundary, - Types of Systems: Closed-Open, Natural-Human-Made-Human-Modified, Physical-Conceptual and Precedented-Unprecedented. Systems science - Systems approaches. Systems Thinking: Concepts, principles and pattens. System of Interest - Systems of System. Systems Engineering: Product, Service, Enterprise. System Life Cycle: Pre-acquisition phase, Acquisition Phase, Utilization Phase and Retirement Phase.

**2.0 Acquisition Phase:** Conceptual Design: Business needs and requirements, Stakeholder needs and requirements, System Requirement Specification, Functional Base Line, System Requirement Review – Functional Architecture. Preliminary Design: Configuration items, Allocated Baseline, Preliminary Design Review – Physical Architecture. Detailed Design and Development: System Modeling, Product Base Line, Critical Design Review. Construction/Production: Formal Qualification Review, Acceptance Test and Evaluation.

**3.0 Systems Modeling:** System Model - Types of models – System Modeling Concepts – Modeling Standards. System Architecture: Logical Architecture Model – Physical Architecture Model. Systems Life Cycle Process Model: Vee model.

## Learning Resources


1. A Guide to Guide to the Systems Engineering Body of Knowledge (SEBoK), version 2.2, INCOSE Systems Engineering Research Center and IEEE Computer Society, Released 31 October 2019 – https://www.sebokwiki.org/w/images/sebokwiki-farm!w/8/8b/SEBoK_v2.1.pdf
2. Systems Engineering Handbook, A Guide for Systems Life Cycle Processes and Activities, 4th Edition, INCOSE-TP-2003-002-04, 2015.
3. R. Ian Faulconbridge, Michael Ryan, “Systems Engineering Practice”, Argos Argos Press, 2014.
4. Jon Holt and Simon Perry, “SysML for Systems Engineering”, The Institution of Engineering and Technology, London, United Kingdom, 2008.
5. Sanford Friedenthal, Alan Moore and Rick Steiner, “A Practical Guide To SysML: The Systems Modeling Language, Third edition, Morgan Kaufmann, an imprint of Elsevier, 2015
6. Coursera course on Introduction to Systems Engineering - R. Ian Faulconbridge, Michael Ryan of The University of New South Wales, Sydney.
7. NPTEL Course: Systems Engineering Theory and Practice – IIT Kanpur – Prof. Deepu Philip (Last offered in 2019) - https://nptel.ac.in/courses/110/104/110104074/

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | | Course Outcome |
|---|---|---|---|---|
| | | In-Class | Hands-on | |
| 1. | **Systems Fundamentals:** System - Definition, System Elements, Interactions, System Boundary | 1 | - | CO1 |
| 1.1 | Types of Systems: Closed-Open, Natural-Human-Made-Human-Modified, Physical-Conceptual and Precedented-Unprecedented. | 1 | 2 | CO1 |
| 1.2 | Systems science - Systems approaches. | 1 | - | CO1 |
| 1.3 | Systems Thinking: Concepts, principles and pattens. | 1 | - | CO1 |
| 1.4 | System of Interest - Systems of System. Systems Engineering: Product, Service, Enterprise System Life Cycle: Pre-acquisition phase, Acquisition Phase, Utilization Phase and Retirement Phase. | 2 | 2 | CO2 |
| 2. | **Acquisition Phase** | | | |
| 2.1 | Conceptual Design: Business needs and requirements, Stakeholder needs and requirements, System Requirement Specification, Functional Base Line, System Requirement Review – Functional Architecture. | 1 | 4 | CO3 |
| 2.2 | Preliminary Design: Configuration items, Allocated Baseline, Preliminary Design Review – Physical Architecture. | 1 | 4 | CO3 |
| 2.3 | Detailed Design and Development: System Modeling, Product Base Line, Critical Design Review. | 1 | 4 | CO4 |
| 2.4 | Construction/Production: Formal Qualification Review, Acceptance Test and Evaluation. | 1 | 4 | CO5 |
| 3. | **Systems Modeling** | | | |
| 3.1 | System Model - Types of models – System Modeling Concepts – Modeling Standards. | 1 | 2 | CO6 |
| 3.2 | System Architecture: Logical Architecture Model – Physical Architecture Model. | 1 | 4 | CO6 |
| 3.3 | Systems Life Cycle Process Model: Vee model. | 1 | 2 | CO6 |
| | Total | 14 | 28 | |

**Course Designers:**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| 18CHAC0 | ESSENCE OF INDIAN KNOWLEDGE | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | AC | 2 | 0 | 0 | 0 |

## Preamble

On the successful completion of the course, the students will be able to explain the concept of Indian Traditional Knowledge along with Indian Modern Knowledge. Traditional Knowledge Systems or Indigenous Knowledge Systems are a body of knowledge, which is very ancient and deep rooted. They have their origins in the remote past. Their systematisation and canonisation gave rise to the elite (the Greater Tradition) science. The nature of Traditional Knowledge System is diverse. It covers, among other things, literary, artistic and scientific works; songs, dances, medical treatments and practices; manufacturing and industry; and agricultural technologies and techniques. There is a dramatically growing national and international interest in incorporating Traditional Knowledge Systems, including Traditional Ecological Knowledge, into truly participatory approaches to development.

## Course Outcome:

On the successful completion of the course students will be able to

| | | |
|---|---|---|
| CO1 | Explain the concept of Traditional Knowledge and Modern knowledge of India. | Understand |
| CO2 | Explain the need and importance of protecting Traditional Knowledge, Knowledge sharing, and Intellectual property rights over Traditional Knowledge. | Understand |
| CO3 | Explain about the use of Traditional Knowledge to meet the basic needs of human being. | Understand |
| CO4 | Explain the rich biodiversity materials and knowledge preserved for practicing traditional lifestyle. | Understand |
| CO5 | Explain the use of Traditional Knowledge in Manufacturing and Industry. | Understand |
| CO6 | Explain about the cultural expression and modern applications of Traditional Knowledge | Understand |

## Mapping with Programme Outcomes

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | - | - | - | S | M | M | M | M | - | L | M | - | M |
| CO2 | M | L | - | - | - | S | M | M | M | M | - | L | M | - | M |
| CO3 | M | L | - | - | - | S | M | M | M | M | - | L | M | - | M |
| CO4 | M | L | - | - | - | S | M | M | M | M | - | L | M | - | M |
| CO5 | M | L | - | - | - | S | M | M | M | M | - | L | M | - | M |
| CO6 | M | L | - | - | - | S | M | M | M | M | - | L | M | - | M |

S- Strong; M-Medium; L-Low

## Syllabus

**Traditional and Modern Knowledge:** Two Worlds of Knowledge - Phase of Explorers, Sir Arthur Cotton and Irrigation, Smallpox Vaccination, Late Nineteenth Century, Voelcker, Howard and Agriculture, Havell and Indian Art; Indians at the Encounter - Gaekwad of Baroda and Technical Education, Science Education and Modern Industries, Hakim Ajmal Khan and Ayurveda, R. N. Chopra and Indigenous Drugs, Gauhar Jaan and Indian Classical Music; Linking Science and the Rural - Tagore's Sriniketan Experiment, Marthandam, the YMCA Model, Gandhi's Thoughts on Development, Nehru's View of Growth; Post-Independence Era - Modernization and Traditional Knowledge, Social Roots of Traditional Knowledge Activism, Global Recognition for Traditional Knowledge. **Global Mechanisms of Protection and Sharing:** For Recognition and Protection - United Nations Educational, Scientific and Cultural Organization (UNESCO), World Health Organization (WHO), International Labour Organization (ILO), UN Working Group on Indigenous Populations, Evolution of Other Organizations; Norms of Sharing - United Nations Environment Programme (UNEP), World Intellectual Property Organization (WIPO), World Trade

Organization (WTO); IPR and Traditional Knowledge - Theoretical Background, Positive Protections of TK, Defensive Strategies, IPR Facilitation for TK. **Traditional Knowledge for Basic Needs:** Indian Midwifery Tradition—The Dai System, Surface Flow Irrigation Tanks, Housing - A Human Right, Changing Priorities—Niyamgiri. **Biodiversity and Genetic Resources:** Jeevani - The Wonder Herb of Kanis, A Holistic Approach - FRLHT, Basmati - In the New Millennium, AYUSH-Based Cosmetics. **Traditional Knowledge in Manufacturing and Industry:** Drug Discovery, A Sweetener of Bengal, The Sacred Ring of Payyanur, Channapatna Toys. **Traditional Cultural Expressions:** Banarasi Saree, Music, Built and Tangible Heritage, Modern Yoga, Sanskrit and Artificial Intelligence, Climate Change and Traditional Knowledge.

**Assessment Pattern**

| **Bloom's category** | **Continuous Assessment Tests** | | **Seminar** |
|---|---|---|---|
| | **1** | **2** | **-** |
| Remember | 40 | 40 | 0 |
| Understand | 60 | 60 | 100 |
| Apply | 0 | 0 | 0 |
| Analyze | 0 | 0 | 0 |
| Evaluate | 0 | 0 | 0 |
| Create | 0 | 0 | 0 |

**Learning Resources:**

1. Nirmal Sengupta "Traditional Knowledge in Modern India Preservation, Promotion, Ethical Access and Benefit Sharing Mechanisms" Springer, 2019.
2. Amit Jha,"Traditional Knowledge System in India", Atlantic Publishers and Distributors Pvt Ltd, 2009.
3. Basanta Kumar Mohanta, Vipin Kumar Singh "Traditional Knowledge System and Technology in India", Pratibha Prakashan, 2012.
4. Kapil Kapoor, Michel Danino "Knowledge Traditions and Practices of India", Central Board of Secondary Education, 2012.
5. NPTEL video lecture on "Ayurvedic Inheritance of India", Video link: https://nptel.ac.in/courses/121/106/121106003/#.
6. Youtube video on "Introduction to Indian Knowledge Systems", Video link: https://www.youtube.com/watch?v=LZP1StpYEPM.
7. Youtube video on "12 Great achievements of Indian Civilization", Video link: https://www.youtube.com/watch?v=xmogKGCmclE.

**Course Designers:**


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- Dr.V.R.Venkatasubramani venthiru@tce.edu

| | | | | | |
|---|---|---|---|---|---|
| CO6 | TPS2 | Understand | Respond | | 1.2, 3.2.3 |
| | | | | | |

**Mapping with Programme Outcomesand Programme Specific Outcomes**

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | S | M | L | | | | | M | | M | | | S | |
| CO 2 | S | M | L | | | | | M | | M | | | S | |
| CO 3 | M | L | | | | | | M | | M | | | M | |
| CO 4 | S | M | L | | | | | M | | M | | | S | |
| CO 5 | S | M | L | | | | | M | | M | | | S | |
| CO 6 | M | L | | | | | | M | | M | | | M | |

S- Strong; M-Medium; L-Low

**AssessmentPattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 30 | 30 | 30 | - | - | - | 30 |
| Apply | 50 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**AssessmentPattern: Psychomotor**

| **Psychomotor Skill** | **Miniproject/Assignment/Practical Component** |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

**Sample Questions for Course Outcome Assessment**

**Course Outcome1(CO1):**

2. What are the advantages of Per Unit Value System?
3. Draw the reactance diagram for the power system shown in fig. Neglect resistance and use a base of 50MVA and 13.8KV on generator $G_1$

$G_1$: 20MVA, 13.8KV, X''=20% ; $G_2$: 30MVA, 18.0KV, X''=20%
$G_3$: 30MVA, 20.0KV, X''=20% ; $T_1$: 25MVA, 220/13.8 KV, X =10%
$T_2$:3Single phase unit each rated 10MVA, 127/18 KV, X =10%
$T_3$: 35MVA, 220/22 KV, X =10%

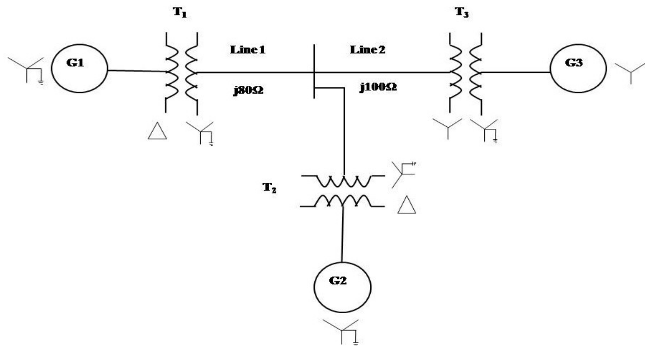



**Fig. 1**

**Course Outcome2(CO2):**

1. Develop the relation between bus admittance matrix, bus incidence matrix and primitive admittance matrix.
2. Form $Y_{bus}$ by inspection method for the 4 bus system with line series impedances in per units as given below:

| Line (bus to bus) | Impedance |
|---|---|
| 1 - 2 | 0.15 + j0.6 p.u |
| 1 - 3 | 0.01 + j0.4 p.u |
| 1 - 4 | 0.15 +j0.6 p.u |
| 2 - 3 | 0.05 +j0.2 p.u |
| 3 - 4 | 0.05 +j0.2 p.u |

**Course Outcome3(CO3):**

1. What are the three types of buses used to define the power flow problem? Is it possible to solve the power flow problem without such definition?
2. The following is the system data for a load flow solution. Determine the voltages at the end of first iteration using Gauss-Seidel method. Take $\alpha$=1.6.

**The line admittances:**

| ***Bus code*** | ***Admittance*** |
|---|---|
| 1-2 | 2-j8.0 |
| 1-3 | 1-j4.0 |
| 2-3 | 0.666-j2.664 |
| 2-4 | 1-j4.0 |
| 3-4 | 2-j8.0 |

**The schedule of active and reactive powers:**

| **Bus code** | **P in p.u** | **Q in p.u** | **V in p.u** | **Remarks** |
|---|---|---|---|---|
| 1 | - | - | 1.06 | Slack |
| 2 | 0.5 | 0.2 | 1+j0.0 | PQ |
| 3 | 0.4 | 0.3 | 1+j0.0 | PQ |

| | | | | |
|---|---|---|---|---|
| 4 | 0.3 | 0.1 | 1+j0.0 | PQ |

**Course Outcome 4 (CO4):**

1. A 50 MVA, 11kV, three phase synchronous generator is subjected to different types of faults. The fault currents are as follows:
   LG fault: 4200 A
   LL fault: 2600 A
   LLG fault: 2000A
   The generator neutral is solidly grounded. Find the p.u values of the three sequence reactance of the generator.
2. Compare the impacts of symmetrical and unsymmetrical faults in a power system.

**Course Outcome 5 (CO5):**

1. A 30MVA, 11KV, 3$\Phi$ synchronous generator has a direct subtransient reactance of 0.25 p.u. The negative and zero sequence reactance are 0.35 and 0.1 p.u respectively. The neutral of the generator is solidly grounded. Determine the sub transient current in the generator and the line to line voltages for subtransient conditions when a single line to ground fault, line to line fault and double line to ground fault occurs at the generator terminals with the generator operating unloaded at rated voltage
2. Two synchronous machines are connected through three-phase transformers to the transmission line as shown in Figure 2. The ratings and reactance of the machines and transformers are:
   Machine 1 and 2: 100MVA, 20 kV; $X_d'' = X_1 = X_2 = 20$ %
   $X_0 = 4\%$, $X_n = 5\%$
   Transformer $T_1$ and $T_2$ : 100MVA, 20$\Delta$/345 Y kV; X=8%

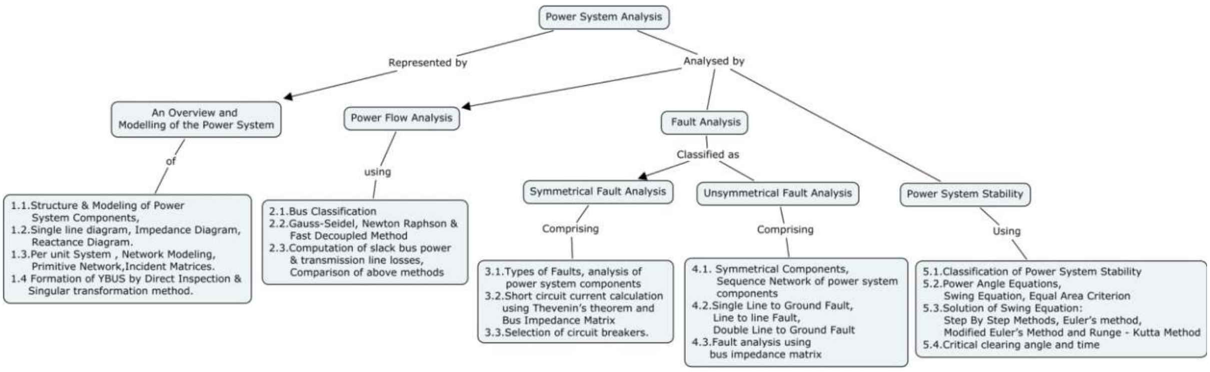

Fig.2

Find the sub transient current in the machine 1 and 2 for a fault at machine 1.

**Course Outcome6(CO6):**

1. Explain the significant differences between direct axis transient reactance and direct axis sub transient reactance of alternator.
2. Distinguish between steady state and transient state stabilities.
3. A generator is delivering 1p.u power to an infinite bus system through a purely reactive network when the occurrence of a fault reduces the generators output power to zero. The maximum power that could be delivered is 2.5p.u. When the fault is cleared, original network conditions again exist. Determine critical clearing angle. If H=6 MJ/MVA, Calculate critical clearing time.

**Concept Map**




## Syllabus

**An Overview and Modelling of the Power System:** Introduction - Structure of Electric Power System - Modeling of Power System Components - Single line diagram - Impedance Diagram - Reactance Diagram - Per unit System - Network Modeling - Bus Frame Network - Primitive Network - Incident Matrices - Formation of bus admittance matrix ($Y_{BUS}$) - Direct Inspection method and Singular transformation methods - Formation of bus impedance matrix ($Z_{BUS}$) without mutual coupling.

**Power Flow Analysis:** Introduction – Bus Classification – Load Flow Equations – Load flow methods – Gauss-Seidel Method – Newton-Raphson Method – Fast Decoupled Method – Computation of slack bus power and transmission line losses – Comparison of above methods.

**Symmetrical Fault Analysis:** Introduction – Types of Faults – Short circuit analysis of power system components: Synchronous Machine and Transmission Line – Short circuit current calculation using Thevenin's theorem and Bus Impedance Matrix – Short circuit capacity – Selection of circuit breakers.

**Unsymmetrical Fault Analysis:** Introduction – Symmetrical Components – Sequence Impedances – Sequence Network of power system components: Synchronous Machines, Transmission Line, Transformer and Loads – Single Line to Ground Fault – Line to line Fault – Double Line to Ground Fault – Unsymmetrical fault analysis using bus impedance matrix. Indian Standards for Short Circuit analysis IS-13234.

**Power System Stability:** Introduction – Classification of Power System Stability – Power Angle Equations – Swing Equation – Transient Stability – Assumptions in transient stability analysis – Equal Area Criterion – Solution of Swing Equation: Step By Step Methods, Euler's method, Modified Euler's Method and Runge – Kutta Method – Critical clearing angle and time.

## Learning Resources

1. John J. Grainger and Stevenson Jr. W.D., 'Power System Analysis', McGraw Hill International Edition, Fourth Edition, 1994.
2. Nagarath.I.J, Kothari.D.P, 'Modern Power System Analysis', Tata McGraw Hill Pub. Co. Ltd., Third Edition, 2004.
3. P. Venkatesh, B. V. Manikandan, S. Charles Raja and A. Srinivasan, 'Electrical Power Systems: Analysis, Security and Deregulation', PHI Learning Pvt. Ltd., First Edition, 2012.

4. HadiSaadat., 'Power System Analysis' Tata McGraw Hill Publishing Company, New Delhi, 2002.
5. E.W.Kimbark, Power system stability, Vol I & III, John Wiley & Sons, 2006
6. **Stagg**, *G.W. and* **El-Abiad**, A.H., Computer Methods in **Power System** Analysis", McGraw-Hill **Book** Co. 1968
7. K.A. Gangadhar., 'Electric Power Systems (Analysis, Stability and Protection)', Khanna Publishers Second Edition, 1992.
8. J. Duncan Glover, Thomas Overbye, Mulukutla S. Sarma,'Power System Analysis and Design' Cengage learning, 5th edition, 2016.
9. www.schneider-electric.com
10. NPTEL courses web: nptel.ac.in/courses/108105067/
11. MOOCs course link:https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1 | **An Overview and Modelling of the Power System** | | |
| 1.1 | Structure of Electric Power System – Modeling of Power System Components. | 1 | CO1 |
| 1.2 | Single line diagram – Impedance Diagram – Reactance Diagram. | 1 | CO1 |
| 1.3 | Per unit System – Network Modeling – Bus Frame Network – Primitive Network – Incident Matrices. | 2 | CO1 |
| 1.4 | Formation of bus admittance matrix ($Y_{BUS}$) – Direct Inspection method and Singular transformation method. | 2 | CO2 |
| 1.5 | Formation of bus impedance matrix ($Z_{BUS}$) without mutual coupling | 1 | CO2 |
| 2. | **Power Flow Analysis** | | |
| 2.1 | Bus Classification, Load Flow Equations | 2 | CO3 |
| 2.2 | Load flow methods: Gauss-Seidel Method, Newton Raphson Method and Fast Decoupled Method | 4 | CO3 |
| 2.3 | Computation of slack bus power and transmission line losses, Comparison of above methods | 2 | CO3 |
| **3** | **Symmetrical Fault Analysis** | | |
| 3.1 | Types of Faults, Short circuit analysis of power system components: Synchronous Machines and Transmission Line | 2 | CO4 |
| 3.2 | Short circuit current calculation using Thevenin's theorem and Bus Impedance Matrix | 2 | CO4 |
| 3.3 | Short circuit capacity, Selection of circuit breakers. | 2 | CO4 |
| **4** | **Unsymmetrical Fault Analysis** | | |
| 4.1 | Symmetrical Components, Sequence Impedances, Sequence Network of power system components: Synchronous Machines, Transmission Line, Transformer and Loads | 2 | CO5 |
| 4.2 | Single Line to Ground Fault, Line to line Fault, Double Line to Ground Fault | 3 | CO5 |
| 4.3 | Unsymmetrical fault analysis using bus impedance matrix. | 2 | CO5 |

| | | | |
|---|---|---|---|
| | Indian Standards for Short Circuit analysis IS-13234. | | |
| **5** | **Power System Stability** | | |
| 5.1 | Classification of Power System Stability, Power Angle Equations, Swing Equation. | 2 | CO6 |
| 5.2 | Transient Stability, Assumptions in transient stability analysis, Equal Area Criterion | 2 | CO6 |
| 5.3 | Solution of Swing Equation: Step By Step Methods, Euler's method, Modified Euler's Method and Runge - Kutta Method | 3 | CO6 |
| 5.4 | Critical clearing angle and time | 1 | CO6 |
| | **Total** | **36** | |

**Course Designers:**


| | | |
|---|---|---|
| 1. | Dr. P. Venkatesh | pveee@tce.edu |
| 2. | Dr. C.K. Babulal | ckbeee@tce.edu |
| 3. | Dr. S. Charles Raja | charlesrajas@tce.edu |

| 18EE620 | DATA STRUCTURES |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| ES | 3 | 0 | 0 | 3 |

## Preamble

This course will cover various data structures and their operations for manipulating them. Students will learn how to organize the data so that, the data can be accessed and updated efficiently using computer programs.

## Prerequisite

18EE360 C and C++ Programming

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Compare the perforamnce of algorithms using asymptotic notations based on time and space complexity | 10 |
| CO2 | Apply the concepts of stack and queue for suitable applications in trade off with time and space complexity. | 10 |
| CO3 | Develop linear list data structure using insertion, deletion, traversing operations | 15 |
| CO4 | Develop non linear list data structure using the insertion, deletion, traversing operations | 20 |
| CO5 | Develop a strategy to store and uniformly distribute data in a hash table without collision. | 10 |
| CO6 | Apply suitable algorithm to retrieve the maximum and minimum data in a collection and merge data using appropriate heap. | 15 |
| CO7 | Apply suitable sorting procedure to arrange the given data of different size | 20 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.1.2, 3.2.3 |
| CO2 | TPS3 | Apply | Value | | 1.3, 2.1.2, 3.2.3 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.2, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.2, 3.2.3 |
| CO5 | TPS3 | Apply | Value | | 1.3, 2.1.2, 3.2.3 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.2, 3.2.3 |
| CO7 | TPS3 | Apply | Value | | 1.3, 2.1.2, 3.2.3 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PS O1 | PS O2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | S | M | L | | | | | M | | M | | | | S |
| CO3 | S | M | L | | | | | M | | M | | | | S |
| CO4 | S | M | L | | | | | M | | M | | | | S |
| CO5 | S | M | L | | | | | M | | M | | | | S |
| CO6 | S | M | L | | | | | M | | M | | | | S |
| CO7 | S | M | L | | | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 10 | - | - | - | 10 |
| Understand | 20 | 20 | 30 | - | - | - | 30 |
| Apply | 60 | 60 | 60 | 100 | 100 | 100 | 60 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **Assignments** |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Define Space Complexity and Time Complexity.
2. Define Efficiency of an algorithm/program and ways to determine it.
3. List down the four different asymptotic notations and their need.

**Course Outcome 2 (CO2):**

1. Create a Queue and demonstrate various operations in it.
2. Create a Stack and demonstrate various operations in it.

3. Demonstrate various applications of stack using suitable data.

**Course Outcome 3(CO3)**

1. Given an array and a singly linked list. Which of these data structures uses more memory space to store the same number of elements? Justify your answer.
2. Check whether a given string is a palindrome or not using a double linked list.
3. Solve the Josephus problem using a circular linked list.

**Course Outcome 4 (CO4)**

1. Perform the AVL algorithm for non AVL trees. In each case, count the number of updated links required by the AVL rotation.Given a simple expression tree, consisting of basic binary operators i.e., + , – ,* and / and some integers, write an algorithm to evaluate the expression tree.
2. Construct a binary tree using inorder and preorder traversal of the binary tree:
   Inorder D, B, H, E, A, I, F, J, C, G
   Preorder A, B, D, E, H, C, F, I, J, G
3. Construct binary tree. Show the step by step process with suitable algorithm.

**Course Outcome 5 (CO5)**

1. Given input {4371, 1323, 6173, 4199, 4344, 9679, 1989} and a hash function h(x) = x (mod () 10), show the resulting
   a. separate chaining hash table
   b. hash table using linear probing, quadratic probing
2. Consider implementing a hash table for an application in which we will build an initial hash table by inserting asubstantial collection of records. After this, we expect that the number of insertions and the number of deletions performed to be roughly the same, although there may be long runs of consecutive insertions or consecutive deletions. Furthermore, the table will use a probe strategy to resolve any collisions that occur during insertion, and therefore we will "tombstone" cells from which a record has been deleted. If we implement the hash table described above, then when we search for a record, we cannot conclude the record is not in the table until we have found an empty cell in the table, not just a tombstone. (We will ensurethat the table never reaches the state that there are no empty cells.) Explain carefully why the search cannot stopwhen a tombstone is encountered.
3. Let m = 17, h1(x) = (k+15)%m, h2(x) = (4k+11)%m, and h3(x) = (7k+2)%m.Insert the keys 23, 7, 50, and 91 into the bit vector, and show the resulting vectors content. Then,find a key that is a false positive; that is, find a key that appears to have been inserted, but wasn't.

**Course Outcome 6(CO6):**

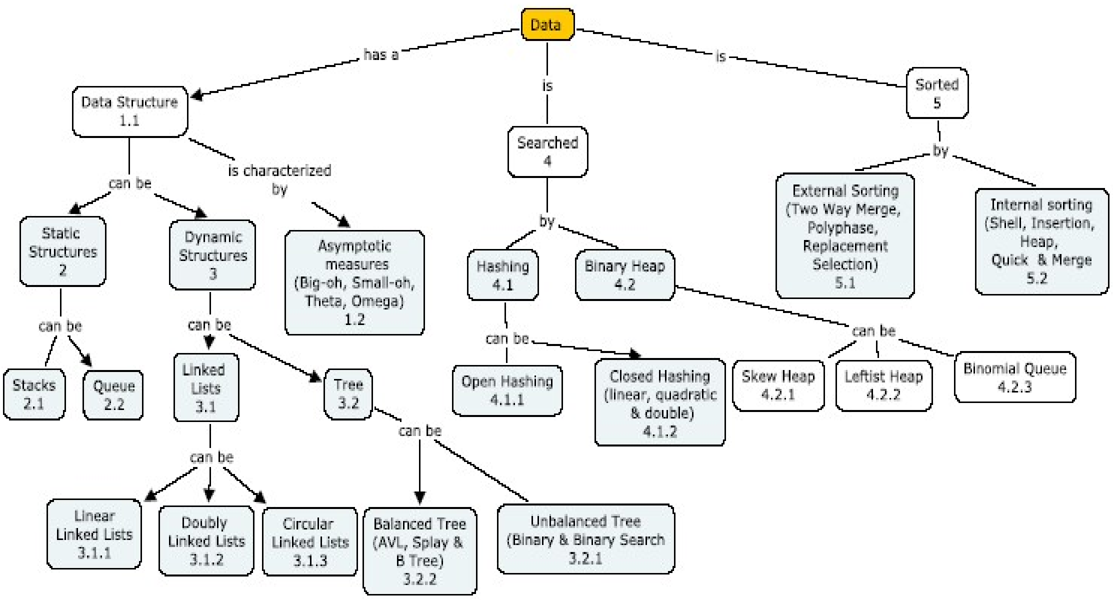
1. For a binary heap stored in an array, the root is stored in position 1, the parent of node i is stored in position floor(i/2), the left child is in position 2i, and the right child is in position 2i+1. What about a d-heap stored in an array? In what positions are the children and parent of node i stored? [Hint: to start, assume that the root is at position 0. Then modify your results to work with the root at position 1]
2. Show the result of inserting keys 1 to 15 in order (i.e. 1 first, then 2 second, then 3 third, etc.) into an initially empty leftist heap. Use the leftist heap insert (i.e. merge) algorithm at each step. Show each step for this process.

3. Prove or disprove: A perfectly balanced tree forms if keys 1 to 2k − 1 are inserted in order (again this means 1 first, then 2 etc) into an initially empty leftist heap. k is a positive integer.

**Course Outcome 7(CO7):**

1. Estimate the execution time of Bubble sort for an reverse order input.
2. Recommend a suitable sorting procedure to operate on a large data set with jusification.
3. Apply quick sort to sort 11,9,13,8,5,7,6,4,18,3,19,1 in ascending order.

## Concept Map




## Syllabus

**Data:** Data Structure, Asymptotic Measures **Static Data Structures:** Stacks, Queues **Dynamic Data Structures:** Linked Lists: Linear Linked Lists, Doubly Linked Lists and Circular Linked Lists, Trees: Unbalanced and Balanced Trees, **Data Search:** Hashing: Open Hashing and Closed Hashing; Heap: Skew Heap, Leftist Heap, Binomial Queue **Data Sorting:** Internal Sorting: Insertion sorting, Shell sorting, Quick sorting, Merge sorting and Heap sorting; External Sorting

## Learning Resources

1. Mark Allen Weiss , "Data Structures and Algorithm Analysis in C++", Pearson, 2007
2. Adam Drozdek, "Data structures and Algorithms in C++", Cengage Learning; 4th edition, 4th Edition, 2012.
3. Y. Langsam, M. J. Augenstein and A. N. Tanenbaum, "Data Structure Using C and C++", Pearson Education, 2nd Edition, 2015.

## Course Contents and Lecture Schedule

| No. | Topic | No.of | Course |
|---|---|---|---|

| | | Lectures | Outcome |
|---|---|---|---|
| 1 | **Data (4)** | | |
| 1.1 | Data Structure | 2 | CO1 |
| 1.2 | Asymptotic Measures | 2 | CO1 |
| 2 | **Static Data Structures (4)** | | |
| 2.1 | Stacks | 3 | CO2 |
| 2.2 | Queues | 2 | CO2 |
| 3 | **Dynamic Data Structures(14)** | | |
| 3.1 | Linked Lists | 1 | CO3 |
| 3.1.1 | Linear Linked Lists | 2 | CO3 |
| 3.1.2 | Doubly Linked Lists | 2 | CO3 |
| 3.1.3 | Circular Linked Lists | 1 | CO3 |
| 3.2 | Trees | 1 | CO4 |
| 3.2.1 | Unbalanced Trees | 2 | CO4 |
| 3.2.2 | Balanced Trees | 5 | CO4 |
| 4 | **Data Search (10)** | | |
| 4.1 | Hashing | 1 | CO5 |
| 4.1.1 | Open Hashing | 1 | CO5 |
| 4.1.2 | Closed Hashing | 2 | CO5 |
| 4.2 | Heap | 2 | CO6 |
| 4.2.1 | Skew Heap | 1 | CO6 |
| 4.2.2 | Leftist Heap | 2 | CO6 |
| 4.2.3 | Binomial Queue | 1 | CO6 |
| 5 | **Data Sorting (8)** | | |
| 5.1 | Internal Sorting | | |
| 5.1.1 | Insertion sorting | 1 | CO7 |
| 5.1.2 | Shell sorting | 1 | CO7 |
| 5.1.3 | Quick sorting | 1 | CO7 |
| 5.1.4 | Merge sorting | 1 | CO7 |
| 5.1.5 | Heap sorting | 2 | CO7 |
| 5.2 | External Sorting | 2 | CO7 |

**Course Designers:**

1. S.Prasanna sprcse@tce.edu

| 18EE670 | ENERGY MANAGEMENT SYSTEM LABORATORY | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PC | 0 | 0 | 2 | 1 |

**Preamble**

The aim of this lab course is to train the students in modelling, designing and analysing solar systems, analysing the various characteristics of solar system and performance of various converters used in solar systems using various state of the art hardware setup.

**Prerequisite**

NIL

**Course Outcomes**

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Analyze the characteristics of solar system using simulation software | 30 |
| CO2 | Analyze the performance of various charge controllers used in solar system module experimentally | 10 |
| CO3 | Analyze the efficiency various converters used in solar system module experimentally | 10 |
| CO4 | Analyze the performance of the PV array at different tilt angles experimentally | 10 |
| CO5 | Analyze the effect of frequency of light on power output of solar panel experimentally | 10 |
| CO6 | Analyze spectral response for different wave lengths of light using spectral response system module experimentally | 10 |
| CO7 | Analyse the energy consumption of an institution using smart metering infrastructure. | 10 |
| CO8 | Perform simulation studies using a state of the art Solar PV WIND Hybrid System with DC Micro Grid setup | 10 |

*** Weightage depends on Bloom's Level, number of contact hours.

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2.11, 2.1.5, 2.2.3 2.4.4, 3.2.3 |
| CO2 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2.11, 2.1.5, 2.2.3, 2.4.4, 3.2.3 |
| CO3 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2.11, 2.1.5, 2.2.3, 2.4.4, 3.2.3 |
| CO4 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2.11, 2.1.5, 2.2.3, 2.4.4, 3.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO5 | TPS3 | Apply | Value | Mechanism | 1.2.11, 2.1.5, 2.2.3, 2.4.4, 3.2.3 |
| CO6 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2.11, 2.1.5, 2.2.3, 2.4.4, 3.2.3 |
| CO7 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.3, 2.1.5, 2.4.4, 3.2.3 |
| CO8 | TPS3 | Apply | Value | Mechanism | 1.3, 2.1.5, 2.4.4, 3.2.3 |

**Mapping with Programme Outcomesand Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | M | L | S | | | M | | M | | | S | |
| CO2 | S | S | M | L | S | | | M | | M | | | S | |
| CO3 | S | S | M | L | S | | | M | | M | | | S | |
| CO4 | S | S | M | L | S | | | M | | M | | | S | |
| CO5 | S | M | L | | | | | M | | M | | | S | |
| CO6 | S | S | M | L | S | | | M | | M | | | S | |
| CO7 | S | M | L | | | | | M | S | S | | | S | |
| CO8 | S | S | M | L | S | | | M | S | S | | | S | |

S- Strong; M-Medium; L-Low

**AssessmentPattern: Cognitive Domain**

| **Cognitive Levels** | **Model Examination** | **Terminal Examination** |
|---|---|---|
| Remember | | |
| Understand | | |
| Apply | 30 | 30 |
| Analyse | 40 | 40 |
| Evaluate | | |
| Create | | |

**AssessmentPattern: Psychomotor**

| **Psychomotor Skill** | **~~Miniproject~~/Practical Component/~~Observation~~** |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 30 |
| Complex Overt Responses | |

| | |
|---|---|
| Adaptation | |
| Origination | |

**List of Experiments/Activities with CO Mapping**

1. Draw I-V and P-V characteristics of solar cell at different series/parallel configurations using solar simulation system module. (CO1)
2. Draw I-V and P-V characteristics of solar cell at different series/parallel configurations using solar simulation system module with change in illumination. (CO1)
3. Draw I-V and P-V characteristics of various solar modules such as mono crystalline, multi crystalline and thin film module using solar PV module technologies training system module. (CO1)
4. Compare and analyze the performance of charge controllers such as MPPT and PWM using solar charge controller module (CO2)
5. Analyze the efficiency of step up and step down converter and DC to AC converter at different power in a solar system using DC-DC and DC-AC converter setup module. (CO3)
6. Measurement of operating parameters i.e. current and voltage of PV array at different tilt angle using solar PV tracking system module. (CO4)
7. Find the variation of power output of solar panel with the various frequencies of light. (CO5)
8. Measurement of minority carrier life time in solar cell using carrier life time measurement system module. (CO6)
9. Measurement and comparison of spectral response for different wave lengths of light and obtain spectral response curve using spectral response training system module. (CO6)
10. Interfacing with software to obtain I-V and P-V characteristics of solar cell for larger number of data using the possible modules (CO1)
11. Analysis of TCE energy report by smart metering infrastructure (CO7)
12. Import and export energy analysis using 1KW grid tie solar PV System.(CO7)
13. DC micro grid system operations for the effect of change in wind speed and pitch angle.(CO8)

**Learning Resources**

1. https://www.kwattsolutions.com
2. Solar Training Manuals prepared by kWatt Solutions Private Limited, Mumbai
3. https://www.elmeasure.com
4. https://www.ecosenseworld.com/labs/wind-energy-labs/wind-energy-training-system

**Course Designers:**

| | | |
|---|---|---|
| 1. | Dr. P. Venkatesh | pveee@tce.edu |
| 2. | Dr. C.K. Babulal | ckbeee@tce.edu |
| 3. | Dr. S. Charles Raja | charlesrajas@tce.edu |

| 18EE680 | POWER ELECTRONICS AND DRIVES LAB |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PC | 0 | 0 | 2 | 1 |

## Preamble

This laboratory gives a practical exposure to the students to learn the power electronics and drives. The students will be able to design and analyze power converters such as AC-DC converters, DC-DC converters, DC-AC converters, AC- to AC converters and their control circuits for real world applications.

## Prerequisite

- 18EE320:DC machines and Transformers
- 18EE420:AC machines
- 18EE530:Power electronics

## Course Outcomes

| CO No. | Course outcomes | Weightage in % |
|---|---|---|
| CO1 | Analyze the performance of driver circuits for SCR/MOSFET/IGBT experimentally | 15 |
| CO2 | Analyze the performance of the SCR commutation circuits designed for the given specifications experimentally | 10 |
| CO3 | Analyze the performance of the designed controlled rectifiers with ‘R’ and ‘RL’ loads experimentally | 10 |
| CO4 | Analyze the performance of the DC chopper and static circuit breakers designed for the given specifications experimentally | 10 |
| CO5 | Analyze the performance characteristics of the given DC and AC drive by conducting suitable experiments | 20 |
| CO6 | Develop a power electronic circuit for the given design specifications | 20 |
| CO7 | Analyze the performance of the given Power electronic circuit using PSIM/ MATLAB-Simulink/ PSPICE/ PLECS/ VSIM/ PSCAD simulation tool | 10 |
| CO8 | Explain the working of Battery simulator, Mixed domain oscilloscope, Programmable AC /DC Power supplies and Picoscope. | 5 |

## CO mapping with CDIO curriculum framework:

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2, 2.2.3, 3.1.2, |
| CO2 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2, 2.2.3,,3.1.2, 4.5.1 |
| CO3 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2, 2.2.3, 3.1.2, 4.5.1 |

| | | | | | |
|---|---|---|---|---|---|
| **CO4** | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2, 2.2.3, ,3.1.2, 4.5.1 |
| **CO5** | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2 , 2.2.3, 3.1.2, 4.5.1 |
| **CO6** | TPS5 | Evaluate | Organize | Complex Overt Responses | 1.2, 2.2.3, 3.1.2, 4.5.1 |
| **CO7** | TPS5 | Evaluate | Organize | Complex Overt Responses | 1.2, 2.2.3, 13 ,3.1.2, 4.5.3 |
| **CO8** | TPS2 | Understand | Respond | Guided response | 1.2 , 2.2.3, 3.1.2 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | M | L | S | | | M | | M | | | S | S |
| CO2 | S | S | M | L | S | | | M | | M | | | S | S |
| CO3 | S | S | M | L | S | | | M | | M | | | S | S |
| CO4 | S | M | L | | S | | | M | | M | | | S | S |
| CO5 | S | S | M | L | S | | | M | | M | | | S | S |
| CO6 | S | S | M | L | S | | | M | | M | | | S | S |
| CO7 | S | S | S | M | S | | | M | | M | | | S | S |
| CO8 | M | L | | | M | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

**Assesment Pattern : congnitive domain:**

| Cognitive Levels | Model Examination | Terminal Examination |
|---|---|---|
| Remember | | |
| Understand | | |
| Apply | 30 | 30 |
| Analyze | 30 | 50 |
| Evaluate | 20 | |
| Create | | - |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | ~~Miniproject~~ /Practical Component/~~Observation~~ |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | 20 |
| Adaptation | |
| Origination | |

## List of Experiments/Activities With CO Mapping

1. 'R' and RC triggering circuits for half wave controlled rectifiers (CO1)
2. UJT triggering circuit for half wave controlled rectifier (CO1)
3. MOSFET/IGBT/SCR Driver circuits (CO1)
4. Voltage, current and complementary commutation techniques(CO2)
5. Half controlled and fully controlled rectifier with 'R' and 'RL' loads(CO3)
6. Static DC and AC circuit breakers(CO4)
7. Single quadrant DC chopper(CO4)
8. Half controlled rectifier fed DC motor(CO5)
9. Voltage commutated chopper fed DC motor(CO5)
10. AC voltage controller fed single phase induction motor(CO5)
11. PLC/DSP based 3 phase induction motor drive(CO5)
12. V/F control of Induction motor(CO5)
13. Switched reluctance motor drive(CO5)
14. Simulation of power electronic converter circuits using PSIM/ MATLAB-Simulink/ PSPICE/PLECS/VSIM/PSCAD (CO7)
15. Study of Battery simulator, Mixed domain oscilloscope, Programmable AC /DC Power suplies and Picoscope.(CO8)
16. Design, implementation and operation of the power electronic circuits for the given design specifications.(CO6)

## Learning Resources


1. Muhammad H.Rashid, Power Electronics Circuits, Devices & Applications - Pearson Education India Publication, New Delhi, 7th Impression, 2009.
2. M.D.Singh & K.B.Khanchandani, Power Electronics – Tata Mc Graw Hill publishing company Ltd, New Delhi, 2008.
3. Ned Mohan, Tore Undeland & William Robbins, Power Electronics : converters Applications and Design-John Willey and sons, 3rd Edition, 2003.
4. P.S. Bimbra, Power Electronics- Khanna Publishers, 3rd Edition, 2004.
5. Daniel W.Hart, Introduction to power Electronics – Prentice Hall International Inc., 1997.
6. L. Umanand, Power Electronics: Essentials and Applications- Wiley India, 2009.
7. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-334-power-electronics-spring-2007/


## Course designers


1. Dr. V. Suresh Kumar - vskeee@tce.edu
2. Dr. S. Arockia Edwin Xavier - saexeee@tce.edu

| | | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| **18EE710** | **ELECTRIC POWER UTILIZATION** | PC | 3 | - | - | 3 |

**Preamble**

This course provides the application oriented basic knowledge to the electrical engineers, with the aspect of effective utilization of electrical energy for various residential as well as industrial applications. This course familiarizes the students in five major electrical energy utilization aspects such as electric drive, electric heating, electric welding, illumination and electric traction.

**Prerequisite**

- 18EE320: DC machines and Transformers
- 18EE420: AC machines

**Course Outcomes**

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Design the rating of suitable drive for the specified industrial applications | 20 |
| CO2 | Design a suitable heating element for an electric heating application. | 15 |
| CO3 | Explain the various types of electric welding | 10 |
| CO4 | Explain the suitable lamp, lighting scheme and its effective utilisation for the specified applications | 20 |
| CO5 | Design lighting schemes to Domestic, Office, Industrial and Commercial applications based on the specific lighting level standards. | 15 |
| CO6 | Explain the principle and operation of electric traction | 20 |

*** Weightage depends on Bloom's Level, number of contact hours.

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.2, 2.1.5, 2.3.1,3.2.3 |
| CO2 | TPS2 | Apply | Value | | 1.2, 2.1.5, 2.3.1,3.2.3 |
| CO3 | TPS2 | Understand | Respond | | 1.2, 2.3.1, 2.3.1,3.2.3 |
| CO4 | TPS2 | Understand | Respond | | 1.2, 2.3.1,3.2.3 |
| CO5 | TPS3 | Apply | Value | | 1.2, 2.1.5, 2.3.1,3.2.3 |
| CO6 | TPS2 | Understand | Respond | | 1.2, 2.3.1,3.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| 18ES690 | ENGINEERING DESIGN PROJECT |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| Project | 1 | 0 | 4 | 3 |

**Preamble**

An engineer must understand the economic, social, political, sustainability and environmental contexts in which the need arises. Engineering solutions are always created in response to some societal/industrial need. Understanding the societal/industrial need is central to success in engineering design. Therefore, the engineering students have been assigned on the problem identification phase of engineering design. Now, they have an opportunity to reflect and realise the knowledge that have been gained through the courses such as 18ES150 Engineering Exploration, 18ES290 Lateral Thinking, 18ES390 Design Thinking, 18XX490 Project Management and 18ES590 System Thinking. This course will enable the students to integrate CDIO Skill-based courses and their domain-specific courses. More specifically, by employing the broad knowledge they gain from experiences in foundation elective, general elective and audit courses, students are better equipped to provide engineering solution societal and/or industrial needs.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage in % |
|---|---|---|
| CO1 | Execute different phases of engineering design project including functional composition and design specification in a team. | 20 |
| CO2 | Evaluate the alternate engineering design approaches as per the performance criteria with design verification and validation. | 20 |
| CO3 | Evaluate a design with the use of test verification matrix / Design Failure Mode Effect Analysis (DFMEA)/ Usability testing | 15 |
| CO4 | Explain the significance of Intellectual Property rights and the procedure for searching and filing a patent. | 15 |
| CO5 | Exhibit team work with appropriate conflict management strategies. | 10 |
| CO6 | Prepare appropriate design documents and deliver effective technical presentations | 10 |

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | Mechanism | 1.1, 1.2, 2.1.1, 3.1.2, 3.2.3, 3.2.6, 4.1.2 |
| CO2 | TPS5 | Evaluate | Organise | Adaptation | 1.1, 1.2, 2.1.2, 2.5.1, 2.5.2, 3.1.2, 3.2.3, 3.2.6, 4.1.2 |
| CO3 | TPS5 | Evaluate | Organise | Adaptation | 1.1, 1.2, 2.1.3, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.3.1 |
| CO4 | TPS2 | Understand | Respond | Guided Response | 1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1 |
| CO5 | TPS3 | Apply | Value | Mechanism | 1.1, 1.2, 2.1.5, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1 |
| CO6 | TPS3 | Apply | Value | Mechanism | 1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1 |

**Mapping with Programme Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | - | - | M | M | M | S | S | S | S |
| CO2 | S | S | S | M | - | M | M | M | S | S | S | S |
| CO3 | S | S | S | M | S | M | M | S | S | S | S | S |
| CO4 | M | L | - | - | - | M | M | - | - | - | - | S |
| CO5 | S | M | L | - | - | M | M | S | S | S | M | S |
| CO6 | S | M | L | - | - | - | - | S | S | S | - | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern:**

| Phases | Deliverables | Marks | Course Outcomes |
|---|---|---|---|
| **Continuous Assessment** | | | |
| Review 1 – Engineering Design Project Selection, functional decomposition and Specification | Technical Report | 10 | CO1, C06 |
| Review 2 – Evaluation of Design Approaches | Technical Report | 20 | CO2, CO5, CO6 |
| Review 3 – Design Verification and validation | Technical Report | 20 | CO3, CO4, CO6 |
| **End-Semester Examination** | | | |
| Demonstration | Prototype | 60 | CO1, CO2, CO3, CO4 CO5, CO6 |
| Design Portfolio Presentation | Portfolio Document | 40 | |

- Reports are to be submitted at each review. The report and presentation will be evaluated based on customized Rubrics for periodic reviews.
- Demonstration and Design Portfolio presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

**Syllabus**

**Project Selection** – Search Phase, Preliminary Design Review (PDR) and Critical Design Review (CDR), Project Specification, Proposal Report, Proposal Presentation

**Engineering Design Process** - The NASA Design Approach, Design Verification and Validation ,Design Verification Plan – DFMEA, test verification matrix, Usability testing, DRIDS-V Design Approach and Plan

**Intellectual Property Rights** – Trademarks, Copyrights and Patents, Types of patents, Searching patents, Filing Patents

**Team formation and Communication –** Types of teams, Team Conflict Management – common causes, cultural styles and conflict, Project Team Evaluation, Conducting Meetings and Making Presentations

**Learning Resources**

- Harvey F. Hoffman, "The Engineering Capstone Course: Fundamentals for Students and Engineers", Springer, 2014
- https://sharepoint.ecn.purdue.edu/epics/teams/Public%20Documents/EPICS_Design_Process.pdf?_ga=2.252800138.2089889711.1612784342-1089955741.1612784342

**Course Contents and Lecture Schedule**

| Module No | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 1 | **Project Selection** | | |
| | Search Phase, Preliminary Design Review (PDR) and Critical Design Review (CDR), Project Specification, | 2 | CO1, CO6 |

| | | | |
|---|---|---|---|
| | Proposal Report, Proposal Presentation | | |
| 2 | **Engineering Design Process** | | |
| 2.1 | The NASA Design Approach | 1 | CO2 |
| 2.2 | Design Verification and Validation | 1 | CO2 |
| 2.3 | Design Verification Plan – DFMEA, test verification matrix, Usability testing, | 2 | CO3 |
| 2.4 | DRIDS-V Design Approach and Plan | 1 | CO3 |
| 3 | **Intellectual Property Rights** | | |
| 3.1 | Trademarks, Copyrights and Patents, | 1 | CO4 |
| 3.2 | Types of patents, Searching patents,. | 1 | CO4 |
| 3.3 | Filing Patents | 1 | CO4 |
| 4 | **Team formation and Communication** | | |
| 4.1 | Types of teams, Team Conflict Management – common causes, cultural styles and conflict, | 1 | CO5 |
| 4.2 | Project Team Evaluation, Conducting Meetings and Making Presentations | 1 | CO5, CO6 |
| | **Total** | **12** | |

**Course Designers:**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- Dr.C.Jeyamala jeyamala@tce.edu

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | S | M | L | | | | | M | | M | | | S | |
| CO 2 | S | M | L | | | | | M | | M | | | S | |
| CO 3 | M | L | | | | | | M | | M | | | M | |
| CO 4 | M | L | | | | | | M | | M | | | M | |
| CO 5 | S | M | L | | | | | M | | M | | | S | |
| CO 6 | M | L | | | | | | M | | M | | | M | |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 30 | 30 | 30 | - | - | - | 30 |
| Apply | 50 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | | | | | | | |
| Evaluate | | | | | | | |
| Create | | | | | | | |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Assignment |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. A 15HP motor has a heating time constant of 2 hours. Determine the time in which it attains a temperature of 40˚C from its value of 10˚C, while working continuously on full load, if its final steady temperature is 45˚C
2. A motor driving a colliery winder equipment has to deliver a load rising uniformly from zero to maximum of 2000HP in 20s during the acceleration period 1000HP for 40s during the full load period and during the deceleration period of 10s when regenerative breaking is taking place, the HP returned to supply falls from 330 to zero. The interval for decking before the next load cycle starts is 20 seconds. Estimate the HP rating of the motor.

**Course Outcome 2 (CO2):**

1. Dielectric heating is to be employed to heat a slab of insulating material 20mm thick and 1530mm2 in area. Power required is 200W and a frequency of 3MHz is to be used. The material has a permittivity of 5 and power factor of 0.05. Determine the voltage necessary and the current which will flow through the material
2. A 22 kW, single phase 220 V resistance oven employs circular Nichrome wire for its heating element. The wire temperature is not to exceed 1250°C and the temperature of the charge is 500°C. Calculate the size and length of the wire required. Assume radiating efficiency (K) is 0.6, emmissivity (ε) is 0.9and specific resistance of the wire (ρ) is 101 x $10^{-6}$ cm.
3. A piece of insulating material is to be heated by dielectric heating. The size is 10 x 10 x 3 cm. A frequency of 20 MHz is used and the power absorbed is 500 Watts. Calculate the voltage necessary for heating and current that flows in the material. The material has relative permittivity of 5 and power factor of 0.05.

**Course Outcome 3(CO3):**

1. Briefly explain the various types of resistance welding.
2. Discuss on any two types of resistance welding.
3. Discuss about modern welding used in industries.

**Course Outcome 4 (CO4):**

1. Define utilization factor.
2. Discuss about the various factors affecting the design of lighting system.
3. A lamp giving 300 CP in all directions below the horizontal is suspended 3 m above the centre of a square table of 1 m side. Calculate the maximum and minimum illumination on the surface of the table.

**Course Outcome 5(CO5):**

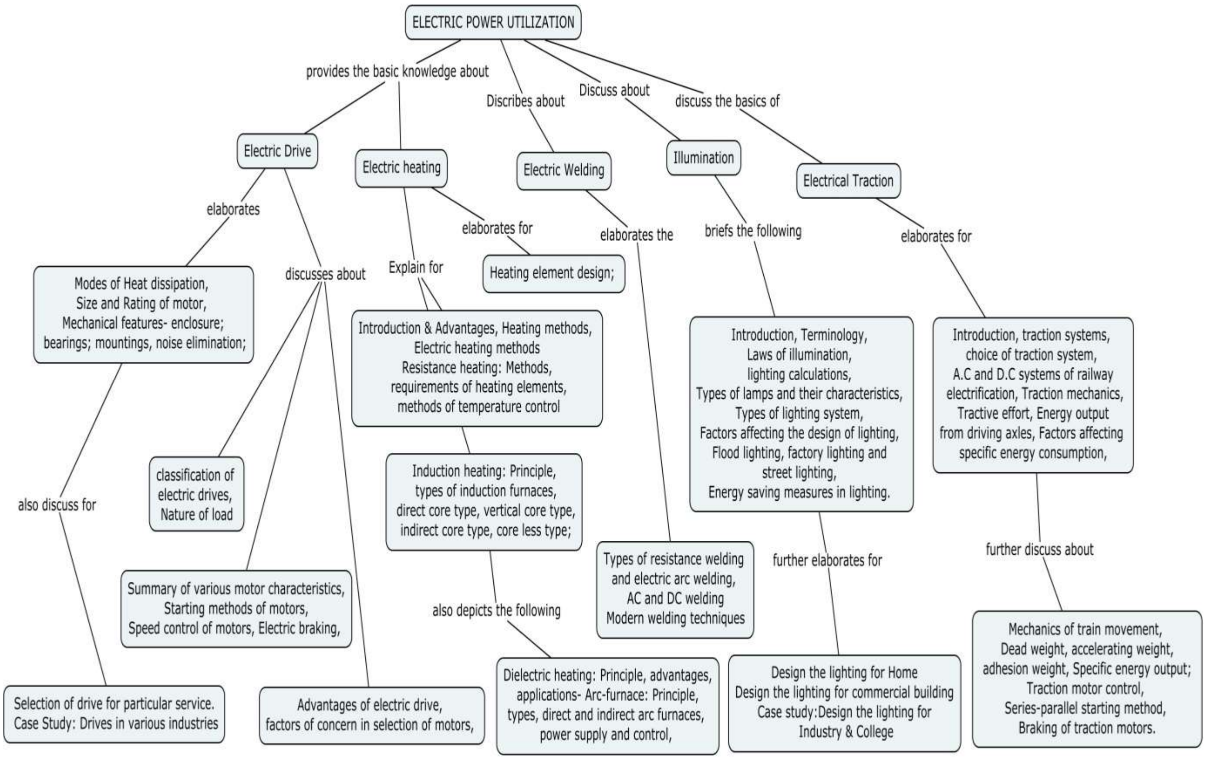
4. It is desired to illustrate a drawing hall with an average illumination of 200lux. The hall is 30x20$m^2$; the lamps are to fitted 4m from ground floor. Find the number of lamps and wattage/lamp for the lighting scheme. Given efficiency of the lamps available at 25lumens/watt, depreciation factor is 0.8 and co efficient of utilization 0.75, space height ratio between 0.8 to 1.2. Give satisfactory spacing arrangements.
5. Two lamps are hung at a height of 9meter from the floor level. The distance between the lamps is 10meters lamp one is of 500C.P. if the illumination on the floor vertically below the lamp is 20 lux. Find the candle power of the second lamp.

**Course Outcome 6 (CO6):**

1. Draw the trapezoidal speed-time curve for main line service.
2. Define coefficient of adhesion.

   A train has schedule speed 80 km/hr. The distance between the stations is 6 km. The values of acceleration and retardation are 1.5 kmphps and 2.5 kmphps. Calculate the maximum speed of the train by assuming trapezoidal speed-time curve.

## Concept Map




## Syllabus

**Electric Drive:** Advantages of electric drive, factors of concern in selection of motors, classification of electric drives, Nature of load, Summary of various motor characteristics, Starting methods of motors, Speed control of motors, Electric braking, Modes of Heat dissipation, Size and Rating of motor, Selection of drive for particular service. Case Study: Drives in various industries.

**Electric heating and welding:** Introduction & Advantages, Electric heating methods, Resistance heating: Methods, requirements of heating elements, methods of temperature control, Heating element design; Induction heating: Principle, types of induction furnaces, direct core type, vertical core type, indirect core type, core less type; Dielectric heating: Principle, advantages, applications, Arc-furnace: Principle, types, direct and indirect arc furnaces, Types of resistance welding and electric arc welding, AC and DC welding

**Illumination:** Introduction, Terminology, Laws of illumination, lighting calculations, Types of lamps and their characteristics, Types of lighting system, Design of lighting scheme, Factors affecting the design of lighting, Flood lighting, factory lighting and street lighting, Energy saving measures in lighting. Case study: Design the lighting for Home, commercial building, Industry, College.

**Electrical Traction:** Introduction, traction systems, choice of traction system, A.C and D.C systems of railway electrification, Traction mechanics, Tractive effort, Energy output from driving axles, Factors affecting specific energy consumption, Mechanics of train movement, Dead weight, accelerating weight, adhesion weight, Specific energy output; Case study: Current scenario in Indian railway

**Learning Resources**

1. Partab.H, “Art and science of utilization of Electrical Energy”, 2015, Dhanpat Rai & Co. (P) Ltd., Delhi, 2016.
2. TAYLOR, OPENSHAW E, “Utilization Of Electrical Energy”, Orient Blackswan, 1971
3. Gupta. J.B., “Utilization of electric power and electric traction”, S.K.Kataria and sons , 2013.
4. Garg.G.C., “Utilization of electric power and electric traction”, Khanna Publishers, 2010.
5. V.Ramanathan, P.S.Kannan, V.Saravanan, P.S.Manoharan, “Generation, Electric Energy Utilization and Conservation”, Charulatha Publications, Chennai, 2008Course Contents and Lecture Schedule

**6. Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1 | **Electric Drive** | | |
| 1.1 | Advantages of electric drive, factors of concern in selection of motors, | 1 | CO1 |
| 1.2 | classification of electric drives, Nature of load | 1 | CO1 |
| 1.3 | Summary of various motor characteristics, Starting methods of motors, | 1 | CO1 |
| 1.4 | Speed control of motors, Electric braking, | 1 | CO1 |
| 1.5 | Modes of Heat dissipation | 1 | CO1 |
| 1.6 | Size and Rating of motor | 1 | CO1 |
| 1.7 | Selection of drive for particular service. Case Study: Drives in various industries | 1 | CO1 |
| 2. | ***Electric heating and welding*** | | |
| 2.1 | Introduction & Advantages, Electric heating methods | 1 | CO2 |
| 2.2 | Resistance heating: Methods, requirements of heating elements, methods of temperature control, | 1 | CO2 |
| 2.3 | Heating element design; | 1 | CO2 |
| 2.4 | Induction heating: Principle, types of induction furnaces, direct core type, vertical core type, indirect core type, core less type; | 1 | CO2 |
| 2.5 | Dielectric heating: Principle, advantages, applications- Arc-furnace: Principle, types, direct and indirect arc furnaces | 1 | CO2 |
| 2.6 | Types of resistance welding and electric arc welding | 2 | CO3 |
| 2.7 | AC and DC welding | 1 | CO3 |
| 3. | ***Illumination*** | | |
| 3.1 | Introduction, Terminology, Laws of illumination, | 2 | CO4 |
| 3.2 | lighting calculations, Types of lamps and their characteristics, | 2 | CO4 |
| 3.3 | Types of lighting system, Design of lighting scheme, | 2 | CO4 |
| 3.4 | Factors affecting the design of lighting, Flood lighting, factory lighting and street lighting, | 1 | CO4 |
| 3.5 | Energy saving measures in lighting. | 2 | CO4 |
| 3.6 | Design the lighting for Home | 2 | CO5 |

| | | | |
|---|---|---|---|
| 3.7 | Design the lighting for commercial building | 2 | CO5 |
| 3.8 | Case study:, Design the lighting for Industry College | 2 | CO5 |
| 4. | ***Electrical Traction*** | | |
| 4.1 | Introduction, traction systems, choice of traction system, A.C and D.C systems of railway electrification, | 1 | CO6 |
| 4.2 | Traction mechanics, Tractive effort, Energy output from driving axles, | 2 | CO6 |
| 4.3 | Factors affecting specific energy consumption, | 1 | CO6 |
| 4.4 | Mechanics of train movement, Dead weight, accelerating weight, adhesion weight, Specific energy output; | 1 | CO6 |
| 4.5 | Case study: Current scenario in Indian railway | 1 | CO6 |

**Course Designers:**

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2. Shanmugavadivoo.N nsveee@tce.edu
3. Nelson Jayakumar D. dnjayakumar@tce.edu

| | | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| **18EE770** | **ELECTRIC POWER SYSTEMS LABORATORY** | PC | 0 | 0 | 2 | 1 |

## Preamble

The aim of this course is to train the students for solving the power system problems using MATLAB coding. The formation of bus admittance matrix followed by power flow solutions using various numerical methods is introduced. Students get the exposure in short circuit analysis and stability analysis under steady state and transient state. Economic load dispatch problem is also performed using MATLAB coding.

## Prerequisite

- 18EE610- Power System Analysis

## Course Outcomes

On the successful completion of the course , students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Analyze the performance of direct inspection and singular transformation methods for determining Y-bus matrix of the given system using simulation software | 20 |
| CO2 | Analyse the performance the given power system using Gauss-Seidel method using simulation software | 15 |
| CO3 | Analyse the performance the given power system using Newton-Raphson method using simulation software | 15 |
| CO4 | Calculate the fault current for various symmterical and unsymmetrical faults on the given power syste using simulation software | 20 |
| CO5 | Analyze the transient stability of the power system by applying different fault clearing time to the circuit breaker using simulation software | 15 |
| CO6 | Compute the optimal dispatch of the given power system using simulation software | 15 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| | | | | | |
| CO1 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2.15, 2.1.5, 2.2.3, 2.4.4, 3.2.3 |
| CO2 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2.15, 2.1.5, 2.2.3, 2.4.4, 3.2.3 |
| CO3 | TPS4 | Analyze | Organize | Complex Overt Responses | 1.2.15, 2.1.5, 2.2.3, 2.4.4, 3.2.3 |
| CO4 | TPS3 | Apply | Value | Mechanism | 1.2.15, 2.1.5,2.2.3, 2.4.4, 3.2.3 |
| CO5 | TPS4 | Analyze | Organize | Complex Overt | 1.2.15, 2.1.5, 2.2.3, |

| | | | | | |
|---|---|---|---|---|---|
| | | | | Responses | 2.4.4, 3.2.3 |
| CO6 | TPS3 | Apply | Value | Mechanism | 1.2.15, 2.1.5, 2.2.3 2.4.4, 3.2.3 |
| | | | | | |

**Mapping with Programme Outcomesand Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | S | M | L | S | | | M | | M | | | S | |
| CO2 | S | S | M | L | S | | | M | | M | | | S | |
| CO3 | S | S | M | L | S | | | M | | M | | | S | |
| CO4 | S | M | L | | S | | | M | | M | | | S | |
| CO5 | S | S | M | L | S | | | M | | M | | | S | |
| CO6 | S | M | L | | S | | | M | | M | | | S | |

S- Strong; M-Medium; L-Low

**AssessmentPattern: Cognitive Domain**

| **Cognitive Levels** | **Model Examination** | **Terminal Examination** |
|---|---|---|
| Remember | | |
| Understand | | |
| Apply | 40 | 40 |
| Analyse | 50 | 50 |
| Evaluate | | |
| Create | | |

**AssessmentPattern: Psychomotor**

| **Psychomotor Skill** | **Miniproject/Practical Component/Observation** |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 10 |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**List of Experiments/Activities with CO Mapping**

1. Formation of bus admittance matrix by direct inspection method and singular transformation method (CO1).
2. Analysis of Gauss-Seidal methods for solving the power flow equation ( (CO2).
3. Analysis of Newton-Raphson methods for solving the power flow equation (CO3).
4. Symmetrical and unsymmetrical fault analysis in Power System (CO4).

5. Analysis of Transient Stability in Power System (CO5).
6. Determination of Economic load dispatch for the given load conditions in a power system (CO6).

**Learning Resources**

1. HadiSaadat., ‘Power System Analysis’ Tata McGraw Hill Publishing Company, New Delhi, 2002.
2. P. Venkatesh, B. V. Manikandan, S. Charles Raja and A. Srinivasan, ‘Electrical Power Systems: Analysis, Security and Deregulation’, PHI Learning Pvt. Ltd., Second Edition, 2017.
3. J. Duncan Glover, Mulukutla S. Sarma, Thomas Overbye,‘Power System Analysis and Design’, Cengage Learning, Fifth Edition, 2011.
4. MOOCs course link:https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/

**Course Designers:**

| | | |
|---|---|---|
| 1. | Dr. P. Venkatesh | pveee@tce.edu |
| 2. | Dr. C.K. Babulal | ckbeee@tce.edu |
| 3. | Dr. S. Charles Raja | charlesrajas@tce.edu |

**CURRICULUM AND DETAILED SYLLABI**

**FOR**

**B.E. EEE DEGREE PROGRAMME**

**PROGRAMME ELECTIVES**

**FOR THE STUDENTS ADMITTED IN THE**

**ACADEMIC YEAR 2018-19 ONWARDS**

**THIAGARAJAR COLLEGE OF ENGINEERING**
(A Government Aided Autonomous Institution affiliated to Anna University)
**MADURAI – 625 015, TAMILNADU**

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

**B.E. Electrical and Electronics Engineering Degree Programme**

**LIST OF PROGRAMME ELECTIVES /PROGRAMME ELECTIVES FOR EXPANDED SCOPE**

(For the students admitted from 2018-19)

| S.No. | Course Code | Course Title | Credits |
|---|---|---|---|
| **Electrical Energy Systems** | | | |
| 1. | 18EEPC0 | Design of Electrical Installations | 3 |
| 2. | 18EEPD0 | Smart Grid | 3 |
| 3. | 18EEPE0 | Power System Operation and Control | 3 |
| 4. | 18EEPF0 | Electrical Machine Design | 3 |
| 5. | 18EEPG0 | Switchgear and Protection | 3 |
| 6. | 18EEPT0 | Wind and Solar Technology | 3 |
| 7. | 18EERC0 | Principles of Energy conservation | 3 |
| 8. | 18EERD0 | Operation and Maintenance of Electrical equipment | 3 |

| S.No. | Course Code | Course Title | Credits |
|---|---|---|---|
| **Analog & Digital Electronic Systems** | | | |
| 1. | 18EEPM0 | Real Time Operating System | 3 |
| 2. | 18EEPH0 | VLSI design | 3 |
| 3. | 18EEPJ0 | FPGA based System Design | 3 |
| 4. | 18EEPK0 | Digital Signal Processing | 3 |
| 5. | 18EEPL0 | Biomedical Instrumentation | 3 |
| 6. | 18EEPN0 | Embedded Systems Design (TCP) | 3 |
| 7. | 18EERG0 | Industrial Electrical and Electronics | 3 |
| 8. | 18EERH0 | Testing & Certification of Automotive Electrical and Electronic Systems | 3 |
| 9. | 18EERL0 | Manufacturing of Automotive Electrical and Electronic Parts | 3 |

| S.No. | Course Code | Course Title | Credits |
|---|---|---|---|
| **Control and Automation** | | | |
| 1. | 18EEPA0 | Control System Design | 3 |
| 2. | 18EEPP0 | Robotics | 3 |
| 3. | 18EEPQ0 | Automotive Electronics | 3 |
| 4. | 18EEPS0 | Soft Computing | 3 |
| 5. | 18EEPB0 | Operation Research | 3 |
| 6. | 18EEPR0 | Automotive Fundamentals and Manufacturing | 3 |
| 7. | 18EERF0 | Industrial instrumentation | 3 |
| 8. | 18EERJ0 | Quality Engineering | 3 |
| 9. | 18EERK0 | Reliability Engineering | 3 |

| S.No. | Course Code | Course Title | Credits |
|---|---|---|---|
| **Power Electronics and Drives** | | | |
| 1. | 18EEPY0 | Power Quality | 3 |
| 2. | 18EEPU0 | Drives and Control | 3 |

| | | | |
|---|---|---|---|
| 3. | 18EEPV0 | FACTS and Custom Power Devices | 3 |
| 4. | 18EEPW0 | HVDC Transmission | 3 |
| 5. | 18EEPZ0 | Special Machines and Drives | 3 |
| 6. | 18EERA0 | Power Electronics for Renewable Energy Systems | 3 |
| 7. | 18EERB0 | Simulation of Power Electronic Systems (TCP) | 3 |

**Engineering Science Elective course**

| S.No. | Course Code | Course Title | Credits |
|---|---|---|---|
| 1. | 18EEEA0 | Internet of Things | 3 |

**List of ONE / TWO credits Courses offered by Experts from Industry**

| S.No. | Course Code | Course Title | Credits |
|---|---|---|---|
| 1 | 18EE1A0 | Design of Power Supplies | 1 |
| 2 | 18EE1B0 | Lead Acid Battery Technology | 1 |
| 3 | 18EE1C0 | Introduction to power electronics system for xEVs | 1 |
| 4 | 18EE1D0 | Industrial control systems | 1 |
| 5 | 18EE1E0 | Thermal Power Plant Instrumentation & Control | 1 |

| 18EEPD0 | SMART GRID |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

**Preamble**

The course content is designed to study about smart grid technologies, distribution automation, information and communication Technologies, and operation of transmission system operation. It is used to get familiarized with smart metering and demand side integration.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the fundamentals of smart power grids and its international & Indian scenarios. | 20 |
| CO2 | Calculate voltage and power loss for the given distribution system. | 20 |
| CO3 | Apply demand side management concepts in advanced metering infrastructure system. | 20 |
| CO4 | Apply synchrophasor measurement technology in the operation of transmission system. | 20 |
| CO5 | Explain the data communication technologies used in smart grid. | 10 |
| CO6 | Explain the standard communication protocols used in smart grid. | 10 |

*** Weightage depends on Bloom's Level, number of contact hours,

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| | | | | | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 2.3.1, 3.2.3 |
| CO2 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 3.2.3 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 3.2.3 |
| CO5 | TPS2 | Understand | Respond | | 1.3, 2.3.1, 3.2.3 |
| CO6 | TPS2 | Understand | Respond | | 1.3, 2.31, 3.2.3 |
| | | | | | |

**Mapping with Programme Outcomesand Programme Specific Outcomes**

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | M | L | | | | | | M | | M | | | M | |
| CO 2 | S | M | L | | | | | M | | M | | | S | |
| CO 3 | S | M | L | | | | | M | | M | | | S | |
| CO 4 | S | M | L | | | | | M | | M | | | S | |
| CO 5 | M | L | | | | | | M | | M | | | M | |
| CO 6 | M | L | | | | | | M | | M | | | M | |

S- Strong; M-Medium; L-Low

**AssessmentPattern: Cognitive Domain**

| **Cognitive Levels** | **ContinuousAssessmentTests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 50 | 60 | 60 | 50 | - | - | 50 |
| Apply | 30 | 20 | 20 | 50 | 100 | 100 | 30 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**AssessmentPattern: Psychomotor**

| **Psychomotor Skill** | **Miniproject/Assignment/Practical Component** |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

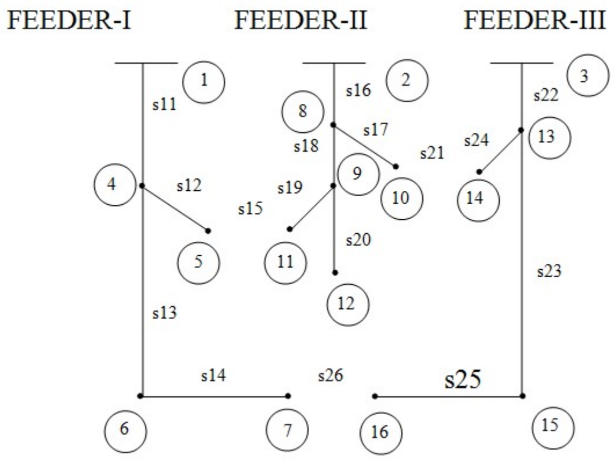
**Sample Questions for Course Outcome Assessment**

**Course Outcome1(CO1):**

1. Explain smart Grid with definitions?
2. Describe the benefits of smart grid with respect to utility and consumer.

**Course Outcome2(CO2):**

1. Determine the voltage drop and power loss for the basic configuration of 16 bus distribution network under half load condition?




2. Explain distribution network section and automation involved in it with necessary diagram?

**Course Outcome3(CO3):**

1. Give the comparison of conventional and smart metering with a neat sketch.
2. Explain the functional block diagram of a smart meter with a neat sketch.

**Course Outcome 4 (CO4):**

1. Explain phasor measurement unit device and an example of PMU connection.
2. Explain a typical EMS system configuration with a neat sketch.

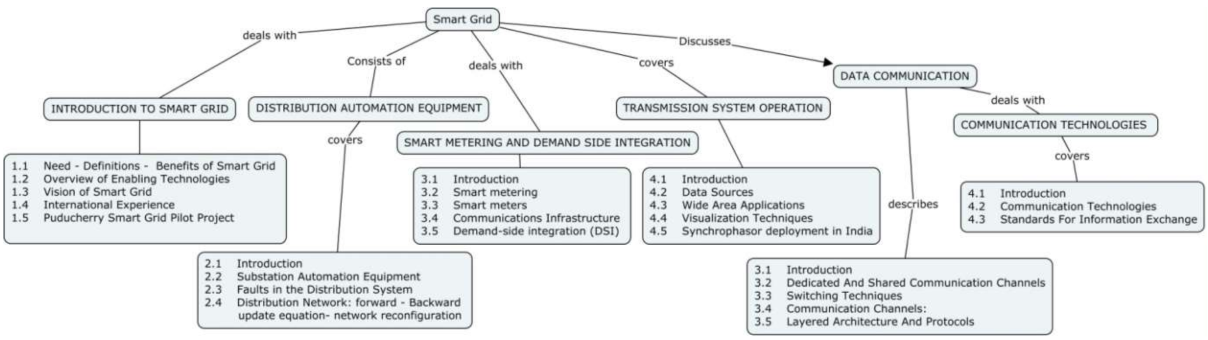
**Course Outcome 5 (CO5):**

1. Explain data transmission devices for Ethernets and transmission path with a neat sketch in detail.
2. Explain various data communication technology used in smart grid.
3. Explain in detail about ISO/OSI model.

**Course Outcome6(CO6):**

1. Explain IEEE 802 series standard, different technologies specified under this standard and architecture in detail.
2. Draw a basic ANSI C 12.22 smart metering architecture and explain in detail.

**Concept Map**




## Syllabus

### INTRODUCTION TO SMART GRID

Need for smart grid- Smart Grid definitions -Benefits of smart grid-Overview of enabling technologies in smart grid-vision of smart grid-International experience-smart grid demonstration and deployment efforts-Puducherry smart grid pilot project

### DISTRIBUTION AUTOMATION EQUIPMENT

Introduction–Substation automation equipment: Current Transformers-Voltage Transformers- Intelligent Electronic Devices- Faults in the distribution system: Components for fault isolation and restoration – Fault location, isolation and restoration - Distribution network: forward update equation-Backward update equation- Determination of voltage, power loss, network reconfiguration for 16 bus standard distribution system

### SMART METERING AND DEMAND SIDE INTEGRATION

Introduction –Smart metering: Evolution - Key components – Smart meters: over view of the hardware used-Communications infrastructure and protocols for smart metering- Demand-side integration (DSI): services -Implementations - Hardware support – Flexibility.

### TRANSMISSION SYSTEM OPERATION

Introduction – Data sources: IEDs and SCADA- Phasor measurement units - Wide area applications: On-line transient stability controller-Pole-slipping preventive controller - Visualization techniques: Visual 2-D presentation-Visual 3-D presentation - Synchrophasor deployment in India

### DATA COMMUNICATION

Introduction-Dedicated and shared communication channels-switching techniques: circuit switching-Message Switching- Packet switching - Communication channels - wired communication- Optical fibre- Radio communication – Cellular mobile communication- Satellite communication -Layered architecture and protocols: The ISO/OSI model-TCP/IP

### COMMUNICATION TECHNOLOGIES FOR THE SMART GRID

Introduction- Communication technologies: IEEE 802 series – Mobile communications- Multi protocol label switching - Standards for information exchange: Standards for smart metering -Modbus-DNP3-IEC 61850

## Learning Resources


1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley & Sons Ltd., February 2012.
2. "Smart Grid primer", Published by Power grid Corporation of India limited, September 2013
3. Stuart Borlase, "Smart Grid: Infrastructure, Technology and Solutions", CRC Press 2012.
4. James Momoh, "Smart Grid Fundamentals of Design and Analysis", IEEE Press, 2012.
5. Tony Flick, Justin morehouse,"Securing the smart grid: Next generation power grid security", Elsevier,2010.
6. MOOCs course link:https://www.edx.org/course/smart-grids-electricity-future-ieeex-smartgrid-x-0


## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| **1.0** | **INTRODUCTION TO SMART GRID** | | |
| 1.1 | Need For Smart Grid - Smart Grid Definitions - Benefits of Smart Grid | 1 | CO1 |
| 1.2 | Overview of Enabling Technologies In Smart Grid | 1 | CO1 |
| 1.3 | Vision of Smart Grid | 1 | CO1 |
| 1.4 | International Experience: Smart Grid Demonstration And Deployment Efforts - Tailoring Smart Grids to Developing Countries and Emerging Economies | 1 | CO1 |
| 1.5 | Puducherry Smart Grid Pilot Project | 1 | CO1 |
| **2.0** | **DISTRIBUTION AUTOMATION EQUIPMENT** | | |
| 2.1 | Introduction | 1 | CO2 |
| 2.2 | Substation Automation Equipment: Current Transformers-Voltage Transformers- Intelligent Electronic Devices | 2 | CO2 |
| 2.3 | Faults in the Distribution System: Components for fault isolation and restoration – Fault location, isolation and restoration | 2 | CO2 |
| 2.4 | Distribution Network: forward update equation- Backward update equation- Determination of voltage, power loss, network reconfiguration for 16 bus standard distribution system | 2 | CO2 |
| 3.0 | **SMART METERING AND DEMAND SIDE INTEGRATION** | | |
| 3.1 | Introduction | 1 | CO3 |
| 3.2 | Smart metering: Evolution - Key components | 1 | CO3 |
| 3.3 | Smart meters: over view of the hardware used | 2 | CO3 |
| 3.4 | Communications Infrastructure And Protocols For Smart Metering | 1 | CO3 |
| 3.5 | Demand-side integration (DSI): services - Implementations - Hardware support – Flexibility | 2 | CO3 |
| 4.0 | **TRANSMISSION SYSTEM OPERATION** | | |
| 4.1 | Introduction | 1 | CO4 |
| 4.2 | Data Sources: IEDs and SCADA- Phasor measurement units | 1 | CO4 |
| 4.3 | Wide Area Applications: On-line transient stability controller-Pole-slipping preventive controller | 1 | CO4 |

| | | | |
|---|---|---|---|
| 4.4 | Visualization Techniques: Visual 2-D presentation-Visual 3-D presentation | 1 | CO4 |
| 4.5 | Synchrophasor deployment in India | 1 | CO4 |
| **5.0** | **DATA COMMUNICATION** | | |
| 5.1 | Introduction | 1 | CO5 |
| 5.2 | Dedicated And Shared Communication Channels | 1 | CO5 |
| 5.3 | Switching Techniques: circuit switching-Message Switching- Packet switching | 1 | CO5 |
| 5.4 | Communication Channels: wired communication-Optical fibre- Radio communication – Cellular mobile communication- Satellite communication | 1 | CO5 |
| 5.5 | Layered Architecture And Protocols: The ISO/OSI model-TCP/IP | 1 | CO5 |
| **6.0** | **COMMUNICATION TECHNOLOGIES FOR THE SMART GRID** | | |
| 6.1 | Introduction | 1 | CO6 |
| 6.2 | Communication Technologies:IEEE 802 series – Mobile communications- Multi protocol label switching | 2 | CO6 |
| 6.3 | Standards For Information Exchange: Standards for smart metering -Modbus-DNP3-IEC 61850 | 1 | CO6 |
| | Total | **36** | |

**Course Designers:**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| | | | | | | |
|---|---|---|---|---|---|---|
| **18EEPE0** | **POWER SYSTEM OPERATION AND CONTROL** | Category | L | T | P | Credit |
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

The primary aim of a power system is to provide adequate uninterrupted supply of power of certain quality to meet all the demands of customers. The quality of the supply depends on the constancy of frequency and voltage and continuity of supply. This means that the generation must be adjusted, in real time, to match prevailing demand. The second objective, to be achieved as long as it is consistent with continuity of service and dependable operation, is to generate the required total output at minimum overall cost.

## Prerequisite

18EE230 - Electric Circuit Analysis

18EE440 - Control Systems

## Course Outcomes

On the successful completion of the course, students will be able to:

| COs No. | **Course outcomes** | Weightage in % |
|---|---|---|
| CO1 | Explain the concept of AGC and analysis of multi area system | 10 |
| CO2 | Explain the real power control by frequency | 20 |
| CO3 | Explain the reactive power control by voltage | 10 |
| CO4 | Describe the various voltage control methods | **10** |
| CO5 | Find the optimum unit commitment for a power system | 15 |
| CO6 | Calculate the economic optimal load dispatch for a system comprising of ‘n’ thermal plants | **20** |
| CO7 | Explain various operating states of a power system and control actions required to obtain secured operation | 15 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Understand | Respond | | 1.3, 2.3.4, 3.2.3 |
| CO2 | TPS2 | Understand | Respond | | 1.3, 2.3.2, 3.2.3 |
| CO3 | TPS2 | Understand | Respond | | 1.3, 2.3.2, 3.2.3 |
| CO4 | TPS2 | Understand | Respond | | 1.3, 2.5.4, 3.2.3 |
| CO5 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.3.1, 2.4.3, 2.4.4, 3.2.3 |
| CO6 | TPS2 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.3.1, 2.4.3, 2.4.4, 3.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO7 | TPS2 | Understand | Respond | | 1.3, 2.5.4, 3.2.3 |

## Mapping with Programme Outcomes

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | S | M | L | | | | | M | | M | | | S | |
| CO 2 | M | L | | | | | | M | | M | | | M | |
| CO 3 | M | L | | | | | | M | | M | | | M | |
| CO 4 | M | L | | | | | | M | | M | | | M | |
| CO 5 | S | M | L | | | | | M | | M | | | S | |
| CO 6 | S | M | L | | | | | M | | M | | | S | |
| CO 7 | M | L | | | | | | M | | M | | | M | |

**S**- Strong; **M**-Medium; **L**-Low

## Assessment Pattern: Cognitive Domain

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **1** | **2** | **3** | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 30 | 30 | 30 | - | - | - | 30 |
| Apply | 40 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. What is meant by primary ALFC loop?
2. Draw the dynamic response of change in frequency for a step load change.
3. Two generators rated 2000 MW and 4000 MW are operating in parallel. The drop characteristics of their governors are 4% and 5% respectively from no load to full load. Assuming the the generators are operating at 50Hz at no load, how would a load of 600MW be shared between them? What will be the system frequency at this load? Assume free governor operation. Also find the load sharing if both governors have a droop of 4%.

**Course Outcome 2 (CO2)**:

1. What are the merits of synchronous compensator?
2. State the difference between P-F and Q-V control.

3. What are the methods to improve the voltage profile in the power system?

**Course Outcome 3 (CO3)**:

1. What are the different types of reactive power compensation?
2. Discuss generation and absorption of reactive power.
3. Explain how voltage control can be affected by injection of reactive power.

**Course Outcome 4 (CO4)**:

1. Compare series and shunt capacitors.
2. Explain the operation of on-load tap changing transformer.
3. A 414 KV line is fed through 132/415 KV transformer from a constant 132 KV supply. At the load end of the line, the voltage is reduced by another transformer of 415/132 KV. The total impedance of line is (20+j40) ohms. Both transformers are equipped with tap-changing. The product of the two off-nominal setting is unity. The load on the system is 250 MW at 0.8 p.f. lagging. Calculate the settings of the tap changer required to maintain the voltage at 132KV.

**Course Outcome 5 (CO5)**:

1. Write a few constraints in unit commitment problem.
2. Define spinning reserve constraint in unit commitment problem.
3. Explain various constraints in UC and indicate the steps involved in solving UC by DP method.

**Course Outcome 6 (CO6):**

1. Write the equality and inequality constraints considered in the economic dispatch problem.

2. The fuel inputs per hour of plants 1 and 2 are given as

   F1 = 0.2 p12 + 40 P1 + 120 Rs/hr.

   F2 = 0.2 p22 + 40 P2 + 150 Rs/hr.

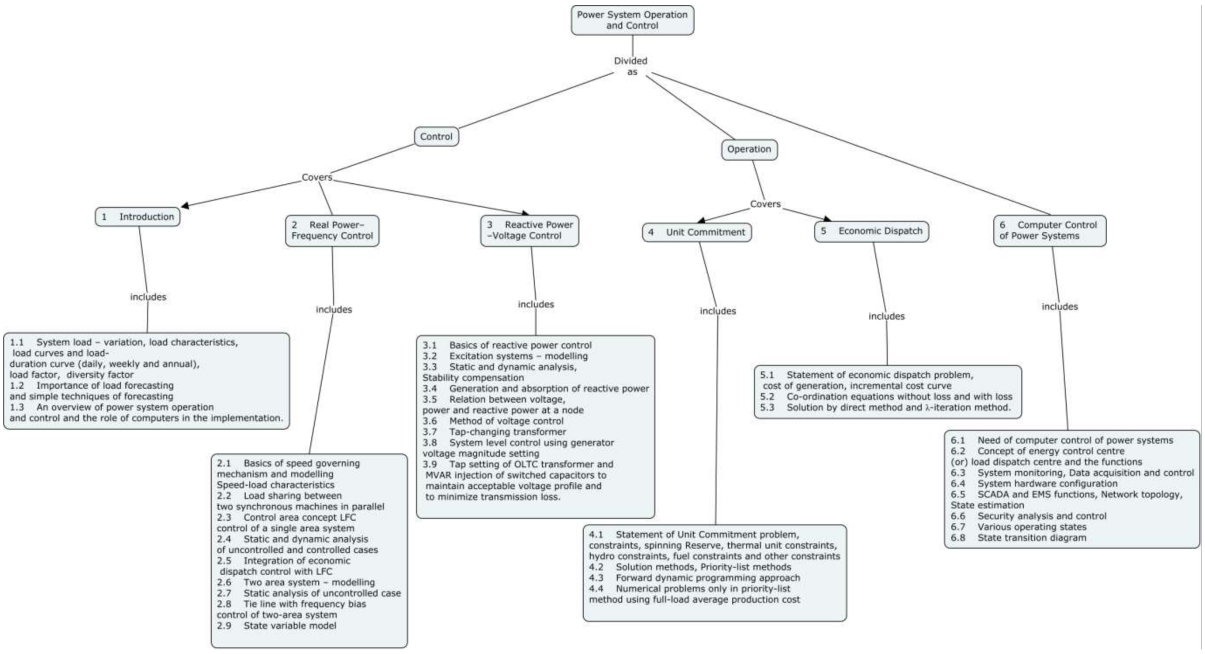
   Determine the economic operating schedule and the corresponding cost of generation if the maximum and minimum loading on each unit is 100 MW and 25 MW. Assume the transmission losses are ignored and the total demand is 180 MW. Also determine the saving obtained if the load is equally shared by both the units.

3. Formulate the co-ordination equations with losses neglected and also explain the algorithmic steps of iterative method to find the solution of co-ordination equations.

**Course Outcomes 7 (C07):**

1. Define ‘network topology’ in a power system.
2. Discuss the functions of ‘SCADA’ in power system operation.
3. Explain the various operating states of power system. Also discuss the state transitions and control strategies.

## Concept Map




## Syllabus

**Introduction:** System load – variation - load characteristics - load curves and load-duration curve (daily, weekly and annual) - load factor - diversity factor - Importance of load forecasting and simple techniques of forecasting - An overview of power system operation and control and the role of computers in the implementation.

**Real Power – Frequency Control:** Basics of speed governing mechanism and modelling - speed-load characteristics – load sharing between two synchronous machines in parallel - Control area concept LFC control of a single area system - Static and dynamic analysis of uncontrolled and controlled cases - Integration of economic dispatch control with LFC - Two-area system – modelling - static analysis of uncontrolled case - tie line with frequency bias control of two-area system - state variable model.

**Reactive Power – Voltage Control:** Basics of reactive power control - Excitation systems – modelling - Static and dynamic analysis - stability compensation - generation and absorption of reactive power - Relation between voltage, power and reactive power at a node - method of voltage control - tap-changing transformer - System level control using generator voltage magnitude setting - tap setting of OLTC transformer and MVAR injection of switched capacitors to maintain acceptable voltage profile and to minimize transmission loss.

**Unit Commitment:** Statement of Unit Commitment problem – constraints – spinning Reserve - thermal unit constraints - hydro constraints, fuel constraints and other constraints - Solution methods - Priority-list methods - forward dynamic programming approach - Numerical problems only in priority-list method using full-load average production cost.

**Economic Dispatch:** Statement of economic dispatch problem – cost of generation – incremental cost curve co-ordination equations without loss and with loss - solution by direct method and λ-iteration method. (No derivation of loss coefficients).

**Computer Control of Power Systems:** Need of computer control of power systems - Concept of energy control centre (or) load dispatch centre and the functions - system monitoring - data acquisition and control. System hardware configuration – SCADA and EMS functions - Network topology - state estimation - security analysis and control - Various operating states (Normal, alert, emergency, in-extremis and restorative) - State transition diagram showing various state transitions and control strategies.

## Learning resources


1. Allen. J. Wood and Bruce F. Wollenberg, 'Power Generation, Operation and Control', John Wiley & Sons, Inc., 2003.
2. V.Ramanathan, P.S.Manoharan, 'Power System Operation and Control' Third Edition, 2015, Charulatha Publications, Chennai.
3. Chakrabarti & Halder, "Power System Analysis: Operation and Control", Prentice Hall of India, 2004 Edition.
4. P.Kundur, 'Power System Stability and Control' MC Craw Hill Publisher, USA, 1994.
5. Olle.I.Elgerd, 'Electric Energy Systems theory an introduction' Tata McGraw Hill Publishing Company Ltd. New Delhi, Second Edition 2003.
6. Leon K. Kirchmayer, 'Economic operation of power systems' Wiley, 2008.
7. D.P. Kothari and I.J. Nagrath, 'Modern Power System Analysis', Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.


## Course Contents and Lecture Schedule

| Module No | Topic | No. of Lecture Hours | COs |
|---|---|---|---|
| **1** | **Introduction** | | |
| 1.1 | System load – variation, load characteristics, load curves and load-duration curve (daily, weekly and annual), load factor, diversity factor | 1 | CO1 |
| 1.2 | Importance of load forecasting and simple techniques of forecasting | 1 | CO1 |
| 1.3 | An overview of power system operation and control and the role of computers in the implementation. | 1 | CO1 |
| **2** | **Real Power–Frequency Control** | | |
| 2.1 | Basics of speed governing mechanism and modelling<br>Speed-load characteristics | 1 | CO2 |
| 2.2 | Load sharing between two synchronous machines in parallel | 1 | CO2 |
| 2.3 | Control area concept LFC control of a single area system | 1 | CO2 |
| 2.4 | Static and dynamic analysis of uncontrolled and controlled cases | 1 | CO2 |
| 2.5 | Integration of economic dispatch control with LFC | 1 | CO2 |
| 2.6 | Two area system – modelling | | CO2 |
| 2.7 | Static analysis of uncontrolled case | 1 | CO2 |
| 2.8 | Tie line with frequency bias control of two-area system | 1 | CO2 |
| 2.9 | State variable model | 1 | CO2 |
| **3** | **Reactive Power–Voltage Control** | | |
| 3.1 | Basics of reactive power control | 1 | CO3 |
| 3.2 | Excitation systems – modelling | 1 | CO3 |
| 3.3 | Static and dynamic analysis, Stability compensation | 1 | CO3 |
| 3.4 | Generation and absorption of reactive power | 1 | CO3 |
| 3.5 | Relation between voltage, power and reactive power at a node | 1 | CO3 |
| 3.6 | Method of voltage control | 1 | CO4 |
| 3.7 | Tap-changing transformer | 1 | CO4 |
| 3.8 | System level control using generator voltage magnitude setting | 1 | CO4 |
| 3.9 | Tap setting of OLTC transformer and MVAR injection of switched capacitors to maintain acceptable voltage profile and | 1 | CO4 |

| | | | |
|---|---|---|---|
| | to minimize transmission loss. | | |
| **4** | **Unit Commitment** | | |
| 4.1 | Statement of Unit Commitment problem, constraints, spinning Reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints | 1 | CO5 |
| 4.2 | Solution methods, Priority-list methods | 1 | CO5 |
| 4.3 | Forward dynamic programming approach | 1 | CO5 |
| 4.4 | Numerical problems only in priority-list method using full-load average production cost | 1 | CO5 |
| **5** | **Economic Dispatch** | | |
| 5.1 | Statement of economic dispatch problem, cost of generation, incremental cost curve | 1 | CO6 |
| 5.2 | Co-ordination equations without loss and with loss | 1 | CO6 |
| 5.3 | Solution by direct method and λ-iteration method. (No derivation of loss coefficients). | 1 | CO6 |
| **6** | **Computer Control of Power Systems** | | |
| 6.1 | Need of computer control of power systems | 1 | CO7 |
| 6.2 | Concept of energy control centre (or) load dispatch centre and the functions | 1 | CO7 |
| 6.3 | System monitoring, Data acquisition and control | 1 | CO7 |
| 6.4 | System hardware configuration | 1 | CO7 |
| 6.5 | SCADA and EMS functions, Network topology, State estimation | 1 | CO7 |
| 6.6 | Security analysis and control | 1 | CO7 |
| 6.7 | Various operating states (Normal, alert, emergency, in-extremis and restorative) | 1 | CO7 |
| 6.8 | State transition diagram showing various state transitions and control strategies | 1 | CO7 |
| | **TOTAL** | 36 | |

**Course Designers:**

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| 18EEPF0 | ELECTRICAL MACHINE DESIGN |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 2 | 1 | 0 | 3 |

**Preamble**

This course furnishes the primary knowledge to design the main dimension and other major parts of Transformer, DC and AC rotating machines. The basic design of an electrical machine involves the dimensioning of the magnetic circuit, electrical circuit, insulation system etc., and is carried out by applying analytical equations.

**Prerequisite**

- 18EE320: DC machines and Transformers
- 18EE420: AC machines

**Course Outcomes**

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Describe the properties of various magnetic materials, conducting materials & insulating materials to fulfil the design requirements of electrical machines. | 5 |
| CO2 | Calculate the mmf required for the given air gap and armature teeth. | 15 |
| CO3 | Design the overall dimensions of transformer along with tank and cooling tubes for the given specifications | 20 |
| CO4 | Design the main dimensions, winding details and field parameters of a DC machine for the given specifications | 20 |
| CO5 | Design the main dimensions and winding details of induction machines for the given specifications | 20 |
| CO6 | Design the main dimensions, winding details and field parameters of synchronous machine for the given specifications | 20 |

*** Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.2, 2.3.1 |
| CO2 | TPS3 | Apply | Value | | 1.2, 2.1.5 |
| CO3 | TPS3 | Apply | Value | | 1.2, 2.1.5 |
| CO4 | TPS3 | Apply | Value | | 1.2, 2.1.5 |
| CO5 | TPS3 | Apply | Value | | 1.2, 2.1.5 |
| CO6 | TPS3 | Apply | Value | | 1.2, 2.1.5 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | |
| CO2 | S | M | L | | | | | M | | M | | | S | |
| CO3 | S | M | L | | | | | M | | M | | | S | |
| CO4 | S | M | L | | | | | M | | M | | | S | |
| CO5 | S | M | L | | | | | M | | M | | | S | |
| CO6 | S | M | L | | | | | M | | M | | | S | |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | - | - | - | 10 |
| Understand | 30 | 30 | 30 | - | - | - | 30 |
| Apply | 60 | 60 | 60 | 100 | 100 | 100 | 60 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **Assignment** |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO1):**

1. Name the various class of insulating materials with its maximum temperature limit.
2. Mention some of the insulating materials used in electrical machines
3. Classify the Insulating materials with respect to temperature and give examples for each.

**Course Outcome 2(CO2):**

1. The temperature rise of a transformer is 25°C after one hour and 37.5°C after 2 hours of starting from cold conditions. Calculate its final steady temperature rise and the heating time constant. If its temperature falls from the final steady value to 40°C in 1.5 hours when disconnected, calculate its cooling time constant. The ambient temperature is 30°C.

2. Estimate the main dimensions including winding conductor area of a 3-phase delta-star core type transformer rated at 300 kVA, 6600/440V, 50 Hz. A suitable core with 3-steps having a circumscribing circle of 0.25m diameter and leg spacing of 0.4m is available. Emf per turn 8.5 V, current density=2.5A/mm$^2$, $K_w$=0.28, stacking factor $S_f$=0.9.
3. Determine the main dimensions of the core of a 5kVA, 11000/400V, 50Hz, 1 phase core type distribution transformer. The net conductor area in the window is 0.6 times the net cross section area of iron in the core. The core is of square cross section, maximum flux density is 1Wb/m$^2$. Current density is 1.4A/mm$^2$. Window space factor is 0.2. Height of the window is 3 times its width.

**Course Outcome 3(CO3):**

1. The tank of 1250kVA natural oil cooled transformer has the dimensions length, width and height as 0.65*1.55*1.85 m respectively. The load loss=13.1kW, loss dissipation due to radiations 6W/m.sq-0 C, improvement in convection due to provision of tubes=40%, temperature rise is 40°C, length of each tube is 1m, diameter of each tube is 50mm. Find the number of tubes for this transformer. Neglect the top and bottom surface of the tank as regards the cooling.
2. A 250kVA, 6600/400V, 3-phase core type transformer has a total loss of 4800V on full load. The transformer tank is 1.25m in height and 1m*0.5m in plan. Design a suitable scheme for cooling tubes if the average temperature rise is to be limited to 35°C. The diameter of the tube is 50mm and are spaced 75mm from each other. The average height of the tube is 1.05m.
3. Question 3

**Course Outcome 4 (CO4):**

1. A 4 pole 50 HP de shunt motor operates with rated voltages of 480 volts at rated speed of rpm. It has wave wound armature with 770 conductors. The leakage factor of the poles is 1.2. The poles are of circular cross section. The flux density in the poles is 1.5 Wb/ m2. Compute diameter of each pole.
2. A 15 kW,230 V,4 pole dc machine has armature diameter=0.25m, armature core length=0.125m, length of airgap at pole centre=2.5mm, flux/pole=11.7x10-3Wb, ratio of pole arc/pole pitch=0.66. Calculate the mmf required for airgap (i)if the armature surface is treated as smooth (ii) if the armature is slotted and the gap contraction factor is 1.18.

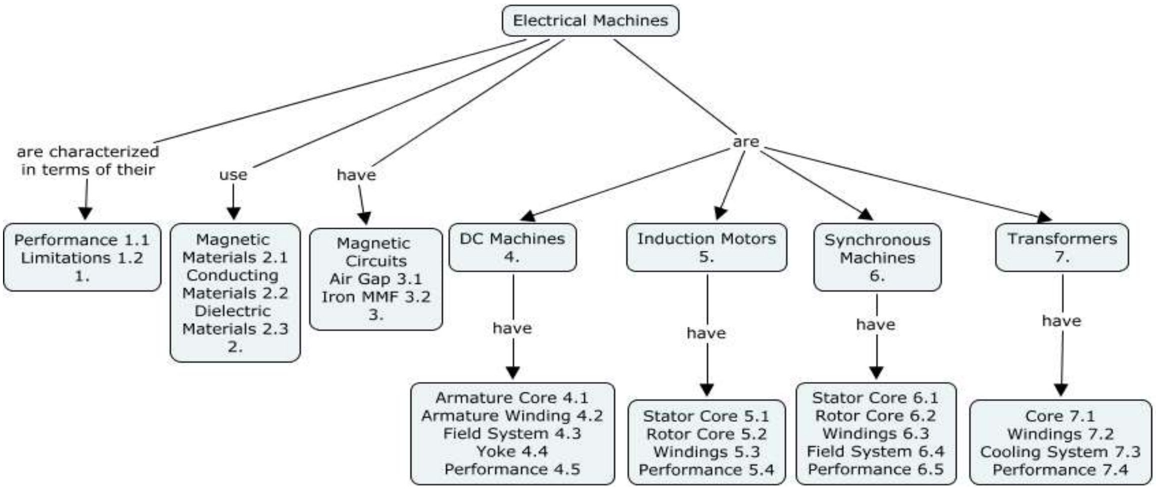
**Course Outcome 5 (CO5):**

1. Calculate the magnetising current of a 450V, 4 pole, 3-phase, 50Hz, induction motor having the following data. No. of slots=36, No. of stator conductors/ slot=30, stator core diameter=13cm, axial length of stator=13cm, effective airgap length=0.1cm, winding is full pitched, phase spread angle is 60°, gap contraction factor=1, assume that the iron loss has infinite permeability.
2. Find the main dimensions of a 15kW, 3phase,400V, 50Hz, 2810rpm, sq. Cage induction motor having an efficiency of 88% and full load PF=0.9. Assume specific magnetic loading=0.5T, specific electrical loading=25000A/m. The rotor peripheral speed should be approximately 20m/s at synchronous speed.

**Course Outcome 6(CO6):**

1. Find main dimension of 100 MVA, 11 KV, 50 Hz, 150 rpm, three phase water wheel generator. The average gap density = 0.65 wb/m2 and ampere conductors / m are 40000. The peripheral speed should not exceed 65 m/s at normal running speed in order to limit runaway peripheral speed.
2. For a 250kVA, 1100V, 12 pole 500rpm, 3-phase 3 alternator. Determine the airgap diameter, core length, No. of stator conductors, No. of stator slots and cross section of stator conductors. Assuming average gap density as 0.6wb/sq.m. and specific electric loading of 30000 amp.cond./m. pole arc to pole pitch is 1.4.

**Concept Map**




## Syllabus

**Introduction:** Performance Specifications, Standard specifications, Duty Cycle, Design factors and Limitations, Thermal and mechanical design aspects.

**Materials**: Properties, selection and applications of Magnetic materials, conducting materials and insulating materials.

**Design of Magnetic Circuits:** MMF calculation for Air gap and Teeth. Performance Calculation of Iron losses and Magnetizing current.

**Design of Transformers**: Design of Core and Overall dimensions. Types of Windings. Design of Tank and cooling tubes. Performance calculations of No load current, Losses and Efficiency.

**Design of DC machines**: Design of Armature Core. Design of Armature windings. Design of Pole and field windings. Design of Yoke.

**Design of Three Phase & Single Phase Induction Motors**: Design of Stator core & Rotor core. Design of Stator & Rotor windings, Insulation specifications, Performance calculations of No load current, Losses and Efficiency.

**Design of Synchronous machines**: Design of Stator core & Rotor core. Design of Stator and Rotor windings. Performance calculations

## Learning Resources


1. Sawhney A.K. ‘A course in Electrical Machine Design’, Dhanpath rai & sons publications, 6th Edition 2010.
2. Rai, H.M. ‘Principles of Electrical machine design’ Satya Prakashan Publication New Delhi, 5th edition 2008Book2 (Author(s), Title, edition, publisher, year of publication)
3. S.K.Sen, ‘Principles of Electrical Machine Design with Computer Programs’, Oxford & IBH Publishing Co. Pvt Ltd. 2nd edition 2006.
4. Say. M.G.,’ The Performance and Design of Alternating Current Machines’, CBC Publishers and Distributers. Pvt Ltd. E book Edition 2017.


## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| **1.0** | **Introduction** | | |
| 1.1 | Performance Specifications Design Factors, Duty Cycle, | 1 | CO1 |
| 1.2 | Limitations, Thermal and mechanical design aspects | 1 | CO1 |
| **2.0** | **Materials** | | |
| 2.1 | Magnetic materials | 1 | CO1 |
| 2.2 | Conducting materials & Insulating materials | 1 | CO1 |
| **3.0** | **Design of Magnetic Circuits** | | |
| 3.1 | MMF calculation for Air gap | 2 | CO2 |
| 3.2 | MMF calculation for Teeth | 1 | CO2 |
| 3.3 | Performance: Iron losses and Magnetizing current | 1 | CO2 |
| **4.0** | **Design of Transformers** | | |
| 4.1 | Design of Core and Overall dimensions | 2 | CO3 |
| 4.2 | Types of Windings | 1 | CO3 |
| 4.3 | Design of Tank and cooling tubes | 2 | CO3 |
| 4.4 | Performance: No load current , Losses and Efficiency | 1 | CO3 |
| **5.0** | **Design of DC machines** | | |
| 5.1 | Design of Armature core | 2 | CO4 |
| 5.2 | Design of Armature windings | 2 | CO4 |
| 5.3 | Design of Poles and filed windings | 2 | CO4 |
| 5.4 | Design of Yoke | 1 | CO4 |
| 5.5 | Performance: Voltage Regulation, losses and Efficiency | 1 | CO4 |
| **6.0** | **Design of Three Phase & Single Phase Induction Motors** | | |
| 6.1 | Design of Stator core | 2 | CO5 |
| 6.2 | Design of Rotor core | 2 | CO5 |
| 6.3 | Design of Stator & Rotor windings | 2 | CO5 |
| 6.4 | Performance calculations of No load current, Losses and Efficiency. | 1 | CO5 |
| **7.0.** | **Design of Synchronous machines** | | |
| 7.1 | Design of Stator core | 2 | CO6 |
| 7.2 | Design of Rotor core | 2 | CO6 |
| 7.3 | Design of stator & rotor windings | 1 | CO6 |
| 7.4 | Design of field systems | 1 | CO6 |
| 7.5 | Performance calculations | 1 | CO6 |
| | Total | 36 | |

**Course Designers:**

1. Latha.S sleee@tce.edu
2. Nelson Jayakumar D. dnjayakumar@tce.edu

| 18EEPG0 | SWITCHGEAR AND PROTECTION |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

## Preamble

The importance of electric supply has constructed such circumstances that we must secure the Power system from large faults and provide protection to the machineries and devices used and to ensure maximum continuity of the power supply. For this purpose, machines such as generators and motors are needed to be switched on and off many times. Means provided to achieve this are called 'Switch Gear'. Power system switchgear and protection is a subject which touches our lives every day, in a very non-intrusive manner. Reliable protection of electric energy systems against faults like short circuits is in fact, the cornerstone of power system reliability. Based on this, the course aims at giving an adequate exposure in Switchgear equipment and protection schemes for various apparatus.

## Prerequisite

NIL

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | **Weightage in %** |
|---|---|---|
| CO1 | Explain the layout of a typical substation and discuss its components | 10 |
| CO2 | Design Circuit breakers and Fuses for a given requirement | 20 |
| CO3 | Discuss the principles of different types of protective relays | 20 |
| CO4 | Design a suitable protective scheme for specific faults in generator and transformers | 15 |
| CO5 | Discuss the principles of various protective schemes of bus bars and feeders. | 15 |
| CO6 | Design a suitable protection method for lines and apparatus against over voltages in Power Systems. | 20 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | --- | 1.3.,2.1.1,2.3.2, 2.4.4,3.2.3 |
| CO2 | TPS3 | Apply | Value | --- | 1.3.,2.1.1,2.3.1,2.3.2, 2.4.4,3.2.3 |
| CO3 | TPS2 | Understand | Respond | --- | 1.3.,2.1.1,2.3.2, 2.4.4,3.2.3 |
| CO4 | TPS3 | Apply | Value | --- | 1.3.,2.1.1,2.3.1,2.3.2, 2.4.4,3.2.3 |
| CO5 | TPS3 | Understand | Respond | --- | 1.3.,2.1.1, 2.3.2, 2.4.4,3.2.3 |
| CO6 | TPS3 | Apply | Value | --- | 1.3.,2.1.1,2.3.1,2.3.2, 2.4.4,3.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| COs | PO 1 | PO2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1. | M | L | | | | | | M | | M | | | M | |
| CO2. | S | M | L | | | | | M | | M | | | S | |
| CO3 | M | L | | | | | | M | | M | | | M | |
| CO4 | S | M | L | | | | | M | | M | | | S | |
| CO5. | S | M | L | | | | | M | | M | | | S | |
| CO6 | S | M | L | | | | | M | | M | | | S | |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 10 | 10 | -- | -- | -- | 10 |
| Understand | 40 | 40 | 40 | -- | -- | -- | 40 |
| Apply | 40 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | 0 | 0 | 0 | -- | --- | --- | 0 |
| Evaluate | 0 | 0 | 0 | -- | -- | -- | 0 |
| Create | 0 | 0 | 0 | -- | -- | -- | 0 |

**Assessment Pattern: Psychomotor**

| **Psychomotor skill** | **Miniproject/ Assignment/ Practical component** |
|---|---|
| Perception | -- |
| Set | -- |
| Guided Response | -- |
| Mechanism | -- |
| Complex Overt Responses | -- |
| Adaptation | -- |
| Origination | -- |
| Perception | -- |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Compare indoor and outdoor substations.
2. Sketch the layout of a typical outdoor type 230KV substation and explain its major components.
3. Discuss the significance of instrument transformers in protective schemes.

**Course Outcome 2(CO2):**

1. Demonstrate how breaking capacity and making capacity of a circuit breaker are tested in a laboratory type testing system.
2. Calculate the natural frequency of transient overvoltage when circuit breaker is

opened on fault. Assume L=0.5 Henry and C=5000pF.Also determine the natural frequency if a deliberate resistance of 10 kilo-ohms is added across the circuit breaker contacts?

**Course Outcome 3(CO3):**

1. Discuss the essential qualities of a protective relay
2. Explain the construction and operation of a static overcurrent relay with a neat block diagram.
3. Discuss the role of negative sequence relay.

**Course Outcome 4(CO4):**

1. Illustrate why the first ground fault on the rotor of Alternator does not cause any damage while a second fault can be catastrophic.
2. Demonstrate why conventional differential protection cannot detect interturn faults on the same phase.
3. A 11kV, 100 MVA generator is grounded through a resistance of 6Ω. The C.T.s have a ratio of 1000/5. The relay is set to operate when there is an out of balance current of 1A. Calculate the percentage of the generator winding that will be protected by the percentage differential scheme of protection.

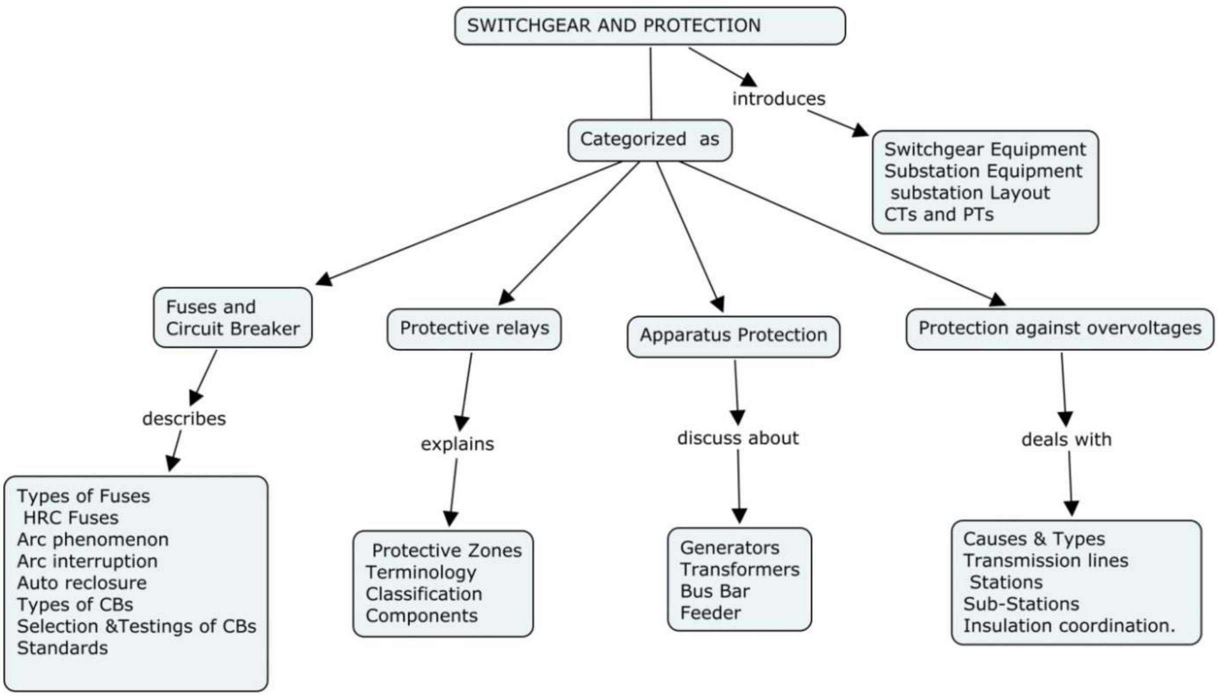
**Course Outcome 5(CO5):**

1. Show the complete working of carrier-aided distance protection schemes with necessary sketches.
2. Choose a suitable protection scheme for the short, medium and long transmission lines against L-G fault.

**Course Outcome 6(CO6):**

1. Compute the magnitude of overvoltages due to direct and indirect lightning strokes on overhead lines.
2. A 132kV, 3-phase, 50Hz transmission line 200km long contains three conductors of effective diameter 2.2 cm, arranged in a vertical plane with 4.5 m spacing and regularly transposed. Find the inductance and kVA rating of the Peterson coil in the system.
3. Demonstrate the fixation of B.I.L.in a power system in the context of insulation coordination.

## Concept Map



## Syllabus

**Introduction**
Switchgear - essential features - Substations – Types – Equipment - Layout of a typical substation- Current and voltage transformers for protection.

**Circuit Breakers and Fuses**
Circuit Breakers **-** Arc phenomenon - restriking and recovery voltage – resistance switching-auto re-closure. Types – air, oil, SF6 and vacuum circuit breakers – ELCB - Selection - testing of circuit breakers according to IS/IEC codes[60947 Standards for Low voltage Switchgear and Control Gears- Part II].
Fuses - Types - HRC Fuses – Characteristics and applications.

**Protective relays**
Need for protective systems– Protection Zones– Essential qualities of protection – Basic relay terminology - classification of protective relays based on technology and their operating principles - components of a protection system- classification of protective schemes.

**Apparatus Protection**
Generator - stator and rotor protection - Transformer –protection against internal faults - Bus bar protection - differential current protection -Feeder protection – Over-current, distance, pilot wire and carrier current protection.

**Protection against over-voltages**
Causes of over voltages – Protection of Transmission lines, Stations and Sub-Stations against direct lightning stroke - Protection against travelling waves - Peterson coil - insulation coordination.

## Learning Resources


1. Badri Ram and D.N. Vishwakarma, “Power System Protection and Switch Gear”, Tata McGraw Hill 2nd edition – 2011
2. Lewis Blackburn, J., Thomas J. Domin, Protective Relaying – Principles and Applications“, 3rd edition, CRC Press, , New York, 2006.
3. B. Ravindranath and N.Chander, “Power System Protection and Switch Gear”, New Age International Ltd., New Delhi, Reprint 2005.
4. Y.G Paithankar and S.R Bhide, “Fundamentals of power system protection”, Prentice-Hall of india, 2003.
5. Oza, Nair, Mehta and Makwana, ― “Power System Protection and Switchgear”, Tata McGraw- Hill. .
6. ABB Electrical installation handbook volume 2 – Electrical devices 3rd edition, June 2005 published by ABB SACE via Baioni, 35-24123, Bergamo (Italy).
7. Sunil S. Rao, “Protection and Switch Gear”, Khanna Publishers- Revised edition, New Delhi, 2011.


## Course Contents and Lecture Schedule

| Module.No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| **1.0** | **Introduction** | | |
| 1.1 | Introduction to Switchgear - essential features | 1 | CO1 |

| | | | |
|---|---|---|---|
| 1.2 | Substations –Types of substations - Equipment- Layout of a typical substation | 3 | CO1 |
| 1.3 | Importance of Current and Potential Transformers in protection schemes | 1 | CO1 |
| **2.0** | **Circuit Breakers and Fuses** | | |
| 2.1 | Arc phenomenon and principles of arc interruption - restriking voltage and recovery voltage – resistance switching– auto re-closure | 3 | CO2 |
| 2.2 | Types of Circuit breakers – air blast, air break, oil, SF6 and vacuum circuit breakers – ELCB (Earth Leakage circuit breaker) | 3 | CO2 |
| 2.3 | Selection and testing of circuit breakers<br>IEC 60947 Standards for Low voltage Switchgear and Control Gears (Part II circuit breakers). | 1 | CO2 |
| 2.4 | Fuses-Types of Fuses - HRC Fuses – Characteristics and applications | 2 | CO2 |
| **3.0** | **Protective relays** | | |
| 3.1 | Need for protective systems– Protection Zones– Essential qualities of protection – Basic relay terminology | 2 | CO3 |
| 3.2 | classification of protective relays based on technology and their operating principles | 3 | CO3 |
| 3.3 | Components of a protection system- classification of protective schemes. | 2 | CO3 |
| **4.0** | **Apparatus Protection** | | |
| 4.1 | Generator - stator and rotor protection<br>Transformer – protection against internal faults | 4 | CO4 |
| 4.2 | Bus bar protection - differential current protection - Feeder protection –Over-Current, distance, pilot wire and carrier current protection. | 3 | CO5 |
| **5.0** | **Protection against over-voltages** | | |
| 5.1 | Causes of over voltages | 2 | CO6 |
| 5.2 | Protection of Transmission lines, Stations and Sub-Stations against direct lightning stroke | 2 | CO6 |
| 5.3 | Protection against travelling waves-Peterson coil | 2 | CO6 |
| 5.4 | Insulation coordination. | 2 | CO6 |
| | **Total** | **36** | |

## Course Designers

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| 18EEPH0 | VLSI DESIGN |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

## Preamble

VLSI is a technology that can be harnessed for various applications covering analog, digital and mixed signal electronics. The current trend is to reduce the entire system design to a single chip solution called as system on chip.VLSI has become a major driving force in modern technology. It provides the basis for computing and telecommunications, and the field continues to grow at an amazing pace.

## Prerequisite

18EE340- Digital Systems

## Course Outcomes

On the successful completion of the course, students will be able to :

| Cos | Course outcomes | Weightage*** in % |
|---|---|---|
| CO1 | Explain the working and characteristics of MOS transistors | 20 |
| CO2 | Explain the CMOS fabrication techniques -n well, p well, Twin tub and Silicon on Insulator( SOI) | 10 |
| CO3 | Estimate the functionality, timing, power, and parasitic effects of VLSI circuits. | 20 |
| CO4 | Design combinational logic circuits using static CMOS Logic, Pseudo NMOS, Ratioed circuits, $C^2$MOS, Dynamic CMOS, Domino logic. | 20 |
| CO5 | Explain the Clocking schemes, I/O structure, and testing methods in VLSI circuits. | 10 |
| CO6 | Simulate the Hardware Description Language(VHDL)model developed for the given digital system | 20 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 2.3.1, 3.2.3 |
| CO2 | TPS2 | Understand | Respond | | 1.3, , 2.1.1, 2.3.1, 3.2.3 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO5 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.3.1, 2.4.4, |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 3.2.3 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | | | | | | | M |
| CO2 | M | L | | | | | | | | | | | | M |
| CO3 | S | M | L | | | | | | | | | | | S |
| CO4 | S | M | L | | | | | | | | | | | S |
| CO5 | S | M | L | | | | | | | | | | | S |
| CO6 | S | M | L | | S | | | | | | | | | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 40 | 40 | 40 | - | - | - | 40 |
| Apply | 40 | 40 | 40 | 100 | 100 | 100 | 40 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. With neat diagrams and waveforms explain the DC characteristics of a complementary CMOS Inverter & also explain its various regions of operation.
2. Consider the nMOS transistor in a 180nm process with a normal threshold voltage of 0.4V and doping level of $8.10^{17}$ $cm^{-3}$. The body is tied to ground with a substrate

contact. How much does the threshold change at room temperature if the source is at 1.1V instead of 0. Assume $t_{ox} = 40^{o}A$.

**3.** Analyze the Gate capacitance effect of n-channel MOSFET.

**Course Outcome 2 (CO2):**

1. Differentiate the positive and negative photo resist.
2. Explain N-well fabrication process with neat sketch.
3. List the advantages of SOI fabrication process.

**Course Outcome 3 (CO3):**

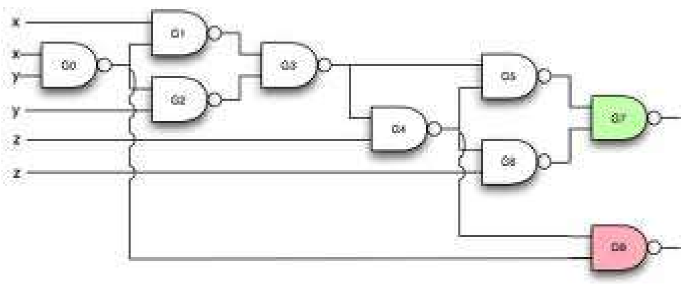
1. Construct the CMOS Physical layout using Lamda rule and estimate the cell width and height for given function. Consider $\beta n = 2 \beta P$.
   Y = ((ABC)+D)'
2. List the Layout Guidelines followed in designing CMOS logic gate.
3. An inverter uses FETs with $\beta n = 2.1 mA/V^2$ $\beta P = 1.8 mA/V^2$. The threshold voltage of nFET and P FET is 0.60V and -0.70V respectively. It has a value of VDD= 4V. The parasitic capacitance at output node is 74fF.
   a) Find midpoint voltage.
   b) Find Rn and Rp
   c) Calculate rise and fall time when external load capacitance of 115fF is connected to the output.

**Course Outcome 4 (CO4)**

1. Draw 2 Input XOR gate using universal gate (NOR and NAND). Compare the fall time and rise time delay.
2. **Draw the transistor level schematic of CMOS 3 input XOR gate.**
3. Consider a 4 input NAND Dynamic circuit (f = A.B.C.D). The input voltage is set to Vin = VDD = 5V and it is given that Vtn= 0.75V. a)Draw the circuit diagram of the function. b)Suppose that the signals are initially at (A,B,C,D) = (1,1,0,0) and switched to (A,B,C,D) = (0,1,1,1). Find the value of Vout.

**Course Outcome 5 (CO5)**

1. For the given circuit generate test pattern using D algorithm. And also apply SCOAP for the same.

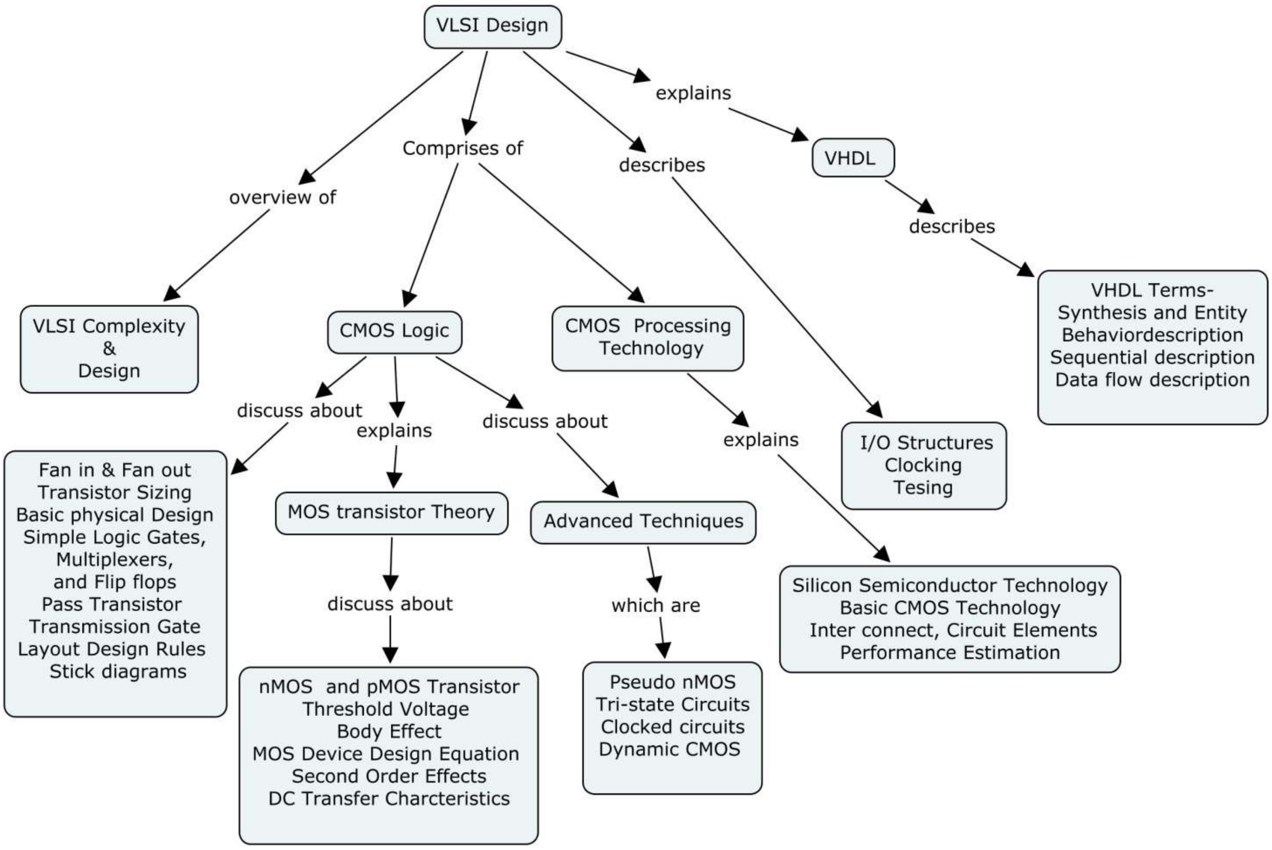


2. Write the advantages of bidirectional pads.
3. Explain PLL clocking technique with neat diagram and give its advantages.

**Course Outcome 6 (CO6)**

1. Develop the model for BCD to Excess 3 converter using VHDL.
2. Write VHDL Code for Ripple Counter using Dataflow modeling.
3. Mention any four capabilities of VHDL.

## Concept Map




## Syllabus

**An overview of VLSI:** Complexity and Design, Basic Concepts

**MOS Transistor Theory**: nMOS and pMOS Enhancement Transistor-Threshold Voltage and Body Effect-MOS Device Design Equation -Second Order Effects-DC Transfer Characteristics- The Complementary CMOS Inverter-Beta Ratio- Noise Margin-Ratioed Inverter Transfer function-Pass Transistor-Tristate Inverter

**CMOS Processing Technology:**

Silicon Semiconductor Technology- Basic CMOS Technology (N-well, P-well, Twin Tub, SOI)- Inter connect, Circuit Elements - **Performance Estimation:** Delay Estimation-Transistor Sizing-Power Dissipation-Interconnect-Design Margin.

**CMOS Logic**: Fan in & Fan out-Transistor Sizing-Basic physical Design of Simple Logic Gates: Inverter, NAND, NOR and Compound gates -Multiplexers and Flip flops-Pass Transistor and Transmission Gate-Layout Design Rules and Stick diagrams.

**Advanced Techniques in CMOS Logic gates :** Pseudo nMOS, Ratioed circuits, Tri-state Circuits, Clocked circuits, Dynamic CMOS Logic Circuits and Domino Logic Circuits.

**VLSI I/O Structures Clocking and Testing of VLSI Circuits :** I/O Structures**,** Clocked FlipFlops, CMOS Clocking Styles, Pipelined Systems, Clock Generation and Distribution. Testing of VLSI Circuits: General Concepts, CMOS Testing, Test Generation Methods.

**VHDL :** Introduction on VHDL & VHDL Terms - Synthesis and Entity, Behavioral description and sequential description, Data flow description.

## Learning Resources


1. Neil H.E. Weste, David Harris & Ayan Banerjee, "CMOS VLSI Design- A Circuits and Systems Perspective", Third Edition, Pearson education, 2008.
2. John P. Uyemura "Introduction to VLSI Circuits and systems" – John Wiley & Sons, Inc., 2008
3. Wayne Wolf, "Modern VLSI Design," 2nd edition, Prentice Hall PTR, 2000.
4. Sung – Mo Kang, Yusuf Leblebici, "CMOS Digital Integrated circuits, Analysis & Design", 3rd edition, Tata Mcgrew – Hill Publishing, 2003.
5. J. Bhaskar, "A VHDL Primer", Third Edition, Addition Wesley, 1999.


## Course Contents and Lecture Schedule

| SNo. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| **1** | **An overview of VLSI** | | |
| 1.1 | Complexity and Design ,Basic Concepts | 1 | CO1 |
| 2 | **MOS Transistor Theory**: | | CO1 |
| 2.1 | nMOS and pMOS Enhancement Transistor | 1 | CO1 |
| 2.2 | Threshold Voltage and Body Effect | 1 | CO1 |
| 2.3 | MOS Device Design Equation | 1 | CO1 |
| 2.4 | Second Order Effects | 1 | CO1 |
| 2.5 | DC Transfer Characteristics: The Complementary CMOS Inverter-Beta Ratio- Noise Margin - Ratioed Inverter Transfer function - Pass Transistor - Tristate Inverter | 2 | CO1 |
| 3 | **CMOS Processing Technology** | | |
| **3.1** | Silicon Semiconductor Technology | **1** | CO2 |
| 3.2 | Basic CMOS Technology (N-well, P-well, Twin Tub, SOI) | 2 | CO2 |
| 3.3 | Inter connect, Circuit Elements | 1 | CO2 |
| **4** | **CMOS Logic** | | |
| 4.1 | Fan in & Fan out-Transistor Sizing | 1 | CO3 |
| 4.2 | Basic physical Design of Simple Logic Gates: Inverter, NAND, NOR and Compound gates | 2 | CO4 |
| 4.3 | Multiplexers and Flip flops | 1 | CO3 |
| 4.4 | Pass Transistor and Transmission Gate | 1 | CO3 |
| 4.5 | Layout Design Rules and Stick diagrams | 2 | CO3 |
| 5 | **Performance Estimation:** | | |
| 5.1 | Delay Estimation | 1 | CO3 |
| 5.2 | Transistor Sizing | 1 | CO3 |
| 5.3 | Power Dissipation | 1 | CO3 |
| 5.4 | Interconnect & Design Margin | 1 | CO3 |
| **6** | **Advanced Techniques in CMOS Logic gates** | | |
| 6.1 | Pseudo nMOS, Ratioed Circuits | 1 | CO4 |
| 6.2 | Tri-state Circuits, Clocked circuits | 1 | CO4 |
| 6.3 | Dynamic CMOS Logic Circuits | 1 | CO4 |
| 6.4 | Dynamic CMOS and Domino Logic Circuits | 1 | CO4 |
| **7** | **VLSI I/O Structures, Clocking and Testing of VLSI** | | |

| | | | |
|---|---|---|---|
| | **Circuits** | | |
| 7.1 | I/O Structures | 1 | CO5 |
| 7.1 | Clocked FlipFlops & CMOS Clocking Styles | 1 | CO5 |
| 7.2 | Pipelined Systems | 1 | CO5 |
| 7.3 | Clock Generation and Distribution | 1 | CO5 |
| 7.4 | Testing of VLSI Circuits - General Concepts, CMOS Testing, Test Generation Methods. | 2 | CO5 |
| **8** | **VHDL** | | |
| 8.1 | VHDL Terms- Synthesis and Entity | 1 | CO6 |
| 8.2 | Behavioral and sequential description | 2 | CO6 |
| 8.3 | Data flow description | 1 | CO6 |
| | Total | 36 | |

**Course Designers:**

1. Dr.M.Saravanan mseee@tce.edu
2. Dr.R.Helen rheee@tce.edu

| 18EEPJ0 | FPGA BASED SYSTEM DESIGN (THEORY CUM PRACTICAL) |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 2 | - | 2 | 3 |

## Preamble

This course is appropriate for all introductory-to-intermediate level courses in FPGAs, Digital designs once built in custom silicon are increasingly implemented in field programmable gate arrays (FPGAs), but effective FPGA system design requires a understanding of new techniques developed for FPGAs. This course deals FPGA fabrics, introduces essential FPGA concepts, and compares multiple approaches to solving basic problems in programmable logic.

## Prerequisite

18EE340 –Digital Systems

## Course Outcomes

On the successful completion of the course, students will be able to

| COs | Course outcomes | Weightage in % |
|---|---|---|
| CO1 | Design digital circuits using PROMs and SPLDs ( PLA,PAL) | 10 |
| CO2 | Describe the architecture and features of XILINX XC9500 CPLD IC | 10 |
| CO3 | Explain architecture and features of SRAM, Flash and antifuse based FPGA | 20 |
| CO4 | Design synchronous circuit with the same functionality of the given asynchronous circuit | 10 |
| CO5 | Implement the given digital circuits in Xilinx FPGA processor using Hardware description Language experimentally | 25 |
| CO6 | Develop the specific digital applications in Xilinx FPGA processor using Hardware description Language experimentally | 25 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO2 | TPS2 | Understand | Respond | | 1.3., 2.1.1, 2.3.1, 3.2.3 |
| CO3 | TPS2 | Understand | Respond | | 1.3., 2.1.1, 2.3.1, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.3., 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO5 | TPS3 | Apply | Value | Mechanism | 1.3, 2.1.1, 2.1.5, 2.2.2, 2.4.2, 2.4.3, 2.4.7, 3.1.1 |
| CO6 | TPS3 | Apply | Value | Mechanism | 1.3, 2.1.1, 2.1.5,2.2.2, 2.4.2, 2.4.3, 2.4.7, 3.1.1 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | | | | | | | | | | | S |
| CO2 | M | L | | | | | | | | | | | | M |
| CO3 | M | L | | | | | | | | | | | | M |
| CO4 | S | M | L | | | | | | | | | | | S |
| CO5 | S | M | L | | S | | | M | | M | | | | S |
| CO6 | S | M | L | | S | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Practical Test | Terminal Examination |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | | |
| Remember | 20 | 20 | 20 | - | 20 |
| Understand | 40 | 40 | 40 | 30 | 40 |
| Apply | 40 | 40 | 40 | 50 | 40 |
| Analyse | - | - | - | - | - |
| Evaluate | - | - | - | - | - |
| Create | - | - | - | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | ~~Miniproject /Assignment/~~Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 20 |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. Explain the architecture of PLA.
2. Show the logic arrangement of both a PROM and a PLA required to implement a binary full adder.
3. Implement the following two Boolean functions with a PLA:

   F1(A, B, C) = $\sum(0,1,2,4)$

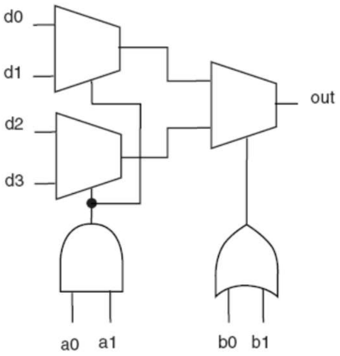
F2(A, B, C) = $\sum(0,5,6,7)$.

**Course Outcome 2 (CO2):**

1. Explain the type of packages used in CPLDs
2. Describe the architecture of XILINX XC9500.
3. List the features of XILINX XC9500.

**Course Outcome 3 (CO3)**

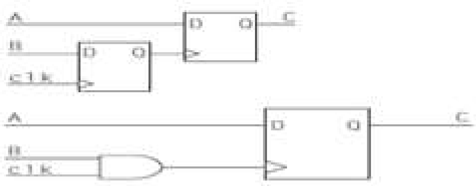
1. Define Design Abstraction of FPGAs.
2. Explain the Methodology for evaluating FPGA fabrics.
3. Redesign the logic element of Figure to be controlled by a0 OR a1 in the first stage and b0 AND b1 on the second stage. Draw the schematic and write the truth table.




**Course Outcome 4 (CO4)**

1. Determine the design problem associated with given asynchronous circuit and find its solution.

2. Design the following circuit as synchronous:



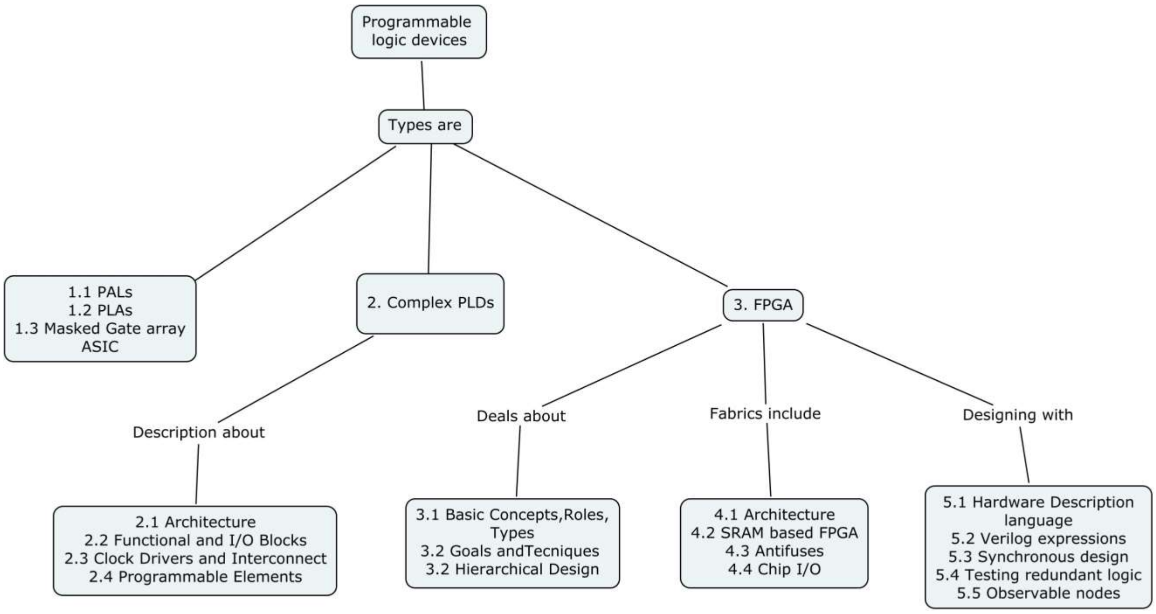
**Course Outcome 5 (CO5)**

1. Write Verilog code using functional modeling to design a counter to count 0 to F. And display the counter output in seven segment display.
2. How many two-input LUTs would be required to implement a four-bit ripple-carry adder?
3. Design a four-input multiplexer that uses a combination of pass transistors and static gates. The first stage of multiplexing should be performed by pass transistors while the remaining multiplexing should be performed by static gates.

**Course Outcome 6 (CO6)**

1. Compare FPGA and DSP processor.
2. Write Verilog code for stepper motor controller.
3. Design of FIR Filter Using Verilog HDL.

## Concept Map




## Syllabus

**Programmable Logic to ASICs:** Programmable Read Only Memories (PROMs), Programmable Logic Arrays (PLAs), Programmable Array Logic (PALs), the Masked Gate Array ASIC, CPLDs and FPGAs.
**Complex Programmable Logic Devices (CPLDs):** CPLD Architectures, Function Blocks, I/O Blocks, Clock Drivers, Interconnect CPLD Technology and Programmable Elements.
**FPGA-Based Systems**: Introduction: Basic Concepts (Boolean algebra and karnaugh map), Digital Design and FPGAs, The roles of FPGAs, FPGA types, FPGA-Based System: Design, Goals & techniques, Hierarchical design, Design abstraction, Methodologies.
**FPGA Fabrics:** FPGA Architectures, SRAM-Based FPGAs, Characteristics of SRAM-Based FPGAs, Characteristics of SRAM-Based FPGAs, Logic elements & Interconnections networks, Chip I/O, Circuit Design of FPGA Fabrics.
**Hardware Description Language**: VHDL and Verilog programming.
**Design Techniques, Rules, and Guidelines :** Top-Down Design, Synchronous Design, Floating Nodes, Bus Contention, One-Hot State Encoding, Design For Test (DFT) , Testing Redundant Logic, Initializing State Machines, Observable Nodes.

## Learning Resources

1. Wayne Wolf “FPGA –Based System Design” Pearson Education, 2004.
2. Bob Zeidman, “Designing with FPGAs and CPLDs”, Elsevier, CMP Books, 2002.
3. M. Morris Mano and Michael D. Ciletti, “Digital Design”, PHI, fourth edition, 2008
4. R.F.Tinder: Engineering Digital Design, (2/e), Academic Press, 2000
5. Digital Electronics Principles, Devices and Applications Anil K. Maini – Wiley 2007
6. Samir Palnitkar, ”Verilog HDL”, Pearson Education, 2nd Edition, 2004.
7. Stephen Brown Zvonko Vranesic “Fundamentals of Digital Logic with VHDL Design” Tata McGraw- Hill Edition.
8. www.xilinx.com
9. www.acctel.com

**Course Contents and Lecture Schedule**

| S.No. | Topic | No. of Lectures | **Course Outcome** |
|---|---|---|---|
| 1 | **Programmable Logic to ASICs** | | |
| 1.1 | Programmable Read Only Memories (PROMs). | 1 | CO1 |
| 1.2 | Programmable Logic Arrays (PLAs) | 2 | CO1 |
| 1.3 | Programmable Array Logic (PALs) | 2 | CO1 |
| 1.4 | The Masked Gate Array ASIC | 1 | CO1 |
| 2 | **Complex Programmable Logic Devices (CPLDs)** | | |
| 2.1 | CPLD Architectures, Function Blocks, I/O Blocks | 1 | CO2 |
| 2.2 | Clock Drivers, Interconnect, CPLD Technology and Programmable Elements | 1 | CO2 |
| **3** | **FPGA-Based Systems** | | CO2 |
| 3.1 | Introduction- Basic Concepts, Digital Design and FPGAs, The roles of FPGAs and FPGA types | 1 | CO2 |
| 3.2 | FPGA Based System Design- Design, Goals & techniques, Hierarchical design, Design abstraction, Methodologies | 1 | CO2 |
| **4** | **FPGA Fabrics** | | |
| 4.1 | FPGA Architectures | 1 | CO3 |
| 4.2 | SRAM-Based FPGAs | 1 | CO3 |
| 4.2.1 | Characteristics of SRAM-Based FPGAs | 1 | CO3 |
| 4.2.2 | Logic elements & Interconnections networks | 1 | CO3 |
| 4.3 | Permanently Programmed FPGAs | 1 | CO3 |
| 4.3.1 | Antifuses, Flash configuration | 1 | CO3 |
| 4.3.2 | Logic blocks and interconnections, Antifuse programming | 1 | CO3 |
| 4.4 | Chip I/O, Circuit Design of FPGA Fabrics | 1 | CO3 |
| **5** | **Design Techniques, Rules,and Guidelines** | | |
| 5.1 | Basics of Hardware Description Language (Verilog) and Expressions | 1 | CO4 |
| 5.2 | Top-Down Design | 1 | CO4 |
| 5.3 | Synchronous Design | 1 | CO4 |
| 5.4 | Floating Nodes, Bus Contention and One-Hot State Encoding | 1 | CO4 |
| 5.5 | Design For Test and Testing Redundant Logic. | 1 | CO4 |
| 5.6 | Initializing State Machines, Observable Nodes | 1 | CO4 |
| | Total | 24 | |

**Tentative List of Experiments (24 Hours)**

1. Construct digital circuits such as, (CO5)
   a. Synchronous Counters
   b. Ripple counters
   c. 4 –Bit adder and Subtractor
   d. Code Converters
   e. MUX, DEMUX, Encoder and decoder
2. Design FPGA based (CO6)
   a. Digital signal processing
   b. Motor Control

**Course Designers:**

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2. Dr.D.Kavitha dkavitha@tce.edu

| 18EEPK0 | DIGITAL SIGNAL PROCESSING (THEORY CUM PRACTICAL) | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 2 | - | 2 | 3 |

## Preamble

Digital processing of a signal has major advantage over analog techniques. With digital filters, linear phase characteristics can be achieved; Filters can be made to work over a wide range of frequencies. Storage of digital data is very easy. Digital processing is more suited for low frequency signals like seismic signals, bio signals.

## Prerequisite

18EE350 –Signals and Systems

## Course Outcomes

On the successful completion of the course, students will be able to

| Cos | Course outcomes | Weightage*** in % |
|---|---|---|
| CO1 | Explain the functional blocks of Digital Signal Processing system. | 10 |
| CO2 | Design a FIR filter using windowing techniques (Rectangular and Hamming) for the given specifications. | 20 |
| CO3 | Design an IIR filter using bilinear and impulse invariance transformation for the given specifications. | 20 |
| CO4 | Explain the architecture of TMS320F67XX Digital Signal Processor. | 10 |
| CO5 | Perform DFT, FFT, convolution and correlation for the given discrete sequences using CCS and Matlab | 20 |
| CO6 | Analyze the perforamnce of designed FIR and IIR filters using MATLAB and DSP processor (TMS320F67XX) for the given specifications. | 20 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO2 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO4 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO5 | TPS3 | Apply | Value | Mechanism | 1.3, 2.1.1, 2.1.5,2.2.2, 2.4.2, 2.4.3, 2.4.7, 3.1.1 |
| CO6 | TPS4 | Analyse | Organise | Complex overt | 1.3, 2.1.1, 2.1.5,2.2.2, 2.4.2, 2.4.3, 2.4.7, 3.1.1 |

| | | | | | |
|---|---|---|---|---|---|
| | | | | response | |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | S | M | L | | | | | M | | M | | | | S |
| CO3 | S | M | L | | | | | M | | M | | | | S |
| CO4 | M | L | | | | | | M | | M | | | | M |
| CO5 | S | M | L | | S | | | M | | M | | | | S |
| CO6 | S | S | M | L | S | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Practical Test | Terminal Examination |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | | |
| Remember | 20 | 20 | 10 | - | 20 |
| Understand | 40 | 40 | 20 | - | 40 |
| Apply | 40 | 40 | 60 | 50 | 40 |
| Analyse | - | - | - | 30 | - |
| Evaluate | - | - | - | - | - |
| Create | - | - | - | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 20 |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. Draw the block diagram of digital signal processing system.
2. Consider the analog signal X(t)= 3cos 100πt. Determine the minimum sampling rate to avoid aliasing.
3. What is the nyquist rate for the given signal, $x(t) = 2sin400\pi t + \cos1000\pi t$ .

**Course Outcome (CO2):**

1. Write the Hamming window function.
2. Design a filter with the following specifications,

$$H(e^{j\omega}) = 1 \qquad -\frac{\Pi}{4} \le |\omega| \le \frac{\Pi}{4}$$
$$= 0 \qquad \frac{\Pi}{4} \le |\omega| \le \Pi.$$

Use hamming window with N=7. Realize its structure.

3. Using the rectangular window technique design a LPF with passband gain of unity, cutoff frequency of 1000Hz and working sampling frequency of 5kHz. The length of impulse be 7.

**Course Outcome (CO3)**

1. Design a digital filter for the given analog system, $H_a(s) = \dfrac{2}{(s+1)(s+4)}$.

Use a) impulse invariance method b) bilinear transformation method.

2. Design a bandpass filter to pass frequencies in the range,
w= 1-2 rad/sec using hamming window with N=5. Realize using direct form-II structure.
3. Design a Chebyshev filter for the following specification using bilinear transformation and realize using cascade form.

$0.8 \le |He^{j\omega}| \le 1 \qquad 0 \le |\omega| \le 0.2\pi$

$|He^{j\omega}| \le 0.2 \qquad 0.6\pi \le |\omega| \le \pi$

**Course Outcome (CO4)**

1. Discuss the are the advantages of floating point DSP.
2. Explain functional block and CPU of TMS320f67XX DSP.
3. Explain PLL and PLL controller of TMS320f67XX DSP.

**Course Outcome (CO5)**

1. Determine the output response y(n ) if h(n)={1,1,1} ; x(n)={1,2,3,1} by using linear convolution , circular convolution and circular convolution with zero padding. And compare the linear and circular convolution using matlab.

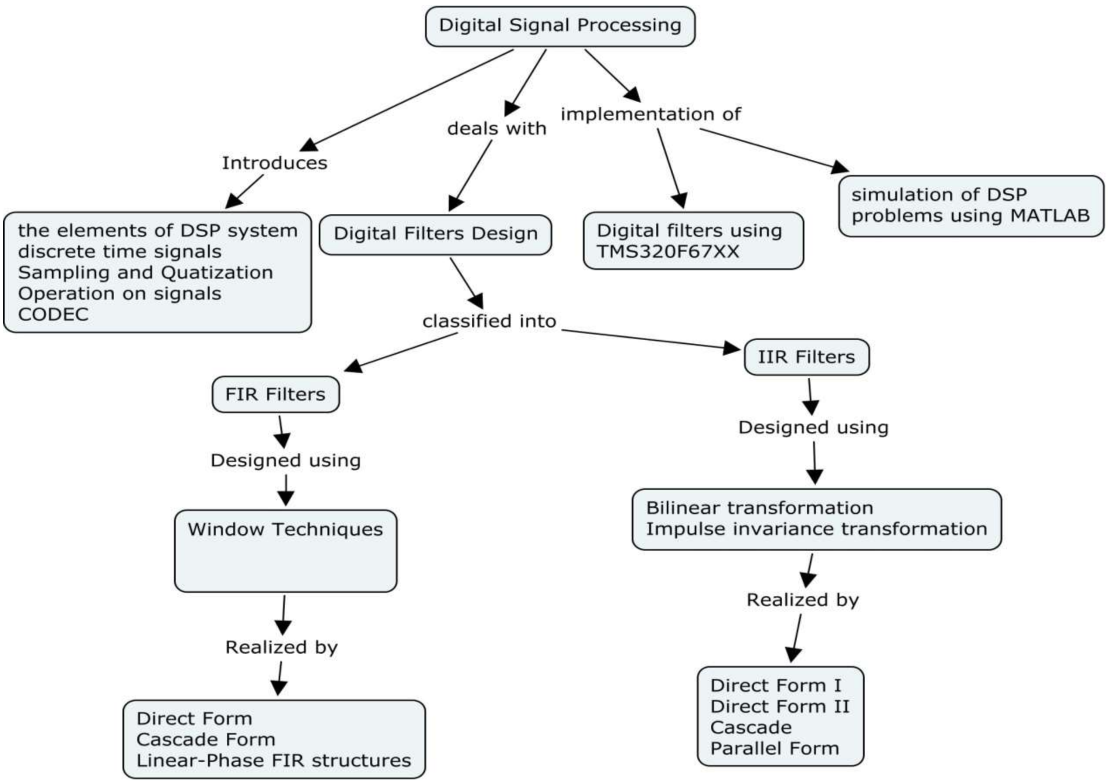
2. Using matlab design a bandstop butterworth filter to meet the following specifications. Stopband 100 t0 600 Hz, 20dB attenuation at 200 to 400Hz, The passband attenuation is 3dB and stopband attenuation is 20dB.
3. Compute 4-point DFT for given sequences and also obtain the graphical display using CCS. x(n)={2,5,3,1}

**Course Outcome (CO6)**

1. Design and realize a 25 tap BSF with cut off frequency 0.25π and 0.75π using hanning window using TMS320F67XX..
2. Design a butterworth filter that has a -2dB passband attenuation at a frequency of 20rad/sec and atleast -10dB stopband attenuation at 30rad/sec and assume the sampling frequency using TMS320F67XX..
3. Design a Chebyshev filter for the following specification using TMS320F67XX.

$$0.8 \le |Hej\omega| \le 1 \quad 0 \le \omega \le 0.2\pi$$
$$|Hej\omega| \le 0.2 \quad 0.6\pi \le \omega \le \pi$$

## Concept Map




## Syllabus

**Introduction:** Basic elements of a digital signal processing system – Advantages of digital over analog signal processing – Continuous time verses discrete time signals – Sampling of analog signals –Quantization of continuous amplitude signals –Introduction on CODEC.

**Digital Filters Design:** Properties and Structures of FIR and IIR filter – Design of FIR filter using windows – Design of IIR filter from analog filters using bilinear and impulse invariance transformation.

**Realization of Digital Filters:** Realization of FIR filters (Direct Form, Cascade Form, Linear-Phase FIR structures)and IIR filters(Direct Form I, Direct Form II, Cascade and Parallel Form) - Applications

**Architecture:** TMS320F67XX floating point DSP architectures, CPU, memory, buses and peripherals. Addressing modes, instruction sets, control operations, interrupts.

**List of Experiments:**

1. Discrete Time Sequences - Generation, Concept of Aliasing and operations using CCS and Matlab (CO5)
2. Convolution and Correlation using CCS and Matlab (CO5)
3. FIR Filter Design using CCS and Matlab (CO5)
4. IIR Filter Design using CCS and Matlab (CO5)
5. Implementation of FIR and IIR filters on TMS320C67XX (CO6)

## Learning Resources

1. John G.Proakis & Dimitris G.Manolakis, - Digital Signal Processing Principles, Algorithm and Applications – Pearson Education, New Delhi, 4th Edition, 2003.

2. P.Ramesh Babu - Digital Signal Processing, Scitech Publications of India, 2012.
3. Emmanuel C. Ifeachor & Barrie W. Jervis - Digital Signal Processing - A practical approach, Pearson Education, New Delhi, 2004.
4. A.V. Oppenheim and R.W.Schafer - Digital Signal Processing, Prentice Hall of India, 2001.
5. Sanjit K.Mishra – Digital Signal Processing-A computer based approach, Tata McGraw-Hill, New Delhi, 2004.


**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Lecture Hours | **Course Outcome** |
|---|---|---|---|
| 1 | **Introduction** | | |
| 1.1 | Basic elements of a digital signal processing system | 1 | CO1 |
| 1.2 | Advantages of digital over analog signal processing | 1 | CO1 |
| 1.3 | Continuous time verses discrete time signals | 1 | CO1 |
| 1.4 | Sampling of analog signals | 1 | CO1 |
| 1.5 | Quantization of continuous amplitude signals | 2 | CO1 |
| 2 | **Digital Filters** | | |
| 2.1 | Properties and Structures of FIR and IIR filter | 1 | CO2 |
| 2.2 | Design of FIR filter using windows | 3 | CO2 |
| 2.3 | Design of IIR filter from analog filters using bilinear and impulse invariance transformation | 3 | CO3 |
| 2.4 | **Realization of Digital Filters** | | |
| 2.4.1 | Realization of FIR (Direct form I, Direct form II, Cascade and parallel form) | 2 | CO2 |
| 2.4.2 | Realization of IIR filters(Direct form I, Direct form II, Cascade and parallel form) | 2 | CO3 |
| 2.4.3 | **Applications** | 1 | CO3 |
| 3 | **Architecture of TMS320F67XX** | | |
| 3.1 | TMS320F67XX floating point DSP architectures, | 2 | CO4 |
| 3.2 | CPU, memory, buses and peripherals. | 2 | CO4 |
| 3.3 | Addressing modes, instruction sets, control operations, interrupts. | 2 | CO4 |
| | **Total** | **24** | |
| | | | |

**Course Designers:**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2. Dr.R.Helen rheee@tce.edu

| 18EEPL0 | BIO-MEDICAL INSTRUMENTATION |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | - | - | 3 |

## Preamble

Biomedical instrumentation is the application of engineering principles and design concepts to medicine and biology. This field seeks to close the gap between engineering and medicine. It combines the design and problem solving skills of engineering with medical and biological sciences to improve healthcare diagnosis, monitoring and therapy. This subject will enable the students to learn the basic principles of different instruments/equipment used in the health care industry.

## Prerequisite

NIL

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the principles of biomedical measurement systems and its characteristics, standards, safety and regulation. | 10 |
| CO2 | Design the diagnostic devices to measure the Bio electric signals ( ECG, EEG, and EMG) | 20 |
| CO3 | Explain the Biomedical instrumentation system used to measure Blood Flow, Blood Pressure, Heart sound, Respiratory system and Blood cell counters | 20 |
| CO4 | Explain the working principle and operation of therapeutic devices like pacemakers, defibrillators, audiometer . | 10 |
| CO5 | Describe the principle and construction of medical imaging systems like MRI, CT for diagnosing applications. | 20 |
| CO6 | Analyze characteristics of real world electrophysiological signals and medical images using MATLAB. | 20 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.2.7, 2.1.1, 2.3.1, 2.5.1, 2.4.6, 3.2.3 |
| CO2 | TPS3 | Apply | Value | | 1.2.7, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO3 | TPS2 | Understand | Respond | | 1.2.7, 2.1.1, 2.4.4, 2.3.1, |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 3.2.3 |
| CO4 | TPS2 | Understand | Respond | | 1.2.7, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO5 | TPS2 | Understand | Respond | | 1.2.7, 2.1.1, 2.4.4, 2.3.1, 3.2.3 |
| CO6 | TPS4 | Analyse | Organise | | 1.2.7, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | M | L | | | | | | **M** | | **M** | | | | M |
| CO 2 | S | M | L | | | | | **M** | | **M** | | | | S |
| CO 3 | M | L | | | | | | **M** | | **M** | | | | M |
| CO 4 | S | M | L | | | | | **M** | | **M** | | | | S |
| CO 5 | M | L | | | | | | **M** | | **M** | | | | M |
| CO 6 | S | M | L | | M | | | **M** | | **M** | | | | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 50 | 50 | 40 | - | - | - | 40 |
| Apply | 30 | 30 | 40 | - | - | - | 40 |
| Analyse | - | - | - | 100 | 100 | 100 | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**
1. Define macro and micro shock.
2. Write the importance of Testing, maintaining and inspecting medical equipment.
3. Explain the impact of leakage Current in cardiac patient.

**Course Outcome 2(CO2):**
1. List the types of brain waves and specify its magnitude and frequency.
2. Illustrate the standard 10-20 electrode system for recording the spontaneous EEG with neat diagram.
3. Design a system to Record the Cardiac Signal.

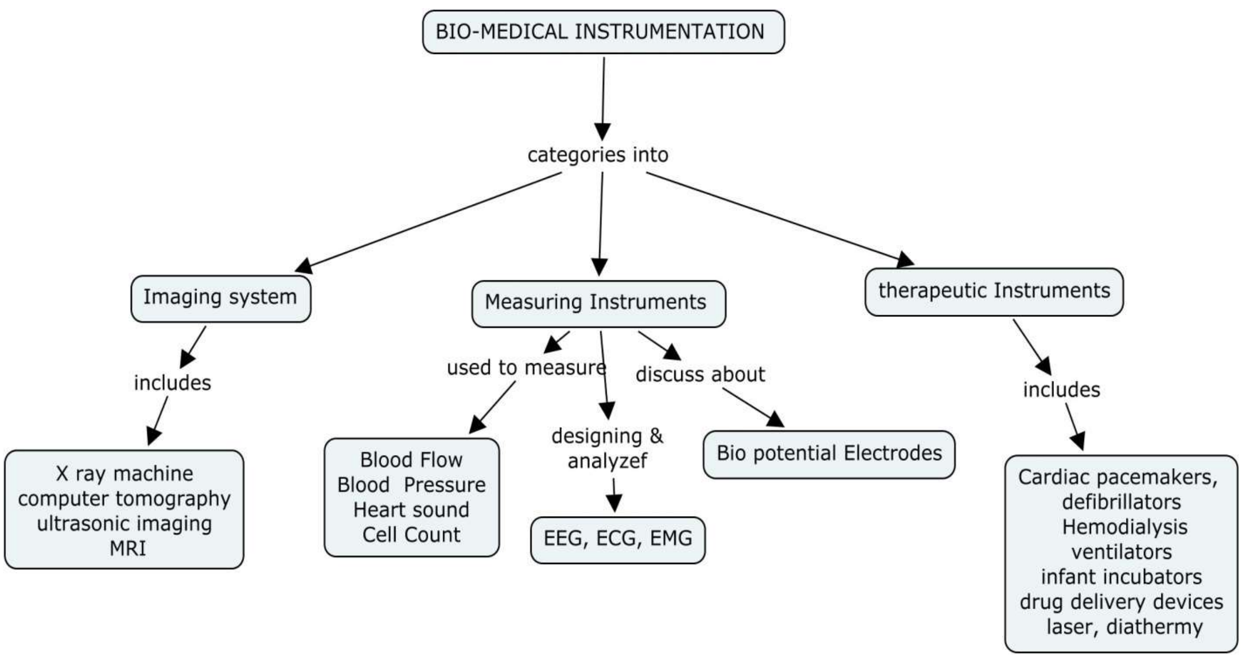
**Course Outcome 3 (CO3):**
1. Explain electromagnetic blood flow meter.
2. Explain with diagram the salient features of Phonocardiography
3. Describe a method for the measurement of total lung capacity.

**Course Outcome 4 (CO4):**
1. Design an external pacemaker.
2. With necessary sketches explain different types of Ventilators
3. Explain the operation of the Heart Lung Machine. Give its applications..

**Course Outcome 5 (CO5):**
1. Classify the X-rays and with neat diagram explain the function X-Ray machine.
2. Explain the principle of Magnetic Resonance imaging systems.
3. Describe the various scanning methods in ultrasonic imaging system.

**Course Outcome 6 (CO6):**
1. Analyze the Sleep pattern of EEG signal using matlab.
2. Using matlab analyze the abnormalities of ECG signal.
3. Using matlab analyzes the different digital filtering techniques for removing noise in the medical images

## Concept Map



## Syllabus

**BASIC CONCEPTS OF BIO MEDICAL INSTRUMENTATION:** Terminology – Generalized medical instrumentation system – Measurement Standards -Regulation of medical devices – Electrical safety in medical environment.
**BIO POTENTIALS AND MEASUREMENTS:** Electric activity and excitable cells – Functional organization of peripheral nervous system. EMG, ECG, EEG – Bio-potential electrodes-Electrodes for electric simulation of tissues – Practical hints for using electrodes.- Computer analysis of real world ECG & EEG signals

**BLOOD FLOW**- Electromagnetic blood flow meter, ultrasonic blood flow meter, Doppler blood flow meter cardiac output measurement. **BLOOD PRESSURE AND HEART SOUND MEASUREMENT**: Indirect and direct Measurement of blood pressure Phonocardiograph. **BLOOD CELL COUNTERS**: Different methods for cell counting, Coulter Counters, automatic recognition and differential counting of cells. **RESPIRATORY MEASUREMENT**: Lung Volume measurement, Plethysmography
**THERAPEUTIC DEVICES:** Cardiac pacemakers, defibrillators, audiometer, Heart Lung Machine, Haemodialysis, ventilators, infant incubators, drug delivery devices, therapeutic applications of the laser, diathermy
**MEDICAL IMAGING SYSTEMS**: X ray machine, computer tomography, ultrasonic imaging system, magnetic resonance imaging system, thermal imaging system, positron emission tomography , medical image processing.

## Learning Resources


1. R. S. Khandpur "Handbook of Bio-Medical Instrumentation", McGraw Hill Education; Third edition (4 August 2014)
2. J.Webster, "Medical Instrumentation application and design", third edition Wiley & Sons 2001.
3. Carr & Brown, "Introduction to Biomedical Equipment Technology" Pearson Education, Asia; 4th Edition, 2001
4. Leslie Cromwell, " Biomedical Instrumentation and Measurements" , Pearson Education India; 2 edition (2015)


## Course Contents and Lecture Schedule

| Module No. | Topics | No of lectures | Course outcomes |
|---|---|---|---|
| 1 | **BASIC CONCEPTS OF BIO MEDICAL INSTRUMENTATION** | | |
| 1.1 | Terminology – Generalized medical instrumentation system | 1 | CO1 |
| 1.2 | Measurement Standards | 1 | CO1 |
| 1.3 | Regulation of medical devices | 1 | CO1 |
| 1.4 | Electrical safety in medical environment | 1 | CO1 |
| 2 | **BIO POTENTIALS AND MEASUREMENTS** | | |
| 2.2 | Electric activity and excitable cells | 1 | CO2 |
| 2.3 | Functional organization of peripheral nervous system. | 1 | CO2 |
| 2.4 | EMG, ECG | 2 | CO2 |
| 2.5 | EEG | 1 | CO2 |

| | | | |
|---|---|---|---|
| 2.6 | Bio-potential electrodes ,Electrodes for electric simulation of tissues | 2 | CO2 |
| 2.7 | Practical hints for using electrodes | 1 | CO2 |
| 2.8 | Computer analysis of real world ECG & EEG signals | 2 | CO6 |
| 3 | **BLOOD FLOW** | | |
| 3.1 | Electromagnetic blood flow meter | 1 | CO3 |
| 3.2 | ultrasonic blood flow meter | 1 | CO3 |
| 3.3 | Doppler blood flow meter cardiac output measurement | 1 | CO3 |
| 3.4 | **BLOOD PRESSURE AND HEART SOUND MEASUREMENT**: | | CO3 |
| 3.4.1 | Indirect Measurement of blood pressure Phonocardiograph | 1 | CO3 |
| 3.4.2 | direct Measurement of blood pressure Phonocardiograph | 1 | CO3 |
| 3.5 | **BLOOD CELL COUNTERS**: Different methods for cell counting, Coulter Counters | 1 | CO3 |
| 3.5.1 | Automatic recognition and differential counting of cells. | 1 | CO3 |
| 3.6 | **RESPIRATORY MEASUREMENT**: Lung Volume measurement, | 1 | CO3 |
| 3.6.1 | Plethysmography | 1 | CO3 |
| 4 | **THERAPEUTIC DEVICES** | | |
| 4.1 | Cardiac pacemakers, defibrillators, Audiometer | 2 | CO4 |
| 4.2 | Heart Lung Machine , Haemodialysis, ventilators | 2 | CO4 |
| 4.3 | Infant incubators, drug delivery devices, | 1 | CO4 |
| 4.4 | Therapeutic applications of the laser, Diathermy | 1 | CO4 |
| 5 | **MEDICAL IMAGING SYSTEMS** | | |
| 5.1 | X ray machine, computer tomography, | 2 | CO5 |
| 5.2 | Ultrasonic imaging system, Magnetic Resonance Imaging system, | 2 | CO5 |
| 5.3 | Thermal imaging system, positron emission tomography | 1 | CO5 |
| 5.4 | Medical image processing using maltab | 2 | CO6 |
| | Total | 36 | |

**Course Designers:**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2. Dr. B.Ashok Kumar ashokudt@tce.edu
3. Mrs. R.Suganya rsaeee@tce.edu

| 18EEPP0 | ROBOTICS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

## Preamble

Robots are becoming back bone of modern day industries. Knowledge of robotics is a mandate even for electrical engineers This course is framed with the idea of inculcating the knowledge of robot anatomy, coordinate frames, mapping and transforms, direct kinematic modelling of robots and inverse kinematics, dynamic modelling, trajectory planning, control of manipulators, robotic sensors and vision.

## Prerequisite

- 18EE440 Control systems
- 18MA210 Matrices and Ordinary Differential Equations

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the anatomy of robot, coordinate frames, mapping and transformations | 20 |
| CO2 | Develop forward kinematic model of a robot manipulator | 20 |
| CO3 | Develop inverse kinematic model and dynamic model for a given Robotic manipulator | 20 |
| CO4 | Use Joint Space techniques and Cartesian space techniques for trajectory planning | 20 |
| CO5 | Explain the role of sensors and controllers in Robotics | 10 |
| CO6 | Use roboanalyser software to simulate the dynamics of the given manipulator | 10 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.1.1 |
| CO2 | TPS3 | Apply | Value | | 1.3, 2.1.2, 2.1.3, 4.1.4 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.2, 2.1.3,4.1.4 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.2,2.1.3,4.1.4 |
| CO5 | TPS2 | Understand | Respond | | 1.3, 2.1.1 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.2,2.1.3,4.1.4 |

## Mapping with Programme Outcomesand Programme Specific Outcomes

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | M | L | | | | | | M | | M | | | | M |
| CO 2 | S | M | L | | | | | M | | M | | | | S |
| CO 3 | S | M | L | | | | | M | | M | | | | S |
| CO 4 | S | M | L | | | | | M | | M | | | | S |
| CO 5 | M | L | | | | | | M | | M | | | | M |
| CO 6 | S | M | L | | M | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

**AssessmentPattern: Cognitive Domain**

| Cognitive Levels | ContinuousAssessmentTests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | **20** | **20** | - | - | - | 20 |
| Understand | 40 | 20 | 40 | - | - | - | 30 |
| Apply | 40 | 60 | 40 | 100 | 100 | 100 | 50 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**CO6 is evaluated through assignments.**

**AssessmentPattern: Psychomotor**

| **Psychomotor Skill** | **Miniproject/Assignment/Practical Component** |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

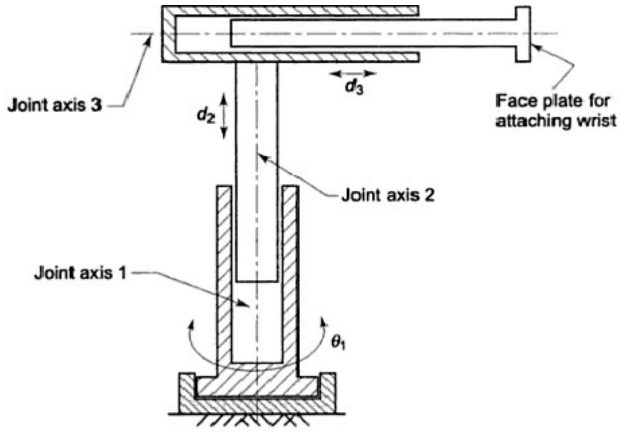
**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Explain about degrees of freedom and dexterous robots.
2. A vector OP defined in the reference frame {0} is [1 2 3]T. Origin of frame is displaced by +2units along y axis and +3 units along z axis. Frame {0} is then rotated about z axis by 90 degree and about x axis by -90 degree. Find the vector OP w.r.t the transformed frame. (Understand)

**Course Outcome 2 (CO2):**

1. Determine the forward kinematics of DOF RR Robot
2. Calculate the forward kinematics model of the cylindrical arm shown below:



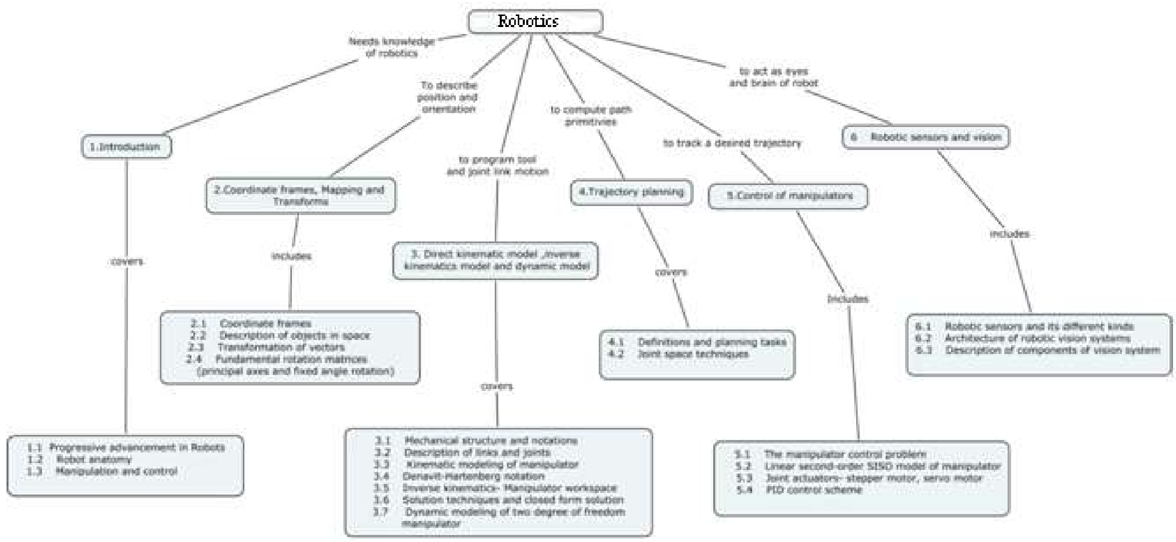

**Course Outcome 3 (CO3):**
1. Determine the inverse kinematics of DOF PP Robot Arm.
2. Calculate the dynamic model of RR 2DOF manipulator.

**Course Outcome 4 (CO4):**
1. A single cubic trajectory is given by $\theta(t) = 10 + 90t^2 - 60t^3$ and is used over time interval from $t = 0$ to $t = 1$. Calculate the starting and final position, velocity and acceleration.
2. Determine the trajectory of pick and place robot which has to pass through three via-points using piecewise linear interpolation with parabolic blends for each segment. The path points are [0 10 45 30 5] degrees and travel times for the segments are [0.5 1.5 2.0 1.0] seconds respectively. Assume the magnitude of acceleration at each parabolic blend is 25 degree / sec^2

**Course Outcome 5 (CO5):**
1. Consider a manipulator with linear, second order dynamic model $\tau = I\ddot{\theta} + B\theta$ , where I is the total inertia and B is the total friction. Design suitable partitioned control scheme to achieve the error dynamics $\ddot{e} + 4\dot{e} + 4e = 0$
2. With a neat diagram explain the architecture of robotic vision system

**Course Outcome 6 (CO6):**
1. Simulate the inverse kinematics of DOF PP robot arm using roboanalyser software
2. Simulate the forward kinematics of DOF RR robot.

**Concept Map**



## Syllabus

**Introduction to Robotics:** Basics of Robots, Progressive advancement in Robots, ApplicationsRobot anatomy, Manipulation and Control, Introduction to mobile robots

**Coordinate frames, Mapping and Transforms:** Coordinate frames, Description of objects in space, Transformation of vectors, Fundamental rotation matrices (principal axes and fixed angle rotation)

**Direct kinematic model**

Mechanical structure and notations, Description of links and joints, Kinematic modeling of manipulator, Denavit-Hartenberg notation

**Inverse kinematics(Limited to 3DOF robots) and dynamic modeling (Limited to 2DOF robots):**

Inverse kinematics- Manipulator workspace, Solution techniques and closed form solution, Dynamic modeling of two degree of freedom manipulator

**Trajectory planning:** Definitions and planning tasks, Joint space techniques,Cartesian space techniques

**Control of manipulators:**The manipulator control problem, Linear second-order SISO model of manipulator, Joint actuators- stepper motor, servo motor, PID control scheme, Force control

**Robotic sensors and vision:** Robotic sensors and its different kinds, Architecture of robotic vision system, Description of components of vision system.

**Robot Software:** Introduction to robot programming languages. Computer aided analysis of robots (using roboanalyzer software)

## Learning Resources

1. R.K. Mittal, I.J. Nagrath, Robotics and control, Tata McGraw-Hill, 2003.
2. John J.Craig, Introduction to Robotics, Mechanics and control, third edition, Pearson education, 2005
3. Mark W.Sponge, M.Vidyasagar, Robot dynamics and control, Wiley India, 2009.
4. KS Fu, Ralph Gonzalez CSG Lee, Robotics, John wiley, 2002.
5. Nptel Course on, “Robotics”, by IIT Kharagpur, https://nptel.ac.in/courses/112105249/
6. http://www.roboanalyzer.com/tutorials.html

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| **1.0** | **Introduction** | | |
| 1.1 | Basics of Robotics, Progressive advancement in Robots | 1 | CO1 |
| 1.2 | Robot anatomy | 1 | CO1 |
| 1.3 | Manipulation and control, Introduction to mobile robots | 1 | CO1 |
| **2.0** | **Coordinate frames, Mapping and Transforms** | | |
| 2.1 | Coordinate frames | 1 | CO1 |
| 2.2 | Description of objects in space | 1 | CO1 |
| 2.3 | Transformation of vectors | 2 | CO1 |
| 2.4 | Fundamental rotation matrices (principal axes and fixed angle rotation) | 2 | CO1 |
| **3.0** | **Direct kinematic model,** | | |
| 3.1 | Mechanical structure and notations | 1 | CO2 |
| 3.2 | Description of links and joints | 2 | CO2 |
| 3.3 | Kinematic modeling of manipulator | 3 | CO2 |
| 3.4 | Denavit-Hartenberg notation | 2 | CO2 |
| **4.0** | **Inverse kinematics and dynamic Modeling** | | |

| | | | |
|---|---|---|---|
| 4.1 | Inverse kinematics- Manipulator workspace | 2 | CO3 |
| 4.2 | Solution techniques and closed form solution | 2 | CO3 |
| 4.3 | Dynamic modeling of two degree of freedom manipulator | 2 | CO3 |
| 4.0 | **Trajectory planning** | | |
| 4.1 | Definitions and planning tasks | 1 | CO4 |
| 4.2 | Joint space techniques | 2 | CO4 |
| 4.3 | Cartesian Space techniques | 1 | CO4 |
| 5.0 | **Control of manipulators** | | |
| 5.1 | The manipulator control problem | 1 | CO5 |
| 5.2 | Linear second-order SISO model of manipulator | 1 | CO5 |
| 5.3 | Joint actuators- stepper motor, servo motor | 1 | CO5 |
| 5.4 | PID control scheme | 1 | CO5 |
| 6.0 | **Robotic sensors and vision** | | |
| 6.1 | Robotic sensors and its different kinds | 1 | CO5 |
| 6.2 | Architecture of robotic vision system | 1 | CO5 |
| 6.3 | Description of components of vision system | 1 | CO5 |
| 7.0 | **Robot software** | | |
| 7.1 | Introduction to robot programming languages | 1 | CO6 |
| 7.2 | Computer aided analysis of robots (using roboanalyzer software) | 2 | CO6 |
| | Total | 36 | |

**Course Designers:**

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3. Mrs.R.Suganya rsaeee@tce.edu

| 18EEPQ0 | AUTOMOTIVE ELECRTONICS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

## Preamble

This course covers the fundamentals of vehicle electrical and electronic system, components and sub systems. It discusses working principle of sensors and actuators, concepts of diagnostics and communication protocols, and gives exposure to Quality, Reliability and Safety aspects.

## Prerequisite

18EE340 – Digital Systems

18EE430 - Measurements& Instrumentation

## Course Outcomes

On successful completion of the course, students will be able to

| No. | Course Outcomes | Weightage*** in % |
|---|---|---|
| CO1 | Explain the vehicle electrical and Electronic systems and their components | 20 |
| CO2 | Explain the working of electrical and electronic subsystems | 20 |
| CO3 | Explain the working principles of sensors and actuators in automotive | 20 |
| CO4 | Determine sensors and actuator outputs under given operating conditions | 20 |
| CO5 | Explain the concepts of diagnostics and communication protocols | 10 |
| CO6 | Explain the Quality, Reliability and Safety aspects of automotive electrical and electronic system requirements | 10 |

*** Weightage depends on Bloom's Level, number of contact hours

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.3.1,3.2.3 |
| CO2 | TPS2 | Understand | Respond | | 1.3,2.3.1, 3.2.3 |
| CO3 | TPS2 | Understand | Respond | | 1.3 ,2.3.1, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.3.1, 2.4.4, |

| | | | | | |
|---|---|---|---|---|---|
| CO5 | TPS2 | Understand | Respond | | 1.3 ,2.5.4, 3.2.3 |
| CO6 | TPS2 | Understand | Respond | | 1.3, 3.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO1 0 | PO1 1 | PO1 2 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | M | L | | | | | | M | | M | | | | M |
| CO3 | M | L | | | | | | M | | M | | | | M |
| CO4 | S | M | L | | | | | M | | M | | | | S |
| CO5 | M | L | | | | | | M | | M | | | | M |
| CO6 | M | L | | | | | | M | | M | | | | M |

S- Strong; M-Medium; L-Low

**Assessment Pattern: : Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 60 | 60 | 60 | - | - | - | 60 |
| Apply | 20 | 20 | 20 | 100 | 100 | 100 | 20 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Explain working of ignition system with neat diagram.
2. Describe the operation of Anti-lock Braking System in an automotive.
3. Explain the functions of engine management system in detail.

**Course Outcome 2 (CO2):**

1. Discuss the automobile headlamp electric circuit with all possible modes.
2. Explain the function of starting system with neat diagram.
3. Discuss the requirement of wiring harness in an automobile.

**Course Outcome 3 (CO3):**

1. Explain the working of oil pressure sensor with neat diagram.
2. Describe the working principle of Hall Effect sensor to measure the crankshaft position.
3. Explain the operation of fuel injector with neat diagram.

**Course Outcome 4 (CO4):**

1. Assume that the temperature of the coolant in an automotive is increasing and it is measured by thermistor. The sensor is supplied with 12 V. Determine the fixed

resistance used, if the sensor variable resistance decreases from 8 ohm to 2 ohm for an output voltage increase from 4V to 8V.

2. Determine the engine load of a vehicle when the fuel injector pulse timing is 30 msec and the duty cycle is 10%.
3. Determine the pulse counter output of an engine speed sensor for 4 minutes when an eight cylinder engine is running at 5000 rpm..

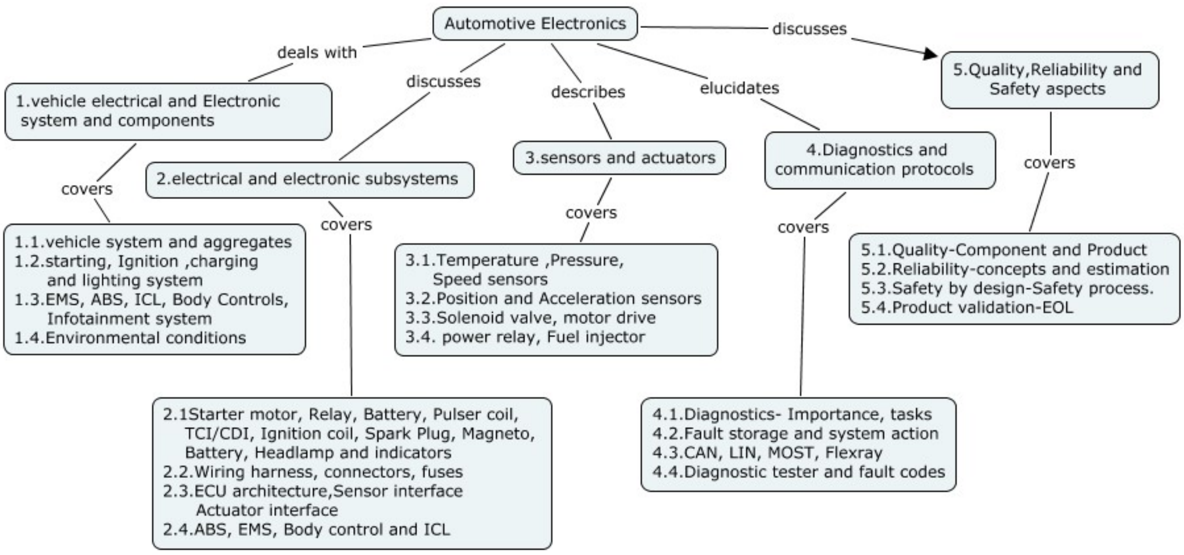
**Course Outcome 5 (CO5):**

1. Discuss the features of On Board Diagnostics II (OBD-II) in detail.
2. Define freeze frame parameters.
3. Explain the CAN bus in detail.

**Course Outcome 6 (CO6):**

1. Define - MTBF.
2. Describe the process of Failure Mode and Effects Analysis.
3. Discuss the five phases of Product Quality Planning.

## Concept Map




## Syllabus

**Vehicle Electrical and Electronic system and components:** Overview of vehicle system and aggregates, Schematic diagram of automotive electrical system - function of starting system, Ignition system, charging system and lighting system -Schematic diagram of electronic system-Function of EMS, ABS, ICL, Body Controls, Infotainment system-Environmental conditions: Electrical and operating-key requirements of automotive systems.

**Electrical and Electronic Subsystems :** Starter motor, Relay, Battery, Pulser coil, TCI/CDI, Ignition coil, Spark Plug, Magneto, Battery, Headlamp and indicators- Requirements of Wiring harness, connectors, fuses-ECU architecture-Sensor interface-Actuator interface-Automotive Electronic Application - ABS, EMS, Body control and ICL.

**Sensors and Actuators:** sensors-Temperature, Pressure, Speed, Position and Acceleration- actuator-Solenoid valve, motor drive, power relay, Fuel injector.

**Diagnostics and Communication protocols :** Diagnostics- Importance, tasks, Fault storage and system action-Communication networks-CAN, LIN, MOST, Flexray-communication protocols- KWP2000, OBD-II-Diagnostic tester and fault codes

**Quality, Reliability and Safety aspects:** Quality-Component and Product-Reliability-concepts and estimation-Safety by design-Safety process-Product validation-EOL.

## Learning Resources

1) Ronald K Jurgen, “Automotive Electronics Handbook”, Tata McGraw Hill, 1999.

2) Robert Bosch , “Automotive Electrics and Automotive Electronics”, GmbH, 2007.

3)Tom Denton, ”Automobile Electrical and Electronics Systems” ,Elsevier Publications,2004

4) Ronald K Jurgen, “Automotive Microcontrollers”, Progress in technology,2008.

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lecture hours | CO |
|---|---|---|---|
| **1.0** | **Vehicle Electrical and Electronic system and components** | | |
| 1.1 | Overview of vehicle system and aggregates, Schematic diagram of automotive electrical system | 2 | CO1 |
| 1.2 | function of starting system, Ignition system, charging system and lighting system | 3 | CO1 |
| 1.3 | Schematic diagram of electronic system- Function of EMS, ABS, ICL, Body Controls, Infotainment system | 2 | CO1 |
| 1.4 | Environmental conditions: Electrical and operating - key requirements of automotive systems. | 1 | CO1 |
| **2.0** | **Electrical and Electronic Subsystems** | | |
| 2.1 | Working principle of Starter motor, Relay, Battery, Pulser coil, TCI/CDI, Ignition coil, Spark Plug, Magneto, Battery, Headlamp and indicators | 3 | CO2 |
| 2.2 | Requirements of Wiring harness, connectors, fuses | 1 | CO2 |
| 2.3 | ECU -Sensor interface-Actuator interface | 2 | CO2 |
| 2.4 | Automotive Electronic Application - ABS, EMS, Body control and ICL | 2 | CO2 |
| **3.0** | **Sensors and Actuators** | | |
| 3.1 | Working principle of sensors-Temperature ,Pressure, Speed | 3 | CO3 |
| 3.2 | Position and Acceleration sensors | 1 | CO3 |
| 3.3 | Working principle of actuator-Solenoid valve, motor drive, | 2 | CO3 |
| 3.4 | power relay, Fuel injector | 2 | CO3 |
| 3.5 | Determination of sensors and actuator outputs under given operating conditions | 3 | CO4 |
| **4.0** | **Diagnostics and Communication protocols** | | |

| | | | |
|---|---|---|---|
| 4.1 | Diagnostics- Importance, tasks | 1 | CO5 |
| 4.2 | Fault storage and system action | 1 | CO5 |
| 4.3 | Communication networks-CAN, LIN, MOST, Flexray- communication protocols- KWP2000, OBD-II | 2 | CO5 |
| 4.4 | Diagnostic tester and fault codes | 1 | CO5 |
| **5.0** | **Quality, Reliability and Safety aspects** | | |
| 5.1 | Quality-Component and Product | 1 | CO6 |
| 5.2 | Reliability-concepts and estimation | 1 | CO6 |
| 5.3 | Safety by design-Safety process. | 1 | CO6 |
| 5.4 | Product validation-EOL | 1 | CO6 |
| | **Total** | **36** | |

**Course Designer:**

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2.Mr.Srinivasa Raghavan(TVS motors)

| 18EEPS0 | SOFT COMPUTING (THEORY CUM PRACTICAL) |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 2 | 0 | 2 | 3 |

## Preamble

The objective of this course is to introduce basic concepts and applications of soft computing tools such as neural networks, fuzzy logic systems, and genetic algorithms. Also it covers soft computing based solutions for real-world Electrical Engineering problems.

## Prerequisite

- Prior knowledge of MATLAB software is required.

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Describe the role of various soft computing techniques in building intelligent systems | 5 |
| CO2 | Explain fuzzy logic operations, relations and inference system | 10 |
| CO3 | Develop the fuzzy logic controler for the given electrical system | 10 |
| CO4 | Explain the architecture and learning methodologies of perceptron, and back propagation neural networks | 20 |
| CO5 | Apply back propagation neural network for modelling and control of the given electrical engineering system | 10 |
| CO6 | Apply genetic algorithm to solve the given optimization problem using hand calculations | 15 |
| CO7 | Use MATLAB Fuzzy logic, Neural network and GA toolboxes effectively to solve a given electrical engineering problem | 30 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 2.1.2, 2.1.4 |
| CO2 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 2.1.2, 2.1.4 |
| CO3 | TPS4 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.1.4, 2.4.6, 3.2.3, 4.5.3, 4.5.3 |
| CO4 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 2.1.2, 2.1.4 |
| CO5 | TPS4 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.4.6, 3.2.3, 4.5.3, 4.5.3 |
| CO6 | TPS4 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.4.6, 3.2.3, 4.5.3, 4.5.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO7 | TPS4 | Analyze | Organize | Complex overt response | 1.3, 2.1.1, 2.1.2, 2.4.6, 3.2.3, 4.5.3, 4.5.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | M |
| CO2 | M | L | | | | | | M | | M | | | M | M |
| CO3 | S | M | L | | | | | M | | M | | | S | S |
| CO4 | M | L | | | | | | M | | M | | | M | M |
| CO5 | S | M | L | | | | | M | | M | | | S | S |
| CO6 | S | M | L | | | | | M | | M | | | S | S |
| CO7 | S | S | M | L | S | | | M | | M | | | S | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Practical Test** | **Terminal Examination** |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | | |
| Remember | 20 | 20 | 20 | - | 20 |
| Understand | 40 | 40 | 40 | - | 40 |
| Apply | 40 | 40 | 40 | 30 | 40 |
| Analyse | 0 | 0 | 0 | 40 | 0 |
| Evaluate | 0 | 0 | 0 | - | 0 |
| Create | 0 | 0 | 0 | - | 0 |

**AssessmentPattern: Psychomotor**

| **Psychomotor Skill** | **~~Miniproject /Assignment~~/Practical Component** |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | 20 |
| Complex Overt Responses | 10 |
| Adaptation | |
| Origination | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Explain the role of soft computing tools in building intelligent systems.

2. Explain the architecture of perceptron neural network.
3. Compare the performance of conventional optimization technique and GA in solving real-world optimization problem.

**Course Outcome (CO2)**

1. Explain the working of fuzzy logic controller with a neat block diagram
2. List the steps involved in the design of fuzzy logic controller
3. For a speed control of DC motor the relation between series resistance and armature current are given as R and the relation between armature current and speed are given as S

$$R = \begin{array}{c c} & \begin{array}{cc} y_1 & y_2 \end{array} \\ \begin{array}{c} x_1 \\ x_2 \end{array} & \begin{bmatrix} 0.5 & 0.3 \\ 0.2 & 0.7 \end{bmatrix} \end{array} \quad \& \quad S = \begin{array}{c c} & \begin{array}{ccc} z_1 & z_2 & z_3 \end{array} \\ \begin{array}{c} y_1 \\ y_2 \end{array} & \begin{bmatrix} 0.9 & 0.4 & 0.3 \\ 0.7 & 0.4 & 0.9 \end{bmatrix} \end{array}$$

Apply the concept of fuzzy relations such as a) max-min composition b) max-product composition and obtain the relation between series resistance and speed

**Course Outcome (CO3)**

1. How will you control the temperature and pressure in a thermal power plant by the control of throttle action using the concept of fuzzy logic? Assume the triangular membership functions for input and output.
2. Consider the speed control of induction motor problem, apply fuzzy logic to exercise this. Let change in speed and error in change in speed as inputs and output as switching frequency of the inverter.

**Course Outcome (CO4)**

1. List the different types of activation functions used in ANN
2. Describe BPN architecture with a neat sketch and explain the steps involved in the training of the network
3. Develop a suitable perceptron neural network model to perform the following classification problem. The vectors (1,1,1,1) and (-1,1,-1,-1) for belonging to the class (target value 1) vectors (1,1,1,-1) and (1,-1,-1,1) for not belonging to the class (target value -1).

**Course Outcome (CO5)**

1. Apply the concept of neural network to model and control the speed of an induction motor.
2. Apply the concept of neural network to model and control the speed of an DC Motor

**Course Outcome (CO6)**

1. Explain the role of reproduction operator in GA
2. Perform two generations of simple binary coded genetic algorithm to solve the following optimization problem. Maximize $f(x) = x^2$ $0 \leq x \leq 31$, x is an integer.
   Use proportionate selection, single point crossover, binary mutation and population size of six.

3. Perform simple binary coded and real coded genetic algorithm to solve the following optimization problem.
   Maximize f(x) = |x| sin(x) -5≤ x≤ 5, x is real number.

   Use proportionate selection, single point crossover, and binary mutation for simple GA and proportionate selection, Arithmetic crossover, and Gaussian mutation for RGA. Evaluate the performance of SGA and RGA after a fixed number of generations with equal population size.

**Course Outcome (CO7)**

**List of Experiments:**

1. Develop a fuzzy logic system for mapping the following relationship. $f(x_1,x_2)=x_1^{\,2}x_2-2x_1x_2+x_2^{\,2}+\sqrt{x_1x_2}$ Where $0 \le x_1 \le 2.0, \quad 0 \le x_2 \le 10.0$
2. Develop the fuzzy logic system for mapping the following data.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| X | -20 | -15 | -12 | -5 | 0 | 5 | 12 | 15 | 20 |
| y | 400 | 300 | 200 | 10 | 0 | -10 | -200 | 300 | 400 |

3. Design a fuzzy logic controller to perform the speed control of DC shunt motor with suitable of choice of input and output, membership functions diagram, and if-then rules.
4. Design a McCulloch – Pitts Neural network model for 2-input bipolar I/O with bias to perform the logical AND/OR/NOT function.
5. Design a Perceptron Neural network model for 3-input bipolar I/O with bias to perform the logical AND/OR/NOT function.
6. Design a BPN Neural network model for 3-input bipolar I/O with bias to perform the logical AND/OR/NOT/XOR function.
7. Apply genetic algorithm to solve the following optimization problem. Maximize $f(x)=(1-x)^2$ Where $0 \le x \le 127$ x is an integer, Assume population size = 6 , single point crossover and binary mutation.
8. Apply the principle of Genetic algorithm to determine the minimum distance from the origin of the xy plane to a circle described by $g(x,y)=(x-8)^2+(y-6)^2$ . The minimum distance is obtained by minimization of the distance square given by $f(x,y)=x^2+y^2$ . Assume the population size as four, use single point crossover, bitwise mutation, Roulette wheel selection and random initialization and perform the operation for one generation.
9. Apply the principle of Genetic algorithm to determine the minimum generation cost of three unit system, The following are the cost functions:

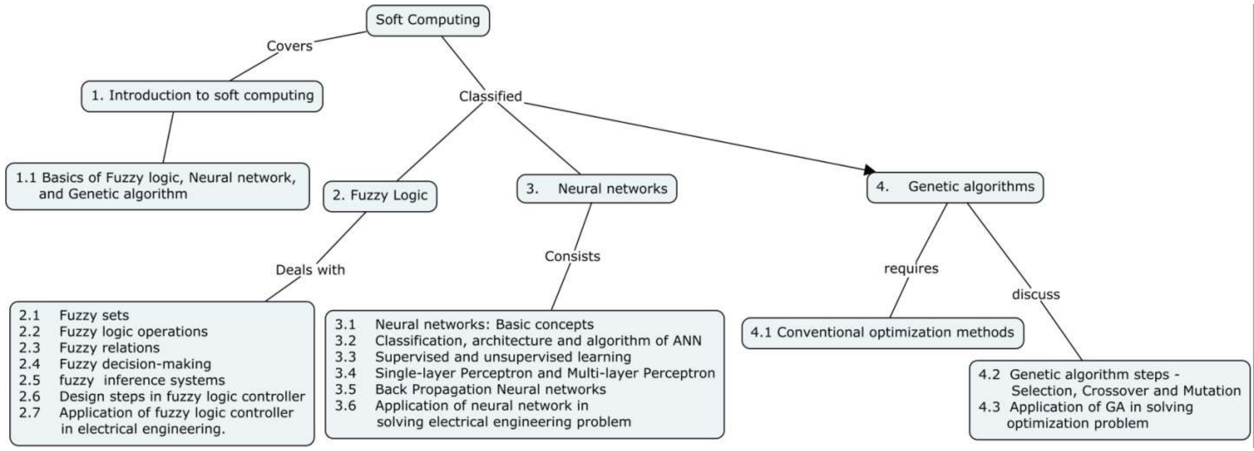
$$\text{Unit A: } 15+1.4P_A+0.04P_A^2 \ \$/h$$

$$\text{Unit B: } 25+1.6P_B+0.05P_B^2 \ \$/h$$

$$\text{Unit C: } 20+1.8P_C+0.02P_C^2 \ \$/h$$

How should these units be dispatched if generation company must supply a load of 350 MW at a minimum cost?

## Concept Map




## Syllabus

Introduction to soft computing - Fuzzy logic, Neural Network and Genetic algorithm

Fuzzy Logic: Fuzzy sets, logic operations, and relations; Fuzzy decision-making; fuzzy inference systems; design steps in fuzzy logic controller; application of fuzzy logic controller in Electrical engineering.

Neural networks: Basic concepts and major classes of neural networks, supervised and unsupervised learning, Single-layer perceptron, Multi-layer perceptron, Back Propagation Neural network, RBF networks. Application of neural network modelling / control problems in Electrical engineering

Genetic algorithms: Introduction - genetic algorithm steps-Selection, Crossover and Mutation; Application of GA to Electrical engineering problems.

Use of MATLAB Fuzzy logic, Neural network and GA toolboxes to solve electrical engineering problems.

## Learning Resources

1. George J.Klir and Bo Yuan, Fuzzy sets and Fuzzy Logic, Second Edition, PHI, 2006
2. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, Third Edition, John Wiley and Sons Ltd., 2010.
3. J.M.Zurada, Introduction to artificial neural systems, Jaico Publishing House, 2006
4. D.E. Goldberg, Genetic algorithms in search, optimization, and machine learning, Addison-Wesley.1989.
5. S.N.Sivanandam, and S.N.Deepa, Principles of Soft computing, Second Edition, Wiley India Pvt. Ltd, 2013.
6. N.P.Padhy and S.P.Simon, Soft computing with MATLAB programming, Oxford publishers, 2015.
7. http://nptel.ac.in/courses/106106046/41
8. https://www.coursera.org/learn/neural-networks
9. http://www.iitk.ac.in/kangal/deb.shtml

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 1 | **Introduction to soft computing** | | |
| 1.1 | Basics of Fuzzy logic, Neural network, and Genetic algorithm | 2 | CO1 |
| 2. | **Fuzzy Logic** | | |
| 2.1 | Fuzzy sets | 1 | CO2 |
| 2.2 | Fuzzy logic operations | 1 | CO2 |
| 2.3 | Fuzzy relations | 1 | CO2 |
| 2.4 | Fuzzy decision-making | 1 | CO2 |
| 2.5 | fuzzy inference systems | 1 | CO2 |
| 2.6 | Design steps in fuzzy logic controller; | 1 | CO3 |
| 2.7 | Application of fuzzy logic controller in electrical engineering. | 2 | CO3 |
| **3** | **Neural networks** | | |
| 3.1 | Neural networks: Basic concepts | 1 | CO4 |
| 3.2 | Classification, architecture and algorithm of ANN | 2 | CO4 |
| 3.3 | Supervised and unsupervised learning | 1 | CO4 |
| 3.4 | Single-layer Perceptron and Multi-layer Perceptron | 2 | CO4 |
| 3.5 | Back Propagation Neural networks | 1 | CO5 |
| 3.6 | Application of neural network in solving electrical engineering problem | 2 | CO5 |
| **4** | **Genetic algorithms** | | |
| 4.1 | Conventional optimization methods | 1 | CO6 |
| 4.2 | Genetic algorithm steps - Selection, Crossover and Mutation | 2 | CO6 |
| 4.3 | Application of GA in solving optimization problem | 2 | CO6 |
| **5** | Use of MATLAB Fuzzy logic, Neural network and GA toolboxes to solve electrical engineering problems. | 24 | CO7 |
| | **Total** | **48** | |

**Course Designers:**



| | | |
|---|---|---|
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| 3. | Dr.C.K.Babulal | ckbeee@tce.edu |

| 18EEPU0 | DRIVES AND CONTROL |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

## Preamble

Electric Drives, both ac and dc types, come in many shapes and sizes. Some are standardized versions for general-purpose applications. Others are intended for specific tasks. In any case, motors should be selected to satisfy the dynamic requirements of the machines on which they are applied without exceeding rated motor temperature. Thus, the first and most important step in motor selection is determining load characteristics, torque and speed versus time. Selection is also based on mission goals, power available, and cost.

## Prerequisite

18EE320:DC machines and Transformers
18EE420:AC machines
18EE530:Power electronics

## Course Outcomes

On the successful completion of the course, students will be able to

| Course Outcome NO. | Course Outcomes | Weightage in % |
|---|---|---|
| CO1 | Select a drive for particular applications | 10 |
| CO2 | Design 1 phase and 3 phase controlled rectifier based dc drive | 20 |
| CO3 | Design various dc to dc converter topology based dc drive | 20 |
| CO4 | Explain the operation of inverter fed induction motor drives | 20 |
| CO5 | Explain the operation of synchronous motor, stepper motor and BLDC motor drive system | 20 |
| CO6 | Analyze the different drives using simulation software such as MATLAB/Simulink, PLECS and PSIM | 10 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.3 |
| CO2 | TPS3 | Apply | Value | | 1.3, 2.1.1, 4.4.4 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.1, 4.4.4 |
| CO4 | TPS2 | Understand | Respond | | 1.3 |
| CO5 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 4.4.4 |
| CO6 | TPS4 | Analyze | organize | | 1.3, 2.1.1 |

## Mapping with Programme Outcomes and Programme specific Outcomes

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | S | M | L | | | | | M | | M | | | | S |
| CO 2 | S | M | L | | | | | M | | M | | | | S |
| CO 3 | S | M | L | | | | | M | | M | | | | S |
| C04 | M | L | | | | | M | | M | | | | | M |
| CO 5 | M | L | | | | | M | | M | | | | | S |
| CO 6 | S | S | M | L | S | | | M | | M | | | | L |

S- Strong; M-Medium; L-Low

**Assessment pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 20 | 20 | 20 | - | - | - | 20 |
| Apply | 60 | 60 | 60 | - | - | - | 60 |
| Analyse | 0 | 0 | 0 | 100 | 100 | 100 | 0 |
| Evaluate | 0 | 0 | 0 | - | - | - | 0 |
| Create | 0 | 0 | 0 | - | - | - | 0 |

CO6 is evaluated through assignments

**Assessment pattern: Psychomotor Domain**

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Select a drive for railway locomotives and justify.
2. Select a drive for a levitated electric vehicles and justify.
3. Calculate the starting time of a drive with the following parameters $j=10kg\text{-}m^2$ , $T=15+0.5\omega_m$, and $Ti=5+0.6\ \omega_m$

**Course Outcome 2 (CO2):**

1. A 220V shunt Motor has an armature resistance of 0.062 Ω and with full field has an emf of 215V at a speed of 960 rpm, the motor is driving an overhauling load with a torque of 172 Nm. Calculate the minimum speed at which the motor can hold the load by means of regenerative braking.
2. A 500V series motor having armature resistance and field resistance of 0.2 Ω and 0.3 Ω respectively runs at 500 rpm when taking 70A. Assuming unsaturated field, find out its speed when field diverter of 0.684 Ω is used constant load torque.
3. A 250V DC Series Motor takes 40A of current when developing a full load torque at 1500 rpm. Its resistance is 0.5 Ω. If the load torque varies as the square of the speed determine the resistance to be connected in series with the armature to reduce the speed to 122 rpm. Assume the flux is proportional to the field current.

**Course Outcome 3 (CO3):**

1. The input to a chopper is from a 100V dc source. The chopper is switched at a frequency of 100KHz with a pulse width of 4□s. What is the average output voltage of the chopper?
2. Discuss the effect of the output voltage, duty ratio and the load current in the determination of the inductor and capacitor value of the filter used in buck converter based DC drives.

**Course Outcome 4 (CO4):**

1. Explain the operation of a 3 phase VSI in 120 degree mode
2. Explain the operation of a 3 phase VSI in 180 degree mode
3. Discuss the operation of 3 phase CSI fed IM.

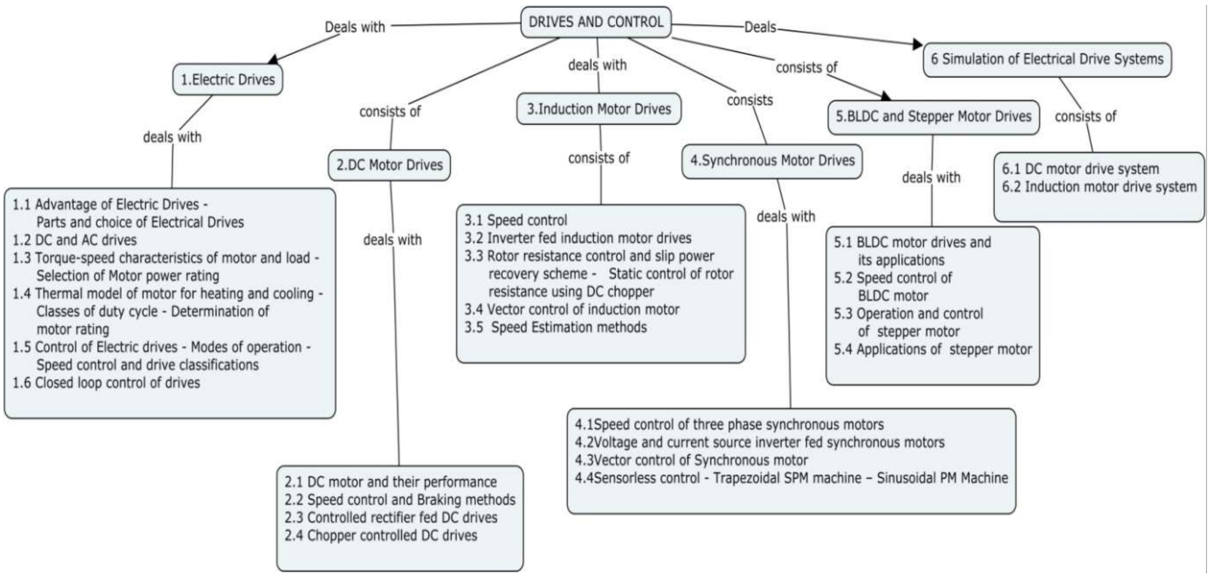
**Course Outcome 5 (CO5):**

1. Explain the operation of a BLDC motor.
2. Discuss the operation of a synchronous motor.
3. Explain the operation of 4 phase stepper motor.

**Course Outcome 6 (CO6):**

1. Simulate a buck converter fed DC motor using PLECS.
2. Simulate a full converter fed DC motor using PSIM.
3. Explain the effect of harmonics on PWM inverters fed IM drives in industries

## Concept Map




## Syllabus

**Electric Drives** - Advantage of solid state electric drives - Parts and choice of electrical drives – Status of DC and AC drives - Torque-speed characteristics of motor and load - Selection of Motor power rating - Thermal model of motor for heating and cooling - Classes of duty cycle - Determination of motor rating - Control of Electric drives - Modes of operation - Speed control and drive classifications - Closed loop control of drives

**DC Motor Drives -** DC motor and their performance - Speed control - Braking Controlled rectifier fed DC drives - Chopper controlled DC drives

**Induction Motor Drives -** Speed control – Stator control-Inverter fed induction motor drives - Rotor resistance control and slip power recovery schemes - Static control of rotor resistance - Vector control of induction motor- Speed Estimation methods

**Synchronous Motor Drives** - Speed control - Inverter fed synchronous motors – Vector control of Synchronous motor – Sensorless control - Sinusoidal PM Machine

**BLDC Motor and Stepper motor Drives -** Operation and control of BLDC motor and Stepper motor drives

**Simulation of Electrical Drive Systems**: DC motor drive- Induction motor drive

## Learning resources

1. G. K. Dubey: Fundamental of Electrical Drives - Narosa Publishing House, Chennai, 2004.

2. Bimal K.Bose – Modern Power Electronics and AC Drives – Pearson Education Asia Publication, 2003.
3. R.Krishnan - Electric motor drives – Modeling, analysis and control, Pearson Education, New Delhi, 2003.
4. Muhammad H.Rashid, Power Electronics Circuits, Devices & Applications - Pearson Education India Publication, New Delhi, II Edition, 2007.
5. Ned Mohan, Tore Undeland & William Robbins, Power Electronics : converters Applications and Design-John Willey and sons 2003.

## Course Contents and Lecture Schedule

| S.No. | Topic | Duration (Hours) | CO |
|---|---|---|---|
| **1.** | **Electric Drives** | | |
| 1.1 | Advantage of Electric Drives - Parts and choice of Electrical Drives | 2 | CO1 |
| 1.2 | DC and AC drives | 1 | CO1 |
| 1.3 | Torque-speed characteristics of motor and load - Selection of Motor power rating | 2 | CO1 |
| 1.4 | Thermal model of motor for heating and cooling - Classes of duty cycle - Determination of motor rating | 2 | CO1 |
| 1.5 | Control of Electric drives - Modes of operation - Speed control and drive classifications | 1 | CO1 |
| 1.6 | Closed loop control of drives | 1 | CO1 |
| **2.** | **DC Motor Drives** | | |
| 2.1 | DC motor and their performance | 1 | CO2 |
| 2.2 | Speed control and Braking methods | 2 | CO2 |
| 2.3 | Controlled rectifier fed DC drives | 2 | CO2 |
| 2.4 | Chopper controlled DC drives | 2 | CO3 |
| **3.** | **Induction Motor Drives** | | |
| 3.1 | Speed control | 2 | CO4 |
| 3.2 | Inverter fed induction motor drives | 1 | CO4 |
| 3.3 | Rotor resistance control and slip power recovery scheme - Static control of rotor resistance using DC chopper | 2 | CO4 |
| 3.4 | Vector control of induction motor | 2 | CO4 |
| 3.5 | Speed Estimation methods | 1 | CO4 |
| **4.** | **Synchronous Motor Drives** | | |
| 4.1 | Speed control of three phase synchronous motors | 1 | CO1 |
| 4.2 | Voltage and current source inverter fed synchronous motors | 1 | CO6 |
| 4.3 | Vector control of Synchronous motor | 1 | CO6 |
| 4.4 | Sensorless control - Trapezoidal SPM machine – Sinusoidal PM Machine | 1 | CO1 |
| **5.** | **BLDC and Stepper Motor Drives** | | |
| 5.1 | BLDC motor drives and its applications | 2 | CO5 |
| 5.2 | Speed control of BLDC motor | 2 | CO5 |

| | | | |
|---|---|---|---|
| 5.3 | Operation and control of stepper motor | 1 | CO5 |
| 5.4 | Applications of stepper motor | 1 | CO5 |
| 6 | **Simulation of Electrical Drive Systems** | | |
| 6.1 | DC motor drive system | 1 | CO6 |
| 6.2 | Induction motor drive system | 1 | CO6 |
| | Total | 36 | |

## Course designers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3. Dr. S.Arockia Edwin xavier saexeee@tce.edu

| 18EEPV0 | FACTS AND CUSTOM POWER DEVICES |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

## Preamble

FACTS are power electronics based system that provides control of AC transmission system parameters to enhance controllability and increase power transfer capability. Rising energy costs and a greater sensitivity to environmental impact of new transmission lines necessitated the application of FACTS controllers to minimize losses and maximize the stable power-transmission capacity of existing lines.

Power distribution networks have always been exposed to traditional factors such as voltage sag, voltage swell, harmonics and capacitor switching which destruct sinusoidal waveforms and decrease power quality as well as network reliability. A reliable power of acceptable quality can be achieved by applying power electronic devices, called Custom Power devices, in power distribution networks. The present study tries to introduce and compare different types of FACTS & custom power devices and explain their applications.

## Prerequisite

18EE530 : Power Electronics
18EE510 : Generation, Transmission and Distribution

## Course Outcomes

On the successful completion of the course, students will be able to:

| Course Outcome No. | Course Outcomes | Weightage*** in % |
|---|---|---|
| CO1 | Explain the necessity of FACTS and custom power devices | 10 |
| CO2 | Describe the performance and applications of various shunt and series type FACTS controllers | 20 |
| CO3 | Explain the performance and applications of hybrid FACTS devices | 20 |
| CO4 | Explain the functioning of custom power devices | 20 |
| CO5 | Determine the performance characteristics of the given power network with FACTS controllers | 15 |
| CO6 | Determine the stability of the given power network with custom power devices | 15 |

*** Weightage depends on Bloom's Level, number of contact hours

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychom | |

| | | | | otor | |
|---|---|---|---|---|---|
| CO1 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 4.1.1, 4.1.2 |
| CO2 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 2.3.1, 4.1.1, 4.1.2 |
| CO3 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 2.3.1, 2.3.2, 4.1.2, 4.3.1, 4.3.2 |
| CO4 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 2.3.1, 2.3.2, 4.1.2, 4.3.1, 4.3.2 |
| CO5 | TPS3 | Apply | Value | - | 1.3, 2.1.2, 2.3.2, 2.3.3, 4.1.2, 4.3.3, 4.3.4 |
| CO6 | TPS3 | Apply | Value | - | 1.3, 2.1.5, 2.3.2, 2.3.3, 4.1.1, 4.1.2, 4.3.3, 4.3.4 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | M |
| CO2 | M | L | | | | | | M | | M | | | M | M |
| CO3 | M | L | | | | | | M | | M | | | M | M |
| CO4 | M | L | | | | | | M | | M | | | M | M |
| CO5 | S | M | L | | | | | M | | M | | | S | S |
| CO6 | S | M | L | | | | | M | | M | | | S | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 10 | 10 | - | - | - | 10 |
| Understand | 80 | 60 | 60 | - | - | - | 60 |
| Apply | - | 30 | 30 | 100 | 100 | 100 | 30 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **Miniproject /Assignment/Practical Component** |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |

| | |
|---|---|
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1 Explain the concept of transmission network.
2 What is passive reactive compensation?
3 What is the need for FACTS controllers?

**Course Outcome 2 (CO2):**

1 Compare TSSC and TCSC.
2 Discuss the application of STATCOM in Power System Damping.
3 How TCSC is used to mitigate SSR?

**Course Outcome 3 (CO3) :**

1 Explain the working of UPFC.
2 Draw the UPFC model used for power flow studies.
3 Draw the phasor diagram of UPFC.

**Course Outcome 4 (CO4) :**

1 Describe the operation of UPQC and DVR. Also discuss how UPQC and DVR are used to mitigate power quality problems.
2 Compute the expression for power transfers and reactive power requirement with diagram to increase the power transfer capability of transmission line using shunt compensator.
3 Design a filter to attenuate the 5th, 7th, and 11th harmonics. Also design such that each filter section is tuned 4 percent below the filtered harmonic.

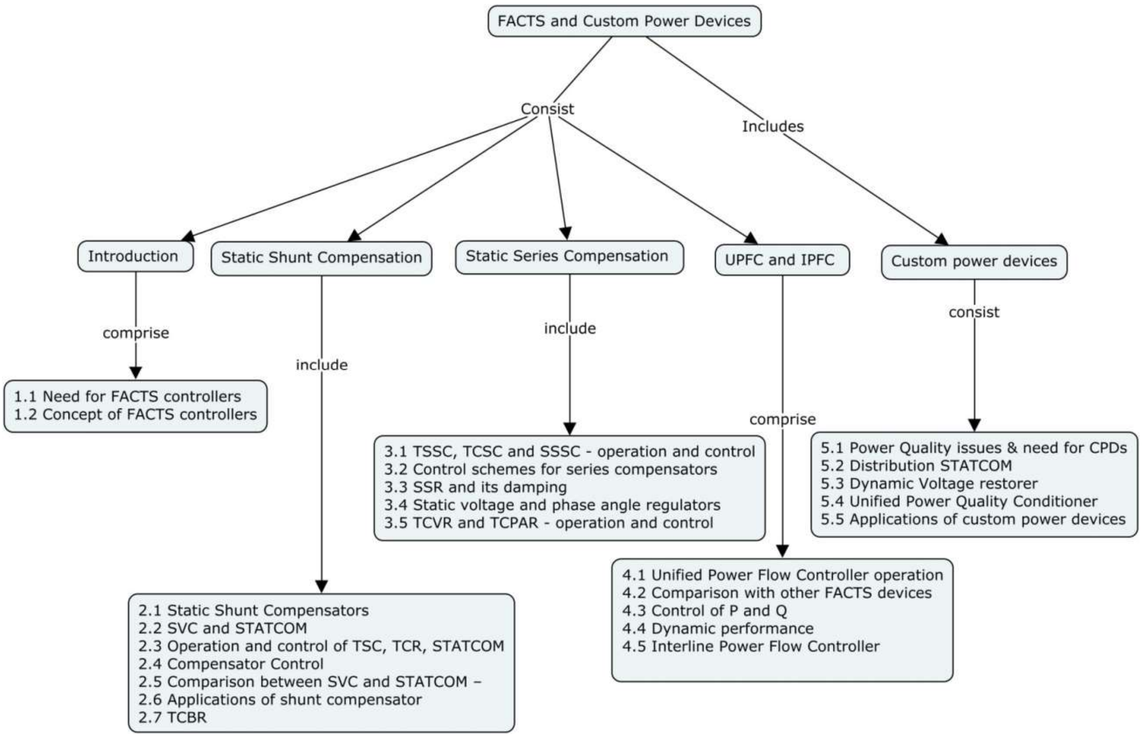
**Course Outcome 5 (CO5) :**

1. Design and illustrate the reactive power handling capability of a STATCOM using SPICE software.
2. Simulate a suitable controlling device for power factor compensation using Matlab software.
3. Simulate and demonstrate various compensation aspects of a UPFC

**Course Outcome 6 (CO6) :**

1. Design simulation model of a DSTATCOM for harmonic reduction using Matlab software.
2. Design and illustrate the voltage sag handling capability of DVR using SPICE software.
3. Simulate a UPQC model and demonstrate various control aspects.

## Concept Map




## Syllabus

**Introduction -** Need for FACTS controllers- Concept of FACTS controllers

**Static Shunt Compensation -** Static Shunt Compensators - SVC and STATCOM - operation and control of TSC, TCR, STATCOM - Compensator Control - Comparison between SVC and STATCOM – Applications of shunt compensators and TCBR.

**Static Series Compensation** - TSSC, TCSC and SSSC - operation and control - Control schemes for series compensators - SSR and its damping - static voltage and phase angle regulators - TCVR and TCPAR - operation and control

**UPFC and IPFC -** The Unified Power Flow Controller - operation, comparison with other FACTS devices - control of P and Q - dynamic performance - Interline Power Flow Controller

**Custom power devices:** Power Quality issues & custom power devices – Distribution STATCOM – Dynamic Voltage restorer – Unified Power Quality Conditioner – Applications of custom power devices.

## Learning Resources

1. K. R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age InternationalPublishers, 2 nd Edition, 2016.
2. R. Mohan Mathur, Rajiv K. Varma. Thyristor-Based FACTS Controllers for Electrical Transmission Systems, Wiley & IEEE Press, 2002.
3. N.G. Hingorani & L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, Wiley & IEEE Press, 1999.
4. T.J.E Miller, Reactive Power Control in Electric Systems, New Age International, New Delhi, 1994.

5. Dr Ashok S & K S Suresh Kumar "FACTS Controllers and applications" course book for STTP, 2003.
6. G.T.Heydt: Electric Power Quality, 2nd edition, Stars in a Circle Publications, 1994.
7. Sankaran C, "Power Quality", CRC press special Indian edition 2009.
8. Arindam Ghosh and Gerald Ledwich: Power Quality Enhancement using Custom Power Devices, Kluwer Academic Publishers, 2002.

**Course Contents and Lecture Schedule**

| Sl No. | Topic | No. of lectures | CO |
|---|---|---|---|
| 1 | **Introduction** | | |
| 1.1 | Need for FACTS controllers | 1 | CO1 |
| 1.2 | Concept of FACTS controllers | 1 | CO1 |
| 2 | **Static Shunt Compensation** | | |
| 2.1 | Static Shunt Compensators | 1 | CO1 |
| 2.2 | SVC and STATCOM | 2 | CO1 |
| 2.3 | Operation and control of TSC, TCR, STATCOM | 2 | CO2 |
| 2.4 | Compensator Control | 1 | CO2 |
| 2.5 | Comparison between SVC and STATCOM – | 1 | CO2 |
| 2.6 | Applications of shunt compensator | 1 | CO3 |
| 2.7 | TCBR | 1 | CO3 |
| 3 | **Static Series Compensation** | | |
| 3.1 | TSSC, TCSC and SSSC - operation and control | 2 | CO2 |
| 3.2 | Control schemes for series compensators | 2 | CO2 |
| 3.3 | SSR and its damping | 2 | CO3 |
| 3.4 | Static voltage and phase angle regulators | 1 | CO3 |
| 3.5 | TCVR and TCPAR - operation and control | 2 | CO3 |
| 4 | **UPFC and IPFC** | | |
| 4.1 | Unified Power Flow Controller operation | 2 | CO4 |
| 4.2 | Comparison with other FACTS devices | 1 | CO4 |
| 4.3 | Control of P and Q | 2 | CO4 |
| 4.4 | Dynamic performance | 1 | CO5 |
| 4.5 | Interline Power Flow Controller | 2 | CO5 |
| 5 | **Custom power devices** | | |
| 5.1 | Power Quality issues & need for CPDs | 2 | CO6 |
| 5.2 | Distribution STATCOM | 1 | CO6 |
| 5.3 | Dynamic Voltage restorer | 1 | CO6 |
| 5.4 | Unified Power Quality Conditioner | 1 | CO6 |
| 5.5 | Applications of custom power devices | 3 | CO6 |
| | **Total** | **36** | |

**Course Designers**

Dr.V.Suresh Kumar vskeee@tce.edu

Dr.G.Sivasankar qsiva@tce.edu

| 18EEPW0 | HVDC TRANSMISSION |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

**Preamble**

High voltage direct current transmission has advantages over ac transmission in special situations. With the advent of thyristor valve converters, HVDC transmission became even more attractive. This course deals with the operation, modelling and control of HVDC link in power system. Also, trends for HVDC applications and practical examples are discussed in this course.

**Prerequisite**

18EE530 : Power Electronics
18EE510 : Generation, Transmission and Distribution

Course Outcomes

On the successful completion of the course, students will be able to

| Course Outcome NO. | Course Outcomes | Weightage*** in % |
|---|---|---|
| CO1 | Explain the significance and necessity of HVDC system | 10 |
| CO2 | Discuss the power converters and harmonic filters used in HVDC system | 20 |
| CO3 | Explain the control strategies and stability techniques used for HVDC system | 20 |
| CO4 | Design a suitable controller for HVDC converter for the given specifications | 15 |
| CO5 | Design a suitable protection scheme by identifying the fault in the system | 15 |
| CO6 | Explain the application of HVDC system with practical examples | 20 |

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, |
| CO2 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 2.3.1, |
| CO3 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 2.3.1, 2.3.2, |
| CO4 | TPS3 | Apply | Value | - | 1.3, 2.1.2, 2.3.2, 2.3.3, |
| CO5 | TPS3 | Apply | Value | - | 1.3, 2.1.5, 2.3.2, 2.3.3, |
| CO6 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 2.3.1, 2.3.2, |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Co | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO1 | PO1 | PO1 | PSO | PSO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| s | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 | 1 | 2 | 1 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | M | L | | | | | | M | | M | | | M | M |
| CO 2 | M | L | | | | | | M | | M | | | M | M |
| CO 3 | M | L | | | | | | M | | M | | | M | M |
| CO 4 | S | M | L | | | | | M | | M | | | S | S |
| CO 5 | S | M | L | | | | | M | | M | | | S | S |
| CO 6 | M | L | | | | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 10 | 10 | - | - | - | 10 |
| Understand | 80 | 60 | 60 | - | - | - | 60 |
| Apply | - | 30 | 30 | 100 | 100 | 100 | 30 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Differentiate AC and DC transmission systems.
2. Explain modern trends in DC transmission system.
3. Explain the specifications and concepts used DC transmission system.
4. List the advantages of DC transmission

**Course Outcome 2 (CO2):**

1. In what way should the firing angle and extinction be controlled to minimize reactive power consumption?
2. Explain the types of power converters.

3. Explain the characteristics of a twelve pulse converter used in HVDC.
4. Explain about current and extinction angle control.

**Course Outcome 3 (CO3):**

1. Explain the advantages of per unit quantities in DC system.
2. Compare the solution of DC power flow over AC power flow in DC system.
3. Perform power flow analysis using substitution of power injection method.

**Course Outcome 4 (CO4):**

1. Model and control DC LINK in a power system.
2. Prove that for same power transmitted and same percentage loss, the insulation level in DC transmission is only87% of that AC transmission.
3. An existing 400 kV 3-phase AC line transmitting a power 100 MW is converted in to bipolar DC line. Evaluate the voltage/pole and DC line losses, if the resistance of each conductor is 0.01 ohm. Assume pf=0.90.
4. Compare the dynamic interactions between DC and AC systems.
5. Design controller parameters to obtain desired output
6. Construct an energy efficient controller for the HVDC system.

**Course Outcome 5 (CO5):**

1. Illustrate the intensity of the fault
2. Select appropriate fault clearance techniques.
3. Design suitable protection circuits
4. A 400 kV 3-phase AC line of 800 km length transmitting 1000MW is converted in to DC line. If the surge impedance pf the line is 320 ohm, calculate the number of conductors required and surge impedance loading of 3-phase AC system.

5. A 400 kV 3-phase AC line of 800 km length transmitting 1000MW is converted in to a DC line. If the surge impedance pf the line is 320 ohm, calculate voltage per pole as DC line power losses, as percentage of AC power losses. Consider pf =0.90.

**Course Outcome 6 (CO6):**

1. Identify the type of system given in Figure 6.1 and discuss the merits compare to other types.

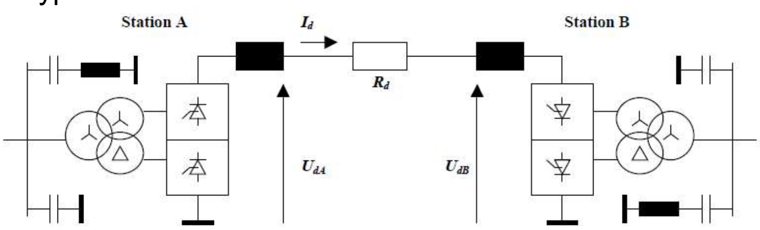
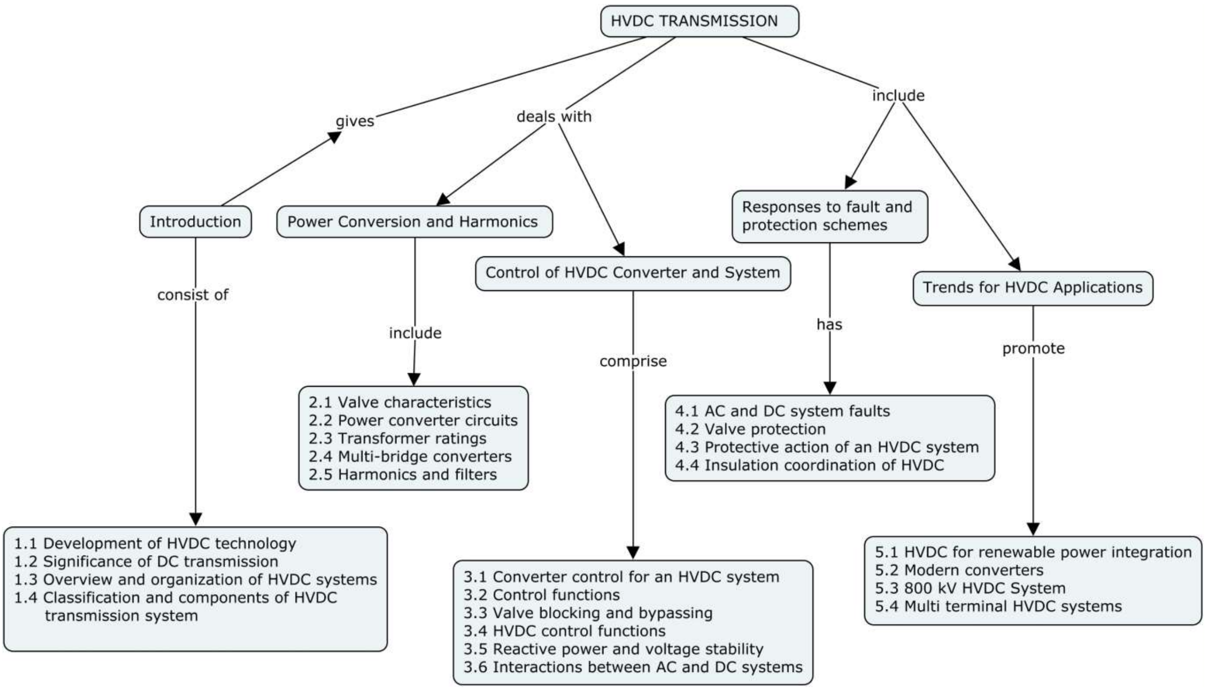



Figure 6.1

2. Illustrate the significance of DC system with a suitable example
3. Explain the importance of DC transmission in wind power generation system

**Concept Map**




## Syllabus

**Introduction to HVDC Technology**

Development of HVDC technology, Significance of DC transmission, Overview and organization of HVDC systems, Classification and components of HVDC transmission system.

**Power Conversion and Harmonics**

Valve characteristics, Power converter circuits, transformer ratings, multi-bridge converters, harmonics and filters.

**Control of HVDC Converter and System**

Converter control for an HVDC system, control functions, valve blocking and bypassing,Reactive power and voltage stability, control of AC/DC interaction.

**Responses to fault and protection schemes**

AC and DC system faults, Valve protection, Protective action of an HVDC system, Insulation coordination of HVDC.

**Trends for HVDC Applications**

HVDC for renewable power integration, Modern converters, 800 kV HVDC System, Multi terminal HVDC systems

## Learning Resources

1. Chan-Ki Kim, "HVDC TRANSMISSION Power Conversion Applications in Power Systems", John Wiley & Sons Pvt. Ltd., 2009

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993
2. K.R.Padiyar, "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002.
3. J.Arrillaga, "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983.
4. Erich Uhlmann, "Power Transmission by Direct Current", BS Publications, 2004.
5. V.K.Sood, "HVDC and FACTS controllers – Applications of Static Converters in Power System", APRIL 2004, Kluwer Academic Publishers.

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Lectures | CO |
|---|---|---|---|
| **1** | **Introduction** | | |
| 1.1 | Development of HVDC technology | 1 | CO1 |
| 1.2 | Significance of DC transmission | 1 | CO1 |
| 1.3 | Overview and organization of HVDC systems | 1 | CO1 |
| 1.4 | Classification and components of HVDC transmission system | 2 | CO1 |
| **2.** | **Power Conversion and Harmonics** | | |
| 2.1 | Valve characteristics | 2 | CO2 |
| 2.2 | Power converter circuits | 2 | CO2 |
| 2.3 | Transformer ratings | 1 | CO2 |
| 2.4 | Multi-bridge converters | 2 | CO2 |
| 2.5 | Harmonics and filters | 2 | CO2 |
| **3** | **Control of HVDC Converter and System** | | |
| 3.1 | Converter control for an HVDC system | 2 | CO3 |
| 3.2 | Control functions | 1 | CO3 |
| 3.3 | Valve blocking and bypassing | 2 | CO3 |
| 3.4 | HVDC control functions | 2 | CO3 |
| 3.5 | Reactive power and voltage stability | 2 | CO4 |
| 3.6 | Interactions between AC and DC systems | 1 | CO4 |
| 4 | **Responses to fault and protection schemes** | | |
| 4.1 | AC and DC system faults | 2 | CO5 |
| 4.2 | Valve protection | 2 | CO5 |
| 4.3 | Protective action of an HVDC system | 2 | CO5 |
| 4.4 | Insulation coordination of HVDC | 1 | CO5 |
| 5 | **Trends for HVDC Applications** | | |
| 5.1 | HVDC for renewable power integration | 1 | CO6 |
| 5.2 | Modern converters | 2 | CO6 |
| 5.3 | 800 kV HVDC System | 1 | CO6 |
| 5.4 | Multi terminal HVDC systems | 1 | CO6 |
| | Total | 36 | |

**Course Designers:**

1. Dr. V. Suresh Kumar vskeee@tce.edu
2. Dr. G. Sivasankar qsiva@tce.edu

| 18EEPC0 | DESIGN OF ELECTRICAL INSTALLATIONS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

## Preamble

Design of Electrical Installations course will illustrate the correct procedure for basic design of installations from initial assessment to final commissioning. The Electrical Installation must be primarily concerned with the safety of persons, property and livestock. The selection of appropriate systems and associated equipment and accessories is an integral part of the design procedure, and as such cannot be addressed in isolation. For example, the choice of a particular type of protective device may have a considerable effect on the calculation of cable size or shock risk, or the integrity of conductor insulation under fault conditions.

## Prerequisite

18EE320 DC Machines and Transformers
18EE420 AC Machines

## Course Outcomes

On the successful completion of the course, students will be able to:

| COs No. | Course outcomes | Weightage in % |
|---|---|---|
| CO1 | Describe the General rules of Electrical Installations design as per the Indian Electricity Rules | 15 |
| CO2 | Design of Electrical Installations based on equipment ratings | 15 |
| CO3 | Discuss the Selection of a right type of Sub-station for an Electrical System | 15 |
| CO4 | Calculate the Size of LV Distribution System Components for a specified Electrical System | 15 |
| CO5 | Draw the Electrical Plan and Selection of System components for the given specification of Residential Electrical Installations. | 20 |
| CO6 | Choose the right type and Ratings of electrical safety and protective devices against electrical hazards | 20 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Understand | Respond | | 1.3, 2.3.1 |
| CO2 | TPS2 | Apply | Value | | 1.3, 2.1.1, 2.3.1, 2.4.3, 2.4.4 |
| CO3 | TPS2 | Understand | Respond | | 1.3, 2.3.1 |
| CO4 | TPS2 | Apply | Value | | 1.3, 2.1.1, 2.1.5 |
| CO5 | TPS2 | Apply | Value | | 1.3, 2.1.1, 2.3.1, 2.4.3, 2.4.4 |
| CO6 | TPS2 | Understand | Respond | | 1.3, 2.3.1, 2.4.3, 2.4.6 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | S | M | L | | | | | M | | M | | | | S |
| CO3 | M | L | | | | | | M | | M | | | | M |
| CO4 | S | M | L | | | | | M | | M | | | | S |
| CO5 | S | M | L | | | | | M | | M | | | | S |
| CO6 | M | L | | | | | | M | | M | | | | M |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment* | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 40 | 40 | 40 | - | - | - | 40 |
| Apply | 40 | 40 | 40 | 100 | 100 | 100 | 40 |
| Analyse | 0 | 0 | 0 | - | - | - | 0 |
| Evaluate | 0 | 0 | 0 | - | - | - | 0 |
| Create | 0 | 0 | 0 | - | - | - | 0 |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. Specify the role of Cut-out on Consumer's premises
2. Explain the identification of earthed and earthed neutral conductors & position of switches and cut-outs.
3. Explain the need of periodical and testing of consumer's installation.
4. Explain in detail the points to be inspected while carry out an annual inspection in a commercial complex.
5. Discuss about the guidelines for electrical contractors for wiring and earthing.

**Course Outcome 2 (CO2):**

1. State the nature of starting current drawn by an induction motor.
2. Define contracted demand and maximum demand.

3. Select a Suitable Size of Transformer in KVA for an Industry has the following connected load. The recommended load factor of the transformer will be 60%. The diversity factor of the load is 1.2.

| 1. Type of Load | 2. Rating |
|---|---|
| 3. Induction Motors | 4. 450HP |
| 5. Lighting System | 6. 25kW |
| 7. Electric Oven | 8. 100kW |

**Course Outcome 3 (CO3)**.

1. List the various types of Sub-station
2. Discuss the factors to be considered, while selecting a sub-station for an Industrial power Distribution.
3. Explain the procedure for the establishment of a new sub-station.
4. Discuss the choice of selecting of Power Generation Source for an Industrial Unit.

**Course Outcome 4 (CO4)**

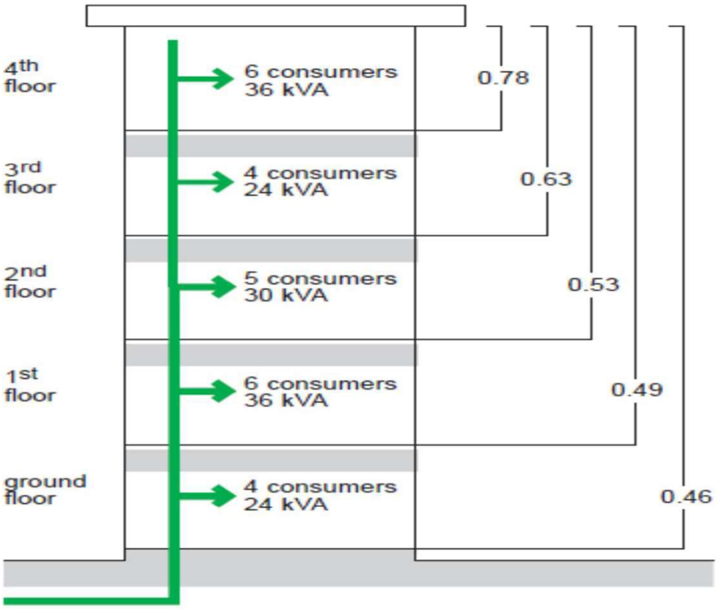
1. List the basic components of a Power Distribution System.
2. Calculate the MCB Ratings of the Main Distribution Board supplying power to a workshop have the following connected loads.

| Equipment Name | Apparent Power in kVA | Utilization Factor | Diversity Factor |
|---|---|---|---|
| Lathe No.1 | 5 | 0.8 | 0.75 |
| Lathe No.2 | 5 | 0.8 | 0.75 |
| Lathe No.3 | 5 | 0.8 | 0.75 |
| Lathe No.4 | 5 | 0.8 | 0.75 |
| Pedestal Drill No.1 | 2 | 0.8 | 0.60 |
| Pedestal Drill No.2 | 2 | 0.8 | 0.60 |
| 5Nos. of Socket Outlets 16Amps | 18 | 1 | 0.20 |
| 30Nos. Fluorescent Lamp | 3 | 1 | 1.00 |

**Course Outcome 5 (CO5)**

1. List the basic components of Domestic Wiring Systems.
2. State the advantages of Concealed Wiring.
3. Design a single phase power distribution system for your house and draw the single line diagram of the same.

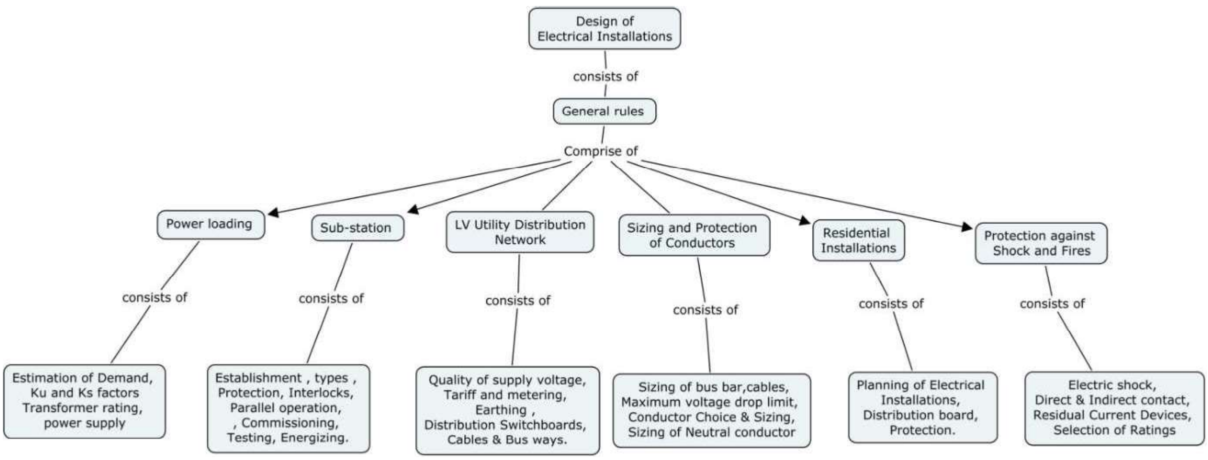
**4.** 5 storey's apartment building with 25 consumers, each having 6 kVA of installed load. The total installed load for the building is: 36 + 24 + 30 + 36 + 24 = 150 kVA. The apparent-power supply required for the building is: 150 x 0.46 = 69 kVA. From the given Figure. Determine the magnitude of currents in different sections of the common main feeder supplying all floors. For vertical rising mains fed at ground level, the cross-sectional area of the conductors can evidently be progressively reduced from the lower floors towards the upper floors.




**Course Outcome 6 (CO6)**

1. Discuss the protective devices in electrical installations.
2. State the purpose of Interlocks and mention the condition of operation.
3. Explain the provision of Interlocks to avoid the contacts between Electricity Board Supply with the Captive Power Supply with a diagram.

## .Concept Map



## Syllabus

**GENERAL RULES OF ELECTRICAL INSTALLATION DESIGN**: Methodology & Characteristics of Installed power loads - Rules and statutory regulations- Voltage Ranges, Standards, Quality & Safety of an electrical installation, Initial Testing of Installation, Periodic Check& Testing of Installation-– Induction motors, Induction Furnace, Resistive type heating applications, Lamps.

**POWER LOADING OF AN INSTALLATION**: Installed Power & Apparent Power, Estimation of Actual Maximum KVA Demand, Shunt Compensation, Automatic Power Factor Correction, Application of factors Ku and Ks, Choice of Transformer rating, Choice of power supply sources.

**SUB-STATION**: Establishment of a new sub-station, Different types of sub-station, Protection of Transformer, Interlocks & conditioned operations, information & requirement provided by utility, Parallel operation of transformers, Generators in stand-alone operation, Generators in parallel operation mode, Commissioning, Testing, Energizing.

**LV UTILITY DISTRIBUTION NETWORK**: Low voltage consumers, Low voltage networks, Consumer service connection, Quality of supply voltage, Tariff and metering, Earthing connections, Standardized earthing schemes, Installation and measurements of earth electrodes, Distribution Switchboards, Cables & Busbar.

**SIZING AND PROTECTION OF CONDUCTORS**: Recommended simplified approach for cables, Sizing of bus bar trunking systems, Maximum voltage drop limit, Calculation of voltage drop in steady load conditions, Short circuit current, Calculation of minimum levels of short circuit current, Conductor Choice & Sizing, Sizing of Neutral conductor, Protection & Isolation of Neutral conductor, Examples of cable calculation.

**RESIDENTIAL INSTALLATIONS**: Planning of Electrical Installations, Distribution board components selection, Protection of People, Circuits, Protection against over voltages & Lightning, Equi-potential Bonding.

**PROTECTION AGAINST ELECTRIC SHOCK AND ELECTRIC FIRES:** Electric shock, Direct & Indirect contact, Measures of protection against direct contact, Measures of protection against indirect contact, Residual Current Devices, Arc Fault Detection Devices, Selection of Ratings.

## Learning Resources


1. Schneider Electric “Electrical Installation Guide”, Schneider Electric Industries - SAS, 2016 Year Edition, 2016.
2. Bureau of Indian Standards, “National Electrical Code 2011”, Government of India, 1st Revision 2011.
3. Siemens “Planning of Electrical Power Distribution – Technical Principles”, Published by Siemens AG, Germany,2014
4. A.J.Watkins, C.Kitcher, “ Electrical Installation Calculations - Basics”, Elsevier Publications, 8th edition, 2009.
5. Brian Scadden,“ IEE Wiring Regulation : Design and Verification of Electrical Installations” Elsevier Publications, 6th edition,

6. Paul Cook, "Electrical Installation Design Guide", The Institution of Engineering & Technology, UK, 2nd Edition, 2013.

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| 1 | **General rules of electrical installation design** | | |
| 1.1 | Methodology & Characteristics of Installed power loads, Rules and statutory regulations | 3 | CO1 |
| 1.2 | Voltage Ranges, Standards, Quality & Safety of an electrical installation, Initial Testing of Installation, Periodic Check& Testing of Installation | 2 | CO1 |
| 1.3 | Induction motors, Induction Furnace, Resistive type heating applications, Lamps | 2 | CO1 |
| 2. | **Power loading of an installation** | | |
| 2.1 | Installed Power & Apparent Power, Estimation of Actual Maximum KVA Demand, Shunt Compensation, Automatic Power Factor Correction Application of factors Ku and Ks | 3 | CO2 |
| 2.2 | Choice of Transformer rating, Choice of power supply sources. | 2 | CO2 |
| 3 | **Sub-station** | | |
| 3.1 | Establishment of a new sub-station, Different types of sub-station | 2 | CO3 |
| 3.2 | Protection of Transformer, Interlocks & conditioned operations, information & requirement provided by utility, Parallel operation of transformers | 2 | CO3 |
| 3.3 | Generators in stand-alone operation, Generators in parallel operation mode, Commissioning, Testing, Energizing. | 2 | CO3 |
| 4 | **LV Utility Distribution Network** | | |
| 4.1 | Low voltage consumers, Low voltage networks, Consumer service connection, Quality of supply voltage, Tariff and metering, | 2 | CO4 |
| 4.2 | Earthing connections, Standardized earthing schemes, Installation and measurements of earth electrodes, | 2 | CO4 |
| 4.3 | Distribution Switchboards, Cables & Busbar. | 1 | CO4 |
| 5. | **Sizing and Protection of Conductors** | | |
| 5.1 | Recommended simplified approach for cables, Sizing of bus bar trunking systems, Maximum voltage drop limit, Calculation of voltage drop in steady load conditions | 3 | CO5 |
| 5.2 | Short circuit current, Calculation of minimum levels of short circuit current | 2 | CO5 |

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| 5.3 | Conductor Choice & Sizing, Sizing of Neutral conductor, Protection & Isolation of Neutral conductor, Examples of cable calculation. | 2 | CO5 |
| 6. | **Residential Installations** | | |
| 6.1 | Planning of Electrical Installations, Distribution board components, Protection of People, Circuits | 3 | CO6 |
| 6.2 | Protection against over voltages & Lightning, Equipotential Bonding. | 1 | CO6 |
| 7. | **Protection against Electric Shock and Electric Fires** | | |
| 7.1 | Electric shock, Direct & Indirect contact, Measures of protection against direct contact, Measures of protection against indirect contact, | 3 | CO6 |
| 7.2 | Residual Current Devices, Arc Fault Detection Devices, Selection of Ratings. | 2 | CO6 |
| | **Total** | **39** | |

## Course Designers


1. Dr.V.Saravanan vseee@tce.edu
2. Dr.P.S.Manoharan psmeee@tce.edu

| 18EEPT0 | WIND AND SOLAR TECHNOLOGY | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

Wind energy is the fast renewable source for the electricity generation. The course presents broad overview of wind energy technology. Due to the growing demand for renewable energy resource especially harnessing power from sun it is felt essential to offer a course on solar photovoltaic technology and systems.

## Prerequisite

**Nil**

## Course Outcomes

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1. | Demonstrate the power produced in wind turbine, types of wind turbine and its effect on tower height, maximum rotor efficiency. | 20 |
| CO2. | Explain the different types of wind electric generators such as Asynchronous (induction) generator, and synchronous generator with a neat block diagram | 15 |
| CO3. | Derive the average power, energy produced in the wind turbine, wind forms and wind turbine economics. | 15 |
| CO4. | Draw simple and accurate equivalent circuit of photovoltaic cell with its IV curve and obtain the fill factor and efficiency | 15 |
| CO5. | Demonstrate Photovoltaic cells, module, arrays and also impact of temperature and insulation on IV curves and impact of shading effect on a PV module. | 15 |
| CO6. | Explain simplified grid connected PV system with simple case study in home, Current voltage curves for loads, DC motor IV curves, Battery IV curves, maximum power point trackers, hourly IV curves, grid connected systems. | 20 |

*** Weightage depends on Bloom's Level, number of contact hours

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | - | 1.3, 2.1.3 |
| CO2 | TPS2 | Understand | Respond | - | 1.3, 2.1.2 |
| CO3 | TPS3 | Apply | Value | - | 1.3, 2.1.3 |
| CO4 | TPS3 | Apply | value | - | 1.3, 2.1.4,2.2.3,3.2.5 |
| CO5 | TPS3 | Apply | Value | - | 1.3, 2.1.4,.2.1.5,3.2.5 |
| CO6 | TPS3 | Apply | value | - | 1.3, 2.1.2,4.3.2 |

## Mapping with Programme Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1. | S | M | L | L | | | | M | | M | | | S | |
| CO2. | M | L | | | | | | M | | M | | | M | |
| CO3. | S | M | L | L | | | | M | | M | | | S | |
| CO4. | S | M | L | L | | | | M | | M | | | S | |
| CO5. | S | M | L | L | | | | M | | M | | | S | |
| CO6. | S | M | L | L | | | | M | | M | | | S | |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 20 | 20 | 20 | - | - | - | 20 |
| Apply | 60 | 60 | 60 | 100 | 100 | 100 | 60 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. What are the types of wind turbines and explain with the necessary diagram
2. Derive the expression for the power produced in the wind.
3. Compare the energy at 15$^{o}$C, 1 atm pressure , contained in 1m$^2$ of the following wind regims: a) 100 hours of 6 m/s wind (13.4 mph) b) 50 hours at 3 m/s plus 50 hours at 9 m/s (i.e. an average wind speed of 6 m/s)
4. Derive the expression for maximum rotor efficiency.

**Course Outcome 2 (CO2):**

1. Explain the operation of Squirrel cage induction generator with a suitable diagram
2. Explain the types of wound rotor induction generator and its operation with suitable diagram
3. Explain the types of synchronous generator and its operation with suitable diagram

**Course Outcome 3 (CO3):**

1. Estimate the average power in the wind at a height of 50m when the wind speed at 10 m averages 6 m/s. Assume Rayleigh statistics, a standard friction coefficient $\alpha$ =1/7, and standard air density =1.225 kg/ m3.
2. Suppose that a wind farm has 4 rotor diameter tower spacing along its rows, with 7 diameter spacing between rows (4D x 7D.) Assume 30% wind turbine efficiency and an array efficiency of80%. a) Find the annual energy production per unit of land area in an area with 400 W/m$^2$. Winds at hub height (the edge of 50 m, class 4 winds) b)Suppose that the owner of the wind turbines leases the land from a rancher for $100 per acre per year (about 10 times what a Texas rancher makes on cattle). What does the lease cost per KWh generated?

**Course Outcome 4 (CO4):**

1. Draw the simplest equivalent circuit for a photovoltaic cell and draw the IV curve for a photovoltaic cell.
2. Draw a more accurate equivalent circuit for a PV cell and draw the IV curve for a photovoltaic cell
3. Obtain the maximum power point from the IV curve of a given PV cell.

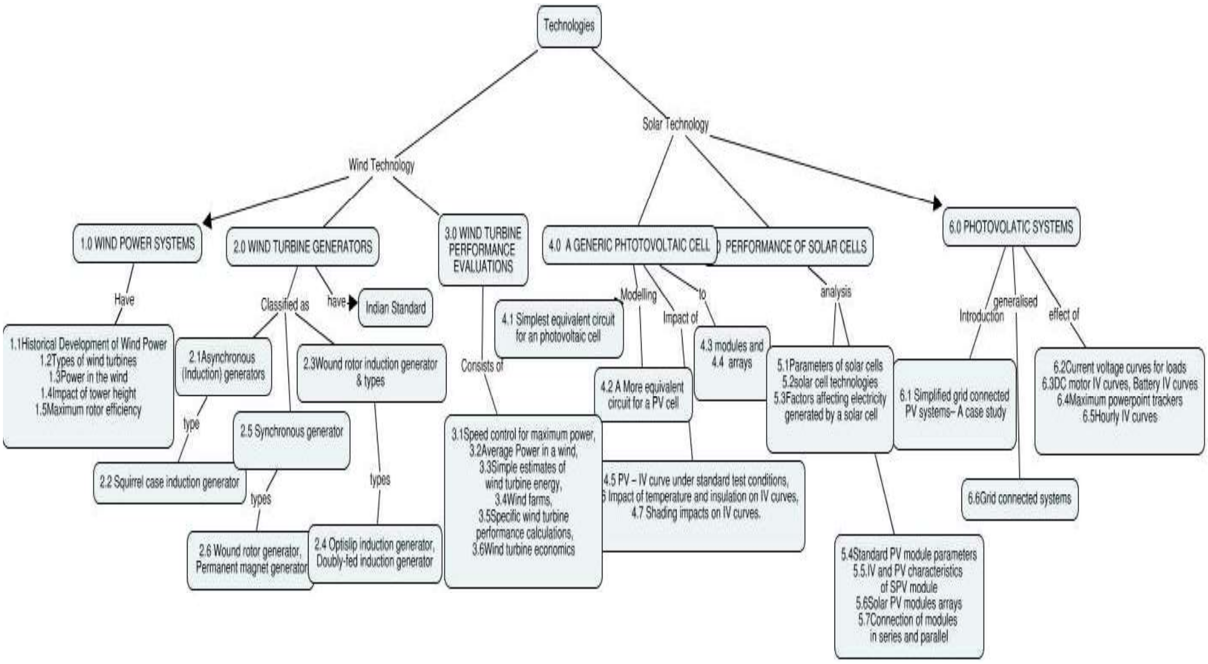
**Course Outcome 5 (CO5):**

1. A PV module is made up of 36 identical cells, all wired in series. With 1 sun– insolation (1 KW/m$^2$), each cell has short circuit current Isc = 3.4 A and at 25$^o$C, its reverse saturation current is $I_o$= 6 x $10^{-10}$ A.A parallel resistance RP = 6.6 Ώ and series resistance Rs = 0.0005Ώ. a. Find the voltage, current and power delivered when the junction voltage of each cell is 0.5 V. b. Set up a spread sheet for I and V and present a few lines of output to show how it works.
2. Explain the operation of PV modules is series and parallel?
3. Explain the impact of temperature and insulation on IV curves?
4. Explain the impact of shading effect on a PV module?

**Course Outcome 6 (CO6):**

1. Explain simplified grid connected PV system with the necessary diagram
2. Design the grid connected PV for a home/ Institution/ company – a case study
3. ExplainIV curves for loads, DC motors and Batteries
4. Design a grid connected PV system for fulfilling the load energy requirement of 12 KWh/day. Assume that grid is available full time and no battery storage is required. Give the details of all components selected for the plant. Take the average ambient temperature of 25*c, and average solar radiation of 5.5 Kwh/m$^2$/day.

## Concept Map




## Syllabus

### Wind Power Systems

Historical Development of Wind Power, Types of wind turbines, Power in the wind, Impact of tower height, Maximum rotor efficiency.

### Wind Turbine Generators

Asynchronous (Induction) generator- Squirrel cage induction generator, wound rotor induction generator- Optislip induction generator- doubly-fed induction generator. Synchronous generator – Wound rotor generator – Permanent magnet generator, Indian standards

### Wind Turbine performance evaluations

Average Power in a wind, Simple estimates of wind turbine energy - Wind farms, Specific wind turbine performance calculations, Wind turbine economics - Capital cost and Annual Cost.

### A Generic Photovoltaic Cell

Simplest equivalent circuit for a photovoltaic cell, A More equivalent circuit for a PV cell, Solar cells to modules, Solar modules to arrays, PV – IV curve under standard test conditions, Impact of temperature and insulation on IV curves, Shading impacts on IV curves

### Performance of solar cells

Parameters of solar cells, solar cell technologies - Factors affecting electricity generated by a solar cell, solar PV module, standard PV module parameters, IV and PV characteristics of SPV module, solar PV modules arrays- connection of modules in series and parallel.

### Photovoltaic Systems

Introduction to Simplified grid connected PV systems, Current voltage curves for loads - DC motor IV curves - Battery IV curves – maximum power point trackers – hourly IV curves, grid connected systems.

## Learning Resources

1. Non Conventional Energy resources – G.S Sawhney – PHI 2012
2. Solar Photovoltaic Technology and Systems – Chetan Singh Solanki – PHI 2018
3. Solar Photovoltaics Third edition - Chetan Singh Solanki – PHI 2017
4. Renewable and Efficient electric power systems – Gilbert M Masters – John Wiley & Sons Inc. 2004
5. Course material on 20th National Training course on wind energy technology organized by NIWE, Chennai.
6. On line courses organized by Udemy, courseera,edx, MOOC, NPTEL and SWAYAM in the area of renewable energy.
7. https://www.hindawi.com/journals/ijp/2014/763106/

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| **1.0 WIND POWER SYSTEMS** | | | |
| 1.1 | Historical Development of Wind Power | 1 | CO1 |
| 1.2 | Types of wind turbines | 1 | CO1 |
| 1.3 | Power in the wind | 1 | CO1 |
| 1.4 | Impact of tower height | 1 | CO1 |
| 1.5 | Maximum rotor efficiency | 1 | CO1 |
| **2.0 WIND TURBINE GENERATORS** | | | |
| 2.1 | Asynchronous (Induction) generators | 1 | CO2 |
| 2.2 | Squirrel cage induction generator | 1 | CO2 |
| 2.3 | Wound rotor induction generator | 1 | CO2 |
| 2.4 | Optislip induction generator, Doubly-fed induction generator | 1 | CO2 |
| 2.5 | Synchronous generator | 1 | CO2 |
| 2.6 | Wound rotor generator, Permanent magnet generator | 1 | CO2 |
| **3.0 WIND TURBINE PERFORMANCE EVALUATIONS** | | | |
| 3.1 | Speed control for maximum power | 1 | CO3 |
| 3.2 | Average Power in a wind | 1 | CO3 |
| 3.3 | Simple estimates of wind turbine energy | 1 | CO3 |
| 3.4 | Wind farms | 1 | CO3 |
| 3.5 | Specific wind turbine performance calculations | 1 | CO3 |
| 3.6 | Wind turbine economics | 1 | CO3 |
| **4.0 A GENERIC PHTOTOVOLTAIC CELL** | | | |
| 4.1 | Simplest equivalent circuit for an photovoltaic cell | 1 | CO4 |
| 4.2 | A More equivalent circuit for a PV cell | 1 | CO4 |

| | | | |
|---|---|---|---|
| 4.3 | Solar cells to modules | 1 | CO4 |
| 4.4 | Solar modules to arrays | 1 | CO4 |
| 4.5 | PV – IV curve under standard test conditions | 1 | CO4 |
| 4.6 | Impact of temperature and insulation on IV curves | 1 | CO4 |
| 4.7 | Shading impacts on IV curves. | 1 | CO4 |
| **5.0 PERFORMANCE OF SOLAR CELLS** | | | |
| 5.1 | Parameters of solar cells | 1 | CO5 |
| 5.2 | solar cell technologies | 1 | CO5 |
| 5.3 | Factors affecting electricity generated by a solar cell | 1 | CO5 |
| 5.4 | Standard PV module parameters | 1 | CO5 |
| 5.5. | IV and PV characteristics of SPV module | 1 | CO5 |
| 5.6 | Solar PV modules arrays | 1 | CO5 |
| 5.7 | Connection of modules in series and parallel | 1 | CO5 |
| **6.0 PHOTOVOLATIC SYSTEMS** | | | |
| 6.1 | Simplified grid connected PV systems – A case study | 1 | CO6 |
| 6.2 | Current voltage curves for loads | 1 | CO6 |
| 6.3 | DC motor IV curves, Battery IV curves | 1 | CO6 |
| 6.4 | Maximum powerpoint trackers | 1 | CO6 |
| 6.5 | Hourly IV curves | 1 | CO6 |
| 6.6 | Grid connected systems | 1 | CO6 |
| | **Total** | **36** | |

**Course Designer:**

1. Dr. P. Venkatesh pveee@tce.edu

| 18EERC0 | PRINCIPLES OF ENERGY CONSERVATION | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

Energy resource scarcity becomes one of the biggest issues in the world and leading to rise in cost. Effective utilization of Electrical energy is one of the key issues to minimize the rising cost of energy and to minimize the global warming. The objective of the course is to provide an introduction to principles of Energy Conservation in Electrical System. This course will educate the power system engineers on the aspect of energy conservation in electrical equipment and Electrical Installations. It will helpful to select an energy efficient electrical system for an establishment.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course, students will be able to

| | Course Outcomes | Weightage % |
|---|---|---|
| CO1 | Describe the principles of Energy Audit, Management and Conservation | 10 |
| CO2 | Estimate the energy performance of Electrical System | 20 |
| CO3 | Estimate the energy performance of Electrical Motors | 20 |
| CO4 | Estimate the energy performance of Lighting System | 20 |
| CO5 | Selection and Operation aspects of DG Set for Energy Efficiency | 10 |
| CO6 | Identify the Energy Efficient gadgets for domestic, commercial and industrial applications | 20 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 2.1.5, 2.2.2 |
| CO2 | TPS3 | Apply | Value | | 1.3, 2.1.4, 2.1.5, 2.3.3 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.4, 2.1.5 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.4, 2.1.5 |
| CO5 | TPS2 | Understand | Respond | | 1.3, 2.1.4, |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.3 |

## Mapping with Programme Outcomesand Programme Specific Outcomes

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | M | L | | | | | | M | | M | | | M | |
| CO 2 | S | M | L | L | | | | M | | M | | | S | |
| CO 3 | S | M | L | L | | | | M | | M | | | S | |
| CO 4 | M | L | | | | | | M | | M | | | M | |
| CO 5 | S | M | L | L | | | | M | | M | | | S | |
| CO 6 | M | L | | | | | | M | | M | | | S | |

S- Strong; M-Medium; L-Low

### Assessment Pattern: Cognitive Domain

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 50 | 40 | 40 | - | - | - | 40 |
| Apply | 30 | 40 | 40 | 100 | 100 | 100 | 40 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

### Assessment Pattern: Psychomotor

| **Psychomotor Skill** | **Miniproject /Assignment/Practical Component** |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

### Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. Mention the types of Energy audit.
2. List down the objective of energy management
3. Explain the implications of part load operation of energy equipment with examples.

**Course Outcome 2 (CO2):**

1. Define contracted demand and billing demand.
2. A textile mill operates with a load of 1800kVA demand at 0.85 power factor lagging. If the power factor is improved from 0.85 to 0.95 lagging by adding additional capacitors, calculate the reduction in demand. The demand charge is Rs.300 per kVA demand per

month. Calculate the demand cost saving per year due to the power factor improvement.

3. In a sub-station 2Nos. of identical 5000kVA 33kV / 11kV Transformers are operated parallel to meet a domestic load. The iron and full load copper loss of the above Transformer is 9.2 kW and 32.5kW respectively. Initially the two transformers are operated in parallel to meet the load. The load pattern of the domestic load is as follows:

| | | | | | |
|---|---|---|---|---|---|
| Load in kW | 6000 | 3500 | 3000 | 8000 | 1500 |
| Power factor | 0.8 Lagging | 0.78 Lagging | 0.75 Lagging | 0.9 Lagging | 0.7 Lagging |
| Time in 24 Hours | 6.00 A.M to 9.00 A.M | 9.00 A.M to 12 Noon | 12 Noon to 6.00 P.M | 6.00 P.M to 10.00 P.M | 10.00 P.M to 6.00 A.M |

Suggest the best operating practice for the sub-station to minimize the transformer loss and also quantify the transformer loss minimized due to the best transformer operating practice.

**Course Outcome 3 (CO3)**.

1. Name three types of motors in industrial practice.
2. An 89% efficient 30HP Size standard efficiency induction motor was replaced with a 93% efficient 30HP size Premium efficiency induction motor to improve energy efficiency. Calculate the Annual energy saving potential and payback period for the above proposal, using the following data given for the above applications.

   | | |
   |---|---|
   | Load factor | - 90% |
   | Operating Hours per year | - 8000 Hours |
   | Cost per kWh of Energy | - Rs.5 |
   | Cost of Premium efficiency induction motor | - Rs.60000/- |
   | Scrap value of old standard efficiency induction motor | - Rs.20000/- |

   Assume the operating efficiency is as that of designed efficiency at 90% load factor condition.

**Course Outcome 4 (CO4)**

1. Describe the methodology of lightning energy audit in an industrial facility.
2. In a factory shop floor lighting 60Nos. of 400Watts High Pressure Mercury Vapour (HPMV) lamps are replaced with 250Watts Metal Halide Lamps to reduce energy consumption. The luminous efficacy of HPMV Lamp and Metal Halide lamp are 60 & 100 Lumens per watt. Calculate the Annual energy saving potential and payback period for the above energy saving proposal, if the lamps are used for 12 Hours daily for 330Days in a year. The cost per fitting of Metal halide lamp is Rs.6000/- and cost per kWh energy is Rs.5/-.
3. In a Textile Mill to minimize the lighting power consumption Conventional 9Watts loss Tube light Ballast was replaced with 2Watts loss Electronic Ballast and 40Watts Tube lights are replaced with 36Watts tube lights in 750Nos. of Single Lamp Tube Light Fittings. The cost of Electronic Ballast and 36Watts Tube lights are Rs. 225 and Rs.45/- per unit. Calculate the Power and Energy Saving Potential, if the mill operates for 8000 Hours in a year. Also calculate the investment required and payback period for the above ENCON Proposal, when the Energy cost is Rs. 4.50 per kWh.

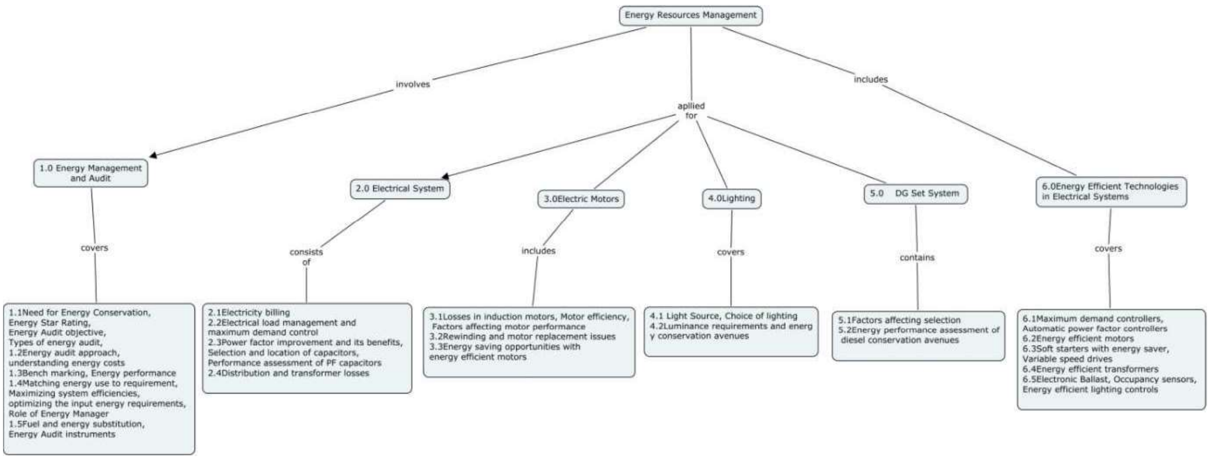
**Course Outcome 5 (CO5)**

1. Specify the role of Turbo chargers.
2. List the energy savings opportunities in an industrial DG Set plant.
3. The Specific Fuel Consumption of a 500KVA Diesel Generating Set is 3.2kWh per litre of Diesel at 40% Load Factor. If the Load Factor is improved from 40% to 70%, the Specific Fuel Consumption is 3.8kWh per litre of Diesel. Calculate the fuel saving per day because of the load factor improvement.

**Course Outcome 6 (CO6)**

1. Specify the advantages of energy efficient motors.
2. What is the function of Automatic Power factor controller?
3. A 500KVA 11KV/415V Transformer was proposed to buy for an Industrial application. The conventional Core Transformer Cost Rs. 2,50,000/-, whereas the Energy Efficient Amorphous core Transformer cost Rs.2,90,000/-. The Iron losses of Conventional and Amorphous core Transformers are 2200 Watts and 800Watts respectively. The copper losses for the both the transformers are same. Calculate the payback period for the excess investment paid for the Energy efficient Amorphous core transformer, when compared to conventional core Transformer. The cost of Electrical Energy is Rs.5 per kWh and the Transformer proposed to operate for 8760 Hours in a year.
4. A Chemical industry planned to install a Maximum Demand Controller and an Automatic Power Factor Controller to minimize the Demand Cost. The existing Contracted Demand is 4500KVA and actual demand is 4375KVA. The electricity board billing is based on 90% of contracted demand or Actual demand reached, whichever is higher. The demand charge is Rs.400 per KVA per month. The existing power factor is 0.92 lagging. After installing the Maximum Demand Controller and Automatic Power factor controller, the Actual Maximum Demand reached is 3900KVA. The investment incurred in the Demand Saving measure is Rs. 9,00,000/-. Calculate the Demand Cost saving per year and Payback period for the above Encon proposal.

## Concept Map




## Syllabus

**Energy Management and Audit –**Need of Energy Conservation, Energy Star Rating/Green Labeling, Energy Audit objective, Types of energy audit, Energy audit approach, understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, optimizing the input energy requirements, Fuel and energy substitution, Simple Payback calculation, Energy Audit instruments, Role of Energy Manager

**Electrical System –** Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefits, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses. (Case Studies)

**Electric Motors –** Types, Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, Energy saving opportunities with energy efficient motors. (Case Studies)

**Lighting –** Light Source, Choice of lighting, Luminance requirements and energy conservation avenues. (Case Studies)

**DG Set System –** Factors affecting selection, Energy performance assessment of diesel conservation avenues. (Case Studies)

**Energy Efficient Technologies in Electrical Systems –** Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic Ballast, Occupancy sensors, Energy efficient lighting controls. Checklist & Tips for Energy Efficiency in Electrical System.

## Learning resources

1. Book I - General aspect of energy management and energy audit, Second Edition 2005, By Bureau of Energy Efficiency, Ministry of Power, India.
2. Book III - Energy efficiency in electrical utilities, Second Edition 2005, By Bureau of Energy Efficiency, Ministry of Power, India.

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| **1.0** | **Energy Management and Audit** | | |
| 1.1 | Need for Energy Conservation, Energy Star Rating, Energy Audit objective, Types of energy audit, | 2 | CO1 |
| 1.2 | Energy audit approach, understanding energy costs | 2 | CO1 |
| 1.3 | Bench marking, Energy performance | 1 | CO1 |
| 1.4 | Matching energy use to requirement, Maximizing system efficiencies, optimizing the input energy requirements, Role of Energy Manager | 2 | CO1 |
| 1.5 | Fuel and energy substitution, Simple Payback calculation Energy Audit instruments | 2 | CO1 |
| **2.0** | **Electrical System** | | |
| 2.1 | Electricity billing | 2 | CO2 |
| 2.2 | Electrical load management and maximum demand control | 1 | CO2 |
| 2.3 | Power factor improvement and its benefits, Selection and location of capacitors, Performance assessment of PF capacitors | 2 | CO2 |
| 2.4 | Distribution and transformer losses | 2 | CO2 |
| **3.0** | **Electric Motors** | | |

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| 3.1 | Losses in induction motors, efficiency, Factors affecting motor performance | 2 | CO3 |
| 3.2 | Rewinding and motor replacement issues | 2 | CO3 |
| 3.3 | Energy saving opportunities with energy efficient motors | 1 | CO3 |
| **4.0** | **Lighting** | | |
| 4.1 | Light Source, Choice of lighting | 1 | CO4 |
| 4.2 | Luminance requirements and energy conservation avenues | 2 | CO4 |
| 5.0 | **DG Set System** | | |
| 5.1 | Factors affecting selection | 1 | CO5 |
| 5.2 | Energy performance assessment of diesel conservation avenues | 1 | CO5 |
| 6.0 | **Energy Efficient Technologies in Electrical Systems** | | |
| 6.1 | Maximum demand controllers, Automatic power factor controllers | 2 | CO6 |
| 6.2 | Energy efficient motors | 2 | CO6 |
| 6.3 | Soft starters with energy saver, Variable speed drives | 1 | CO6 |
| 6.4 | Energy efficient transformers | 2 | CO6 |
| 6.5 | Electronic Ballast, Occupancy sensors, Energy efficient lighting controls | 1 | CO6 |
| 6.6 | Checklist & Tips for Energy Efficiency in Electrical System. | 1 | CO6 |
| | **Total** | **35** | |

**Course Designers:**

1. Dr.V.Saravanan vseee@tce.edu
2. Dr.D.Nelson Jayakumar dnjayakumar@tce.edu

| 18EERD0 | OPERATION AND MAINTENANCE OF ELECTRICAL EQUIPMENT | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

This course will provide the possible technical and practical information required for ensuring correct operation, maintenance and troubleshooting of electrical equipment and systems such as transformer, motor, generator, substation, switchgear and transmission and distribution system.

## Prerequisite

18EE320 - DC Machines and Transformers,
18EE420 -AC Machines
18EE510 - Generation, Transmission and Distribution

## Course Outcomes

On the successful completion of the course, students will be able to

| | Course Outcomes | Weightage % |
|---|---|---|
| CO1 | Describe the causes of electrical accidents, safety measures, regulations and annual inspection of building installation. | 15 |
| CO2 | Discuss the fundamentals of different types of maintenance, their procedures and records. | 10 |
| CO3 | Identify the suitable earthing method and Calculate the earth resistance for a given electric system. | 15 |
| CO4 | Select the suitable operation and maintenance practices for transformers, motors and starters | 25 |
| CO5 | Identify the suitable operation and maintenance practices for Generation, Transmission and Distribution systems. | 25 |
| CO6 | Select suitable troubleshooting practices for various electrical equipment and systems. | 10 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.3.1,3.2.3 |
| CO2 | TPS2 | Understand | Respond | | 1.3, 2.3.1,3.2.3 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.5,3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.5,3.2.3 |
| CO5 | TPS3 | Apply | Value | | 1.3, 2.1.5,3.2.3 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.5,3.2.3 |

## Mapping with Programme Outcomes

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | |
| CO2 | M | L | | | | | | M | | M | | | M | |
| CO3 | S | M | L | | | | | M | | M | | | S | |
| CO4 | S | M | L | | | | | M | | M | | | S | |
| CO5 | S | M | L | | | | | M | | M | | | S | |
| CO6 | S | M | L | | | | | M | | M | | | S | |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 50 | 40 | 40 | - | - | - | 40 |
| Apply | 30 | 40 | 40 | 100 | 100 | 100 | 40 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

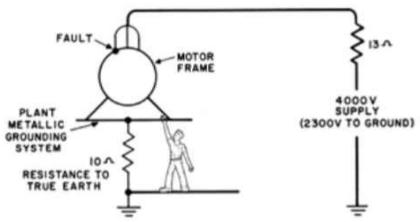
1) Specify the few safety regulations in Indian electricity act.
2) Explain the operation of different types of fire extinguishers.

**Course Outcome 2 (CO2):**

1) List the various data to be recorded in the History card of equipment.
2) Under which condition Production maintenance is preferred and explain its procedure?

**Course Outcome 3 (CO3)**.

1) Is it necessary to run a continuous earth wire on the overhead line posts? Why?
2) Identify the effect on the human shown in the following system (shown in figure) with an exposed wire touches the motor frame (Fault).




3) Identify the solution to avoid the above mentioned accidents (As given in the above figure)

**Course Outcome 4 (CO4)**

1) How heavy a single phase load can be connected to a three phase transformer?
2) Connecting 3000 kVA and 1000 kVA transformers in parallel, each with 5.75% impedance, each with the same turn ratios, connected to a common 4000 kVA load. What is the loading on each transformer?
3) Identify the effects of voltage imbalance in a three phase motor.

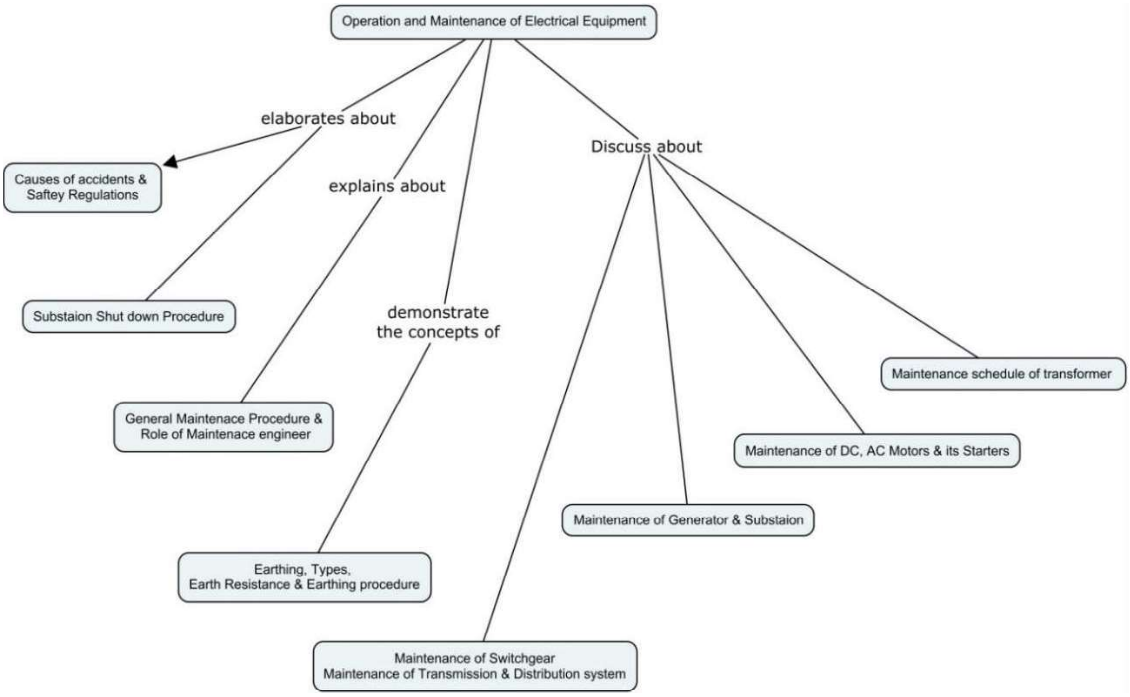
**Course Outcome 5 (CO5)**

1) Summarize the substation shut down procedure.
2) Describe the effect of connecting two dc generators with different characteristics.
3) If the generators are not developing the armature voltage explain the causes.

**Course Outcome 6 (CO6)**

1) If a motor starter's overload mechanism trips frequently what action will you suggest?
2) Prepare an action plan, for the following complaints raised by a consumer.
   (i) Abnormal Power Consumption,
   (ii) Lamps burning out frequently & (iii) dim Light

## Concept Map




## Syllabus

**Electrical Accidents and Safety:** Causes of electrical accidents – Factors affecting severity of electrical shock - Actions to be taken when a person gets attached to live part - Safety regulations and safety measures- Indian electricity supply act 1948-1956; Factory Act -1948; Fire extinguishers- Building Electrical Installations – Annual Inspection, Safe working of Electrical Equipments- Electrical inspectorate's rules for operation and maintenance

**Maintenance:** Types and Importance of Plant maintenance, Preventive, Breakdown and Production - Preventive maintenance: need, classification, advantages, activities, Frequency of maintenance- Breakdown maintenance: concept, advantages - Maintenance Records, Role of Maintenance Engineer.

**Earthing:** Necessity of earthing - System earthing: advantage of neutral earthing of generator in power station; Equipment earthing: Objective - Types of earth electrodes - Methods of earthing : plate earthing, pipe earthing and coil earthing - Earthing in extra high voltage and underground cable, Earthing resistance- factors affecting, Determination of maximum permissible resistance of the earthing system - Comparison between equipment earthing and system grounding - Earthing procedure - Building installation, Domestic appliances, Industrial premises, Earthing of substation, generating station and overhead line.

**Transformer, Motors (DC and AC) and Starters:** Maintenance schedule of transformer**:** Insulation co-ordination and Impulse voltage testing-Lightning arrestor. Maintenance and Troubleshooting-Oil Purification & Testing.

Maintenance of DC, AC Motors and their Starters: – Operation, Routine and Breakdown Maintenance, Causes of failure, Precautions and Trouble shooting.

**Generator and Substation :** Maintenance of Generator: Operation, Routine and breakdown Maintenance, Causes of Failure and Precautions.

Maintenance of Substation**:** Operation, Routine and breakdown Maintenance, Causes of Failure and Precautions, Sub-station shut down procedure - certificate of requisition for shut down; certificate of Permit to work and certificate of Line clear - Instruction for the safety of persons working on a job with a permit to work.

**Switchgears, Transmission and Distribution system:** Maintenance of Switchgear: – Operation, Routine and breakdown Maintenance, Causes of Failure and Precautions. Maintenance of Transmission and Distribution system: – Rules for Low, Medium and High voltages, Factor of safety, precautions - Minimum Clearance, Conductors, System protection.

## Learning resources

1. B.V.S.Rao, "Operation and Maintenance of Electrical Equipment", Volume I & II, 2008 Edition, Media Promoters & Publishers Pvt. Ltd., Mumbai.
2. S. Rao, "Testing Commissioning Operation and Maintenance of Electrical Equipments", Sixth Edition, Khanna Publishers, New Delhi, 2010.
3. Tarlok Singh, "Installation Commissioning and Maintenance of Electrical Equipments", First Edition, S. K. Kataria & Sons, 2013.
4. Paul Gill, "Electrical Power Equipment Maintenance and Testing", Second Edition, CRC Press, 2013.
5. https://www.weschler.com/wp-content/uploads/2020/01/gettingdowntoearth.pdf

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| 1. | **Electrical Accidents and Safety** | | |
| 1.1 | Causes of electrical accidents – Factors affecting severity of electrical shock - Actions to be taken when a person gets attached to live part | 1 | CO1 |
| 1.2 | Safety regulations and safety measures- Indian electricity supply act 1948-1956; Factory Act -1948 | 1 | CO1 |
| 1.3 | Fire extinguishers | 1 | CO1 |
| 1.4 | Building Electrical Installations – Annual Inspection, Safe working of Electrical Equipments- Electrical inspectorate's rules for operation and maintenance | 2 | CO1 |
| 2 | **Maintenance** | | |
| 2.1 | Types and Importance of Plant maintenance, Preventive, Breakdown and Production - Preventive maintenance: need, classification, advantages, activities, Frequency of maintenance- | 2 | CO2 |
| 2.2 | Breakdown maintenance: concept, advantages - Maintenance Records, Role of Maintenance Engineer | 1 | CO2 |

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| 3. | **Earthing** | | |
| 3.1 | Necessity of earthing - System earthing: advantage of neutral earthing of generator in power station; Equipment earthing: Objective - Types of earth electrodes | 1 | CO3 |
| 3.2 | Methods of earthing : plate earthing, pipe earthing and coil earthing - Earthing in extra high voltage and underground cable, Earthing resistance- factors affecting | 1 | CO3 |
| 3.3 | Determination of maximum permissible resistance of the earthing system - Comparison between equipment earthing and system grounding | 2 | CO3 |
| 3.4 | Earthing procedure - Building installation, Domestic appliances, Industrial premises, Earthing of substation, generating station and overhead line. | 1 | CO3 |
| 4. | **Transformer, Motors (DC and AC) and Starters** | | |
| 4.1 | Maintenance schedule of transformer *:* | 3 | CO4 |
| 4.2 | Insulation co-ordination and Impulse voltage testing-Lightning arrestor. | 3 | CO4 |
| 4.3 | Maintenance and Troubleshooting-Oil Purification & Testing. | 2 | CO6 |
| 4.4 | Maintenance of DC, AC Motors and their Starters: – Operation, Routine and Breakdown Maintenance, Causes of failure, Precautions and Trouble shooting. | 3 | CO4 & CO6 |
| 5. | **Generator and Substation** | | |
| 5.1 | Maintenance of Generator: Operation, Routine and breakdown Maintenance, Causes of Failure & Precautions. | 3 | CO5 |
| 5.2 | Maintenance of Substation**:** Operation, Routine and breakdown Maintenance, Causes of Failure & Precautions. | 2 | CO5 |
| 5.3 | Sub-station shut down procedure - certificate of requisition for shut down; certificate of Permit to work and certificate of Line clear - Instruction for the safety of persons working on a job with a permit to work. | 1 | CO6 |
| 6 | **Switchgears, Transmission and Distribution system** | | |
| 6.1 | Maintenance of Switchgear: – Operation, Routine & breakdown Maintenance, Causes of Failure and Precautions. | 3 | CO5 |
| 6.2 | Maintenance of Transmission and Distribution system: – Rules for Low, Medium and High voltages, | 2 | CO5 |
| 6.3 | Factor of safety, precautions - Minimum Clearance, Conductors, System protection | 1 | CO6 |
| | Total | 36 | |

**Course Designers:**


1. Dr. N.Shanmuga Vadivoo nsveee@tce.edu
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| 18EEPM0 | REAL TIME OPERATING SYSTEM | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

Real-time systems are complex embedded systems that operate with real time constraints. Real time systems include automotive electronics, air traffic control, nuclear power plants, telecommunications, and robotics, etc. Most of the real time embedded systems use a real time operating system (RTOS) that determines which applications should run in what order and how much time should be allowed for each application before giving processor's or CPU's access to another application.The functions of the RTOS are to manage the sharing of internal memory among multiple tasks, to handle input and output to and from attached hardware devices such as serial ports, buses, and I/O device controllers and to send messages about the status of operation and any errors that may have occurred.

## Prerequisite

18EE520- Microcontrollers

## Course Outcomes

On the successful completion of the course, students will be able to:

| COs No. | **Course outcomes** | Weightage in % |
|---|---|---|
| CO1 | Explain the concepts underlying the real-time systems | 10 |
| CO2 | Describe  the basic functions in a real-time operating system | 20 |
| CO3 | Explain the various interface functions used in real-time operating system for matrix keyboard interfacing | 15 |
| CO4 | Outline the RTOS µCOS-II Programming concepts | 15 |
| CO5 | Develop RTOS program for an automatic chocolate vending machine using µCOS-II | 25 |
| CO6 | Develop RTOS program for  digital camera using µCOS-II | 15 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.3.1 2.3.4 |
| CO2 | TPS2 | Understand | Respond | | 1.3, 2.3.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO3 | TPS2 | Understand | Respond | | 1.3, 2.3.3 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.5.4 |
| CO5 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.2.3, 2.3.1, 2.4.3, 2.4.4, 2.5.4 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.2.3, 2.3.1, 2.4.3, 2.4.4, 2.4.7, 2.5.4 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | M | L | | | | | | M | | M | | | | M |
| CO3 | M | L | | | | | | M | | M | | | | M |
| CO4 | S | M | L | | | | | M | | M | | | | M |
| CO5 | S | M | L | | | | | M | | M | | | | S |
| CO6 | S | M | L | | | | | M | | M | | | | S |

**S**- Strong; **M**-Medium; **L**-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 30 | 30 | 30 | - | - | - | 30 |
| Apply | 50 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. What is the need for RTOS ?
2. What are the types of real time system?
3. List the names of any four RTOSes.

**Course Outcome 2 (CO2)**:

1. Define critical section of a task.
2. Write the operation done when the function OSSemPend ( ) is executed.

3. What is the function of a semaphore ?

**Course Outcome 3 (CO3)**:
1. Define auto-repeat in keyboard.
2. Draw the matrix keyboard driver flow diagram and explain.
3. Develop the 'C' code for matrix keyboard module.

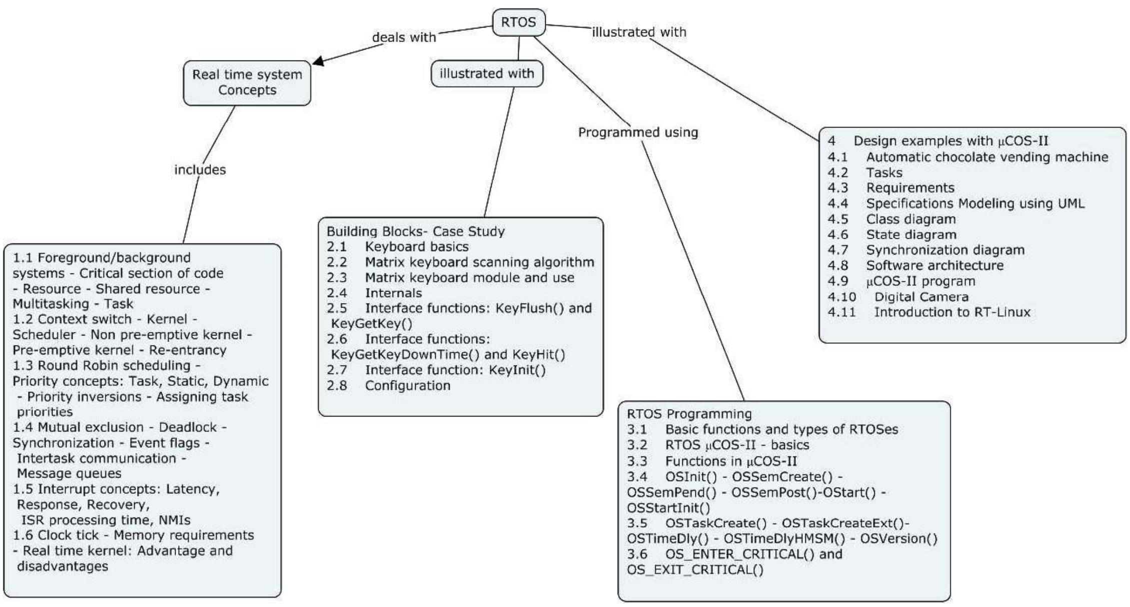
**Course Outcome 4 (CO4)**:
1. List the functions in µC/ OS-II for OS related operation and explain them.
2. List the functions in µC/ OS-II for time management and explain them.
3. How semaphore is used to execute critical section of a task in a multitasking system?

**Course Outcome 5 (CO5):**
1. Show how the timer functions can be applied
   a) to reduce the light level in a mobile phone with full brightness
   b) to switch off the LCD display in a mobile phone after 15 seconds from the time it was switched on.
2. Draw an FSM model of an automatic chocolate-vending machine program. The machine permits only one type of coin, Rs. 1, one chocolate at a time and one chocolate cost is Rs. 8.
3. How will you create and display SMS message in T9 keypad of a mobile phone? Use the states, FSM model and state tables for all keys 0, 1 to 9 with T9 keypad. Use suitable templates.

**Course Outcome 6 (CO6):**

1.Explain the application of timer functions in digital camera.
2.Draw an FSM model of a digital camera.
3. Write the features of RT-Linux.

## Concept Map



## Syllabus

**Introduction:** Real-time system concepts - Foreground/background systems - Critical section of code - Resource - Shared resource - Multitasking - Task - Context switch - Kernel - Scheduler - Non preemptive kernel - Preemptive kernel - Reentrancy - Round Robin scheduling - Priority concepts: Task, Static, Dynamic - Priority inversions - Assigning task priorities - Mutual exclusion - Deadlock - Synchronization - Event flags - Intertask communication - Message queues - Interrupt concepts: Latency, Response, Recovery, ISR processing time, Non-maskable Interrupts (NMIs) - Clock tick - Memory requirements - Real time kernel: Advantage and disadvantages.

**Interface Functions in RTOS – Case Study:** Keyboard basics - Matrix keyboard scanning algorithm - Matrix keyboard module and use - Internals - Interface functions: KeyFlush(), KeyGetKey(), KeyGetKeyDownTime(), KeyHit(), KeyInit() - Configuration.

**RTOS programming:** Basic functions and types of RTOSes - RTOS µCOSII: basics - Functions in µCOSII - OSInit() - OSSemCreate() - OSSemPend() - OSSemPost() - OSStart()- OSStartInit()- OSTaskCreate()- OSTaskCreateExt()- OSTimeDly()- OSTimeDlyHMSM() - OSVersion() - OS_ENTER_CRITICAL() and OS_EXIT_CRITICAL().

**Design examples with µCOS-II**: Automatic chocolate vending machine - Tasks - Requirements - Specifications Modeling using UML - Class diagram - State diagram - Synchronization diagram - Software architecture - µCOS-II program - Digital Camera- Introduction to RT-Linux.

## Learning Resources

1. Raj Kamal, “Embedded Systems- Architecture, Programming and Design” Second edition , Tata McGraw Hill, 2011.
2. Jean J. Labrosse, ‘Embedded Systems Building Blocks’, Second Edition, CMP Books, USA, 2000.
3. Phillip A. Laplante,Seppo A.Ovaska, Real Time Systems Design and Analysis, Tools for the Practisoner, fourth Edition, John Wiley Publishers, 2012.
4. Qin Li, Real time concepts for embedded systems, CRC Press, 2003
5. David E.Simon, “An Embedded Software Primer”, Pearson Education, 2006
6. µC/ OS-II,Second edition, Micrium Documenatation, https://doc.micrium.com/download/attachments/10753158/100-uC-OS-II-002.pdf
7. Introduction to RT-Linux (https://www.cis.upenn.edu/~lee/06cse480/lec-RTOS_RTlinux.pdf)
8. https://www.freertos.org/index.html

## Course Contents and Lecture Schedule

| S.No. | Topics | No. of Lectures | Cos |
|---|---|---|---|
| 1. | **Introduction** | | |
| 1.1 | Real-time system concepts - Foreground/background systems - Critical section of code - Resource - Shared resource - Multitasking – Task | 2 | CO1 |
| 1.2 | Context switch - Kernel - Scheduler - Non pre-emptive kernel - Pre-emptive kernel - Re-entrancy | 2 | CO1 |

| | | | |
|---|---|---|---|
| 1.3 | Round Robin scheduling - Priority concepts: Task, Static, Dynamic - Priority inversions - Assigning task priorities | 2 | CO2 |
| 1.4 | Mutual exclusion - Deadlock - Synchronization - Event flags - Intertask communication - Message queues | 2 | CO2 |
| 1.5 | Interrupt concepts: Latency, Response, Recovery, ISR processing time, NMIs | 1 | CO2 |
| 1.6 | Clock tick - Memory requirements - Real time kernel: Advantage and disadvantages | 1 | CO2 |
| **2.** | **Interface functions in RTOS– Case Study** | | |
| 2.1 | Keyboard basics | 1 | CO3 |
| 2.2 | Matrix keyboard scanning algorithm | 1 | CO3 |
| 2.3 | Matrix keyboard module and use | 1 | CO3 |
| 2.4 | Internals | 1 | CO3 |
| 2.5 | Interface functions: KeyFlush() and KeyGetKey() | 1 | CO3 |
| 2.6 | Interface functions: KeyGetKeyDownTime() and KeyHit() | 1 | CO3 |
| 2.7 | Interface function: KeyInit() | 1 | CO3 |
| 2.8 | Configuration | 1 | CO3 |
| **3** | **RTOS programming** | | |
| 3.1 | Basic functions and types of RTOSes | 1 | CO4 |
| 3.2 | RTOS µCOS-II - basics | 1 | CO4 |
| 3.3 | Functions in µCOS-II | 1 | CO4 |
| 3.4 | OSInit() - OSSemCreate() - OSSemPend() - OSSemPost()-OStart() - OSStartInit() | 1 | CO4 |
| 3.5 | OSTaskCreate() - OSTaskCreateExt()-OSTimeDly() - OSTimeDlyHMSM() - OSVersion() | 1 | CO4 |
| 3.6 | OS_ENTER_CRITICAL() and OS_EXIT_CRITICAL() | 1 | CO4 |
| **4** | **Design examples with µCOS-II** | | |
| 4.1 | Automatic chocolate vending machine | 1 | CO5 |
| 4.2 | Tasks | 1 | CO5 |
| 4.3 | Requirements | 1 | CO5 |
| 4.4 | Specifications Modeling using UML | 1 | CO5 |
| 4.5 | Class diagram | 1 | CO5 |
| 4.6 | State diagram | 1 | CO5 |
| 4.7 | Synchronization diagram | 1 | CO5 |
| 4.8 | Software architecture | 1 | CO5 |
| 4.9 | µCOS-II program | 2 | CO5 |
| 4.10 | Digital Camera | 1 | CO6 |
| 4.11 | Introduction to RT-Linux | 1 | CO6 |
| | **Total** | **36** | |

**Course Designers:**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| 18EEPN0 | EMBEDDED SYSTEMS DESIGN (TCP) |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 2 | 0 | 2 | 3 |

## Preamble

An embedded system is a computer system with a dedicated function present within a larger electrical or electronics or mechanical system, often with real-time computing constraints. An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular function. Industrial machines, automobiles, medical equipments, digital cameras, household appliances, airplanes, vending machines, toys, cellular phone and PDA are among the numerous possible hosts of an embedded system. Embedded systems that are programmable are provided with programming interfaces. In order to meet real time constraints, most of the embedded systems use a real-time operating system (RTOS). This course introduces the architecture, design and development process of embedded systems. The architecture and programming of ARM Cortex M4 microcontrollers (STM32407xx, TM4C123) are covered in this course.

## Prerequisite

- 18EE520–Microcontrollers

## Course Outcomes

On the successful completion of the course, students will be able to:

| COs No. | Course outcomes | Weightage in % |
|---|---|---|
| CO1 | Explain embedded system architecture, building blocks, software tools and design process. | 20 |
| CO2 | Explain the architecture and function of on-chip peripherals (DMA, interrupt controllers, Clocks, RTC, WDT, I²C, USART, SPI,SDIO) in ARM Cortex M4 (STM32407xx) Microcontroller | 15 |
| CO3 | Explain the architecture and function of on-chip peripherals (DMA, interrupt controllers, RTC, Timers and watchdogs, CAN, USB, PWM, QEI) in TM4C123 Microcontroller. | 15 |
| CO4 | Develop Embedded C programs for interfacing LED, LCD, Keyboard, 7-segment display, ADC, DAC with STM32407xx Microcontroller | 20 |
| CO5 | Develop Embedded C programs for interfacing Bluetooth, Zigbee, Sensor modules with TM4C123 Microcontroller. | 20 |
| CO6 | Develop mini project to solve real time problems using microcontrollers | 10 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |

| | | | | | |
|---|---|---|---|---|---|
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.3.1 |
| CO2 | TPS2 | Understand | Respond | | 1.3, 2.3.1 |
| CO3 | TPS2 | Understand | Respond | | 1.3, 2.3.1, 2.4.3, 2.4.6 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.4.4 |
| CO5 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.3.1, 2.4.3, 2.4.4 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.3.1, 2.4.3, 2.4.4 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | M | L | | | | | | M | | M | | | | M |
| CO 2 | M | L | | | | | | M | | M | | | | M |
| CO 3 | M | L | | | | | | M | | M | | | | M |
| CO 4 | S | M | L | | | | | M | | M | | | | S |
| CO 5 | S | M | L | | | | | M | | M | | | | S |
| CO 6 | S | M | L | | | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests 1 | 2 | 3 | Practical Test | Terminal Examination |
|---|---|---|---|---|---|
| Remember | 40 | 40 | 20 | - | 20 |
| Understand | 60 | 60 | 40 | - | 40 |
| Apply | 0 | 0 | 40 | 100 | 40 |
| Analyse | - | - | - | - | - |
| Evaluate | - | - | - | - | - |
| Create | - | - | - | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |

| Origination | |
|---|---|

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1)**:
1. Distinguish between GPP and ASIP.
2. What are the power down modes ?
3. How the embedded systems are classified ?
4. Write the need of RTC in embedded system.
5. Demonstrate the layers of an embedded system.
6. Demonstrate the process of converting C program into the file for ROM image.
7. Illustrate the various types of serial communication devices.

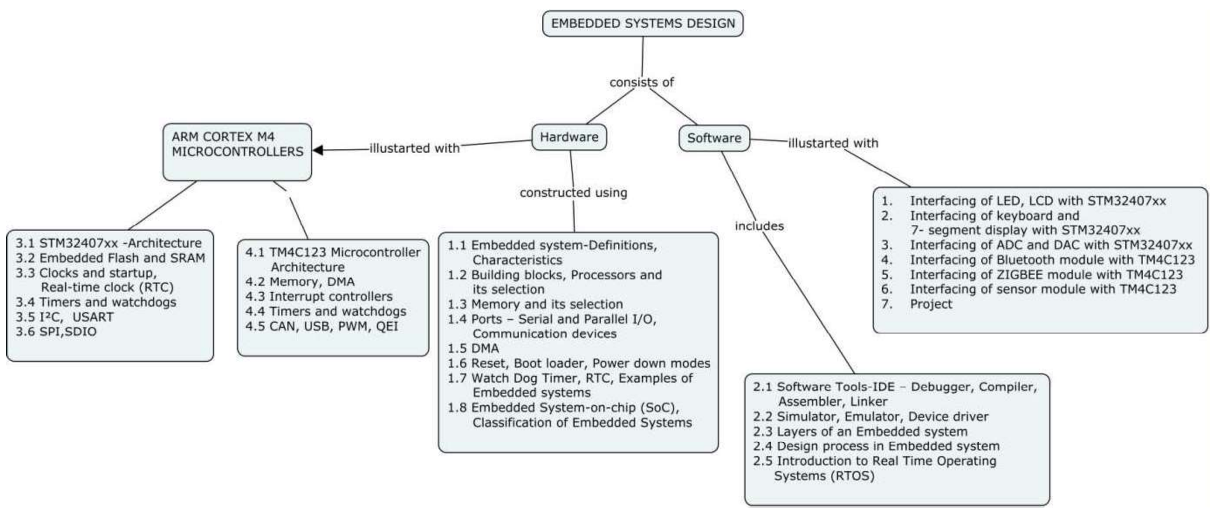
**Course Outcome 2 (CO2):**
1. Explain the architecture of STM32407xx Microcontroller.
2. Explain the different interrupts in STM32407xx Microcontroller.
3. Explain the operation of RTC and WDT in STM32407xx Microcontroller.
4. With neat diagram, explain the working of SPI interface in STM32407xx Microcontroller.

**Course Outcome 3 (CO3)**:
1. Explain the architecture of TM4C123 Microcontroller.
2. Explain the different interrupts in TM4C123 Microcontroller.
3. Explain the operation of USB interface in TM4C123 Microcontroller.
4. With neat diagram, explain the working of CAN interface in TM4C123 Microcontroller.

**Course Outcomes 4 & 5 (C04 & CO5):**
The evaluation is based on the following experiments done in laboratory:
1. Interfacing of LED, LCD with STM32407xx Microcontroller
2. Interfacing of keyboard and 7- segment display with STM32407xx Microcontroller
3. Interfacing of ADC and DAC with STM32407xx Microcontroller
4. Interfacing of Bluetooth module with TM4C123 Microcontroller
5. Interfacing of ZIGBEE module with TM4C123 Microcontroller
6. Interfacing of sensor module with TM4C123 Microcontroller
7. DC motor / stepper motor speed control.

**Course Outcome 6 (CO6):**
1. In a shopping mall to count the customers, a counting device is required that increments every time when an enter key is pressed and the counter is reset by pressing a reset key. Develop a prototype using microcontroller.
2. Develop a prototype for lift controller.

## Concept Map



## Syllabus

**EMBEDDED SYSTEMS:** Definitions – Characteristics, Building blocks – Processors and its selection - Memory and its selection - Ports - Serial and Parallel I/O Communication devices - DMA - Reset - Boot loader - Power down modes - Watch Dog Timer - RTC - Examples of Embedded systems - Embedded System-on-chip (SoC) - Classification of Embedded Systems.

**SOFTWARE TOOLS:** IDE - Debugger - Compiler - Assembler - Linker - Simulator - Emulator - Device driver - Layers of an Embedded system - Design process in Embedded system - Introduction to Real Time Operating Systems (RTOS).

**ARM CORTEX M4 MICROCONTROLLER:** STM32407xx -Architecture - Embedded Flash and SRAM- Clocks and startup - Real-time clock (RTC) - Timers and watchdogs - I²C - USART - SPI - SDIO.

**TM4C123 MICROCONTROLLER:** Architecture – Memory - DMA - Interrupt controllers - Timers and watchdogs – CAN - USB - PWM - QEI.

**EMBEDDED C PROGRAM**: Interfacing of LED, LCD, Keyboard, 7-segment display, ADC, DAC, DC/Stepper Motor with STM32407xx Microcontroller- Interfacing of Bluetooth, Zigbee, Sensor modules with TM4C123 Microcontroller

## Learning Resources

1. Raj kamal, 'Embedded Systems, Architecture, Programming and Design', Tata McGraw-Hill, second edition 2010.
2. D.P.Kothari, Shriram K.Vasudevan, Embedded Systems, New Age International Publishers, 2012.
3. ARM Cortex M4 (STM32407xx) Data sheet, ST Microelectronics.
4. ARM Cortex M4 (TM4C123) Data sheet, Texas Instruments.
5. Shibu K V, 'Introduction to Embedded Systems', Tata McGraw Hill Education Pvt. Ltd.
6. Frank Vahid and Tony Givargis, 'Embedded System Design: A Unified Hardware/Software Introduction', John Wiley & Sons, Inc. 2002.
7. Steve Heath, Embedded Systems Design, Second Edition, Elsevier, 2003.

## Course Contents and Lecture Schedule

| Module No | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| 1. | **Embedded Systems** | | |
| 1.1 | Embedded systems Definitions, Characteristics | 1 | CO1 |
| 1.2 | Building blocks, Processors and its selection | 1 | CO1 |
| 1.3 | Memory and its selection | 1 | CO1 |
| 1.4 | Ports – Serial and Parallel I/O, Communication devices | 1 | CO1 |
| 1.5 | DMA | 1 | CO1 |

| | | | |
|---|---|---|---|
| 1.6 | Reset, Boot loader, Power down modes | 1 | CO1 |
| 1.7 | Watch Dog Timer, RTC, Examples of Embedded systems | 1 | CO1 |
| 1.8 | Embedded System-on-chip (SoC), Classification of Embedded Systems | 1 | CO1 |
| 2 | **Software Tools** | | |
| 2.1 | IDE – Debugger, Compiler, Assembler, Linker | 1 | CO2 |
| 2.2 | Simulator, Emulator, Device driver | 1 | CO2 |
| 2.3 | Layers of an Embedded system | 1 | CO2 |
| 2.4 | Design process in Embedded system | 1 | CO2 |
| 2.5 | Introduction to Real Time Operating Systems (RTOS) | 1 | CO2 |
| 3. | **ARM Cortex M4 Microcontrollers** | | |
| 3.1 | STM32407xx -Architecture | 1 | CO3 |
| 3.2 | Embedded Flash and SRAM | 1 | CO3 |
| 3.3 | Clocks and startup, Real-time clock (RTC) | 1 | CO3 |
| 3.4 | Timers and watchdogs | 1 | CO3 |
| 3.5 | $I^2C$, USART | 1 | CO3 |
| 3.6 | SPI,SDIO | 1 | CO3 |
| 4 | **TM4C123 Microcontroller** | | |
| 4.1 | Architecture | 1 | CO4 |
| 4.2 | Memory, DMA | 1 | CO4 |
| 4.3 | Interrupt controllers | 1 | CO4 |
| 4.4 | Timers and watchdogs | 1 | CO4 |
| 4.5 | CAN, USB, PWM, QEI | 1 | CO4 |
| | **Total** | **24** | |

**Practical (24 Hours)**

**Design of Embedded System using STM32407xx/ TM4C123 Microcontroller**

1. DC motor speed control and display of speed
2. Stepper motor speed control and display of speed
3. Temperature measurement and display
4. Measurement of power and energy
5. LED illumination control using PWM
6. Data communication using Ethernet/USB/CAN
7. Wireless data communication using Bluetooth/ ZIGBEE module
8. Measurement of position and pressure

## Course Designers

1. Dr.M.Saravanan mseee@tce.edu
2. Dr.P.S.Manoharan psmeee@tce.edu

| 18EERG0 | INDUSTRIAL ELECTRICAL AND ELECTRONICS | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

Industrial process control and production automation requires proficiency in industrial electrical and electronics. This is achieved by linking equipment such as PCs, PLCs, SCADA, distributed control systems and simple instrument together with data communications systems that are correctly designed and implemented. This course highlights the industrial controllers, networks and communication requirement for smart instrumentation.

## Prerequisite

- Nil

## Course Outcomes

On the successful completion of the course, students will be able to :

| CO No | Course Outcomes | Weightage*** in % |
|---|---|---|
| CO1 | Determine the performance of manufacturing engineering systems | 10 |
| CO2 | Explain the basic subsystems and sequence of SPM and GPM machines | 30 |
| CO3 | Explain the architecture of Industrial machine controllers | 20 |
| CO4 | Develop efficient industrial design for all modern requirements. | 10 |
| CO5 | Select, install and maintain the industrial protocols in most cost-effective manner for the plant. | 20 |
| CO6 | Construct PLC ladder diagram for various industrial process control | 10 |

*** Weightage depends on Bloom's Level, number of contact hours

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 4.1.1, 4.1.2 |
| CO2 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 2.3.1, 4.1.1, 4.1.2 |
| CO3 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 2.3.1, 2.3.2, 4.1.2, 4.3.1, 4.3.2 |
| CO4 | TPS3 | Apply | Value | - | 1.3, 2.1.2, 2.3.2, 2.3.3, 4.1.2, 4.3.3, 4.3.4 |
| CO5 | TPS3 | Apply | Value | - | 1.3, 2.1.2, 2.3.2, 2.3.3, 4.1.2, 4.3.3, 4.3.4 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.5, 2.3.2, 2.3.3, 4.1.1, 4.1.2, 4.3.3, 4.3.4, 4.5.5 |

## CO Mapping with CDIO Curriculum Framework

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1. | M | L | | | | | | M | | M | | | M | M |
| CO2. | M | L | | | | | | M | | M | | | M | M |
| CO3. | M | L | | | | | | M | | M | | | M | M |
| CO4. | S | M | L | | | | | M | | M | | | M | M |
| CO5. | S | M | L | | | | | M | | M | | | M | M |
| CO6. | S | M | L | | | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 40 | 20 | 20 | - | - | - | 20 |
| Understand | 40 | 40 | 40 | - | - | - | 40 |
| Apply | 20 | 40 | 40 | 100 | 100 | 100 | 40 |
| Analyze | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

## Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Calculate the takt time for producing 35000vehicles/month, assuming two shift operations with each shift working for 466 minutes?
2. Define Line balancing
3. Where do we use standard operation combination chart?

**Course Outcome 2 (CO2):**

4. Write the differences between special purpose machines and general purpose machines.
5. Explain "Through Coolant" system and its advantages.
6. Outline different components that are used in a machine tool to achieve different levels of safety.

**Course Outcome 3 (CO3)**

7. Draw the architecture of machine controllers for a Variable Frequency Drive.
8. Explain the operating principle of an inductive proximity sensor.
9. State the factors influencing the choice of transducer.

**Course Outcome 4 (CO4)**

1. Design and develop the ladder diagram for ON delay timer using PLC.
2. Develop ladder logic for semi automatic starter for starting of three phase induction motor using PLC.
3. A reamer is said to be fit for operating 5000 auto cycles. Once 4999 cycles are over PLC has to pop up an warning bit saying "Tool life over". Write ladder logic for tool life monitoring in a machine.

**Course Outcome 5 (CO5)**

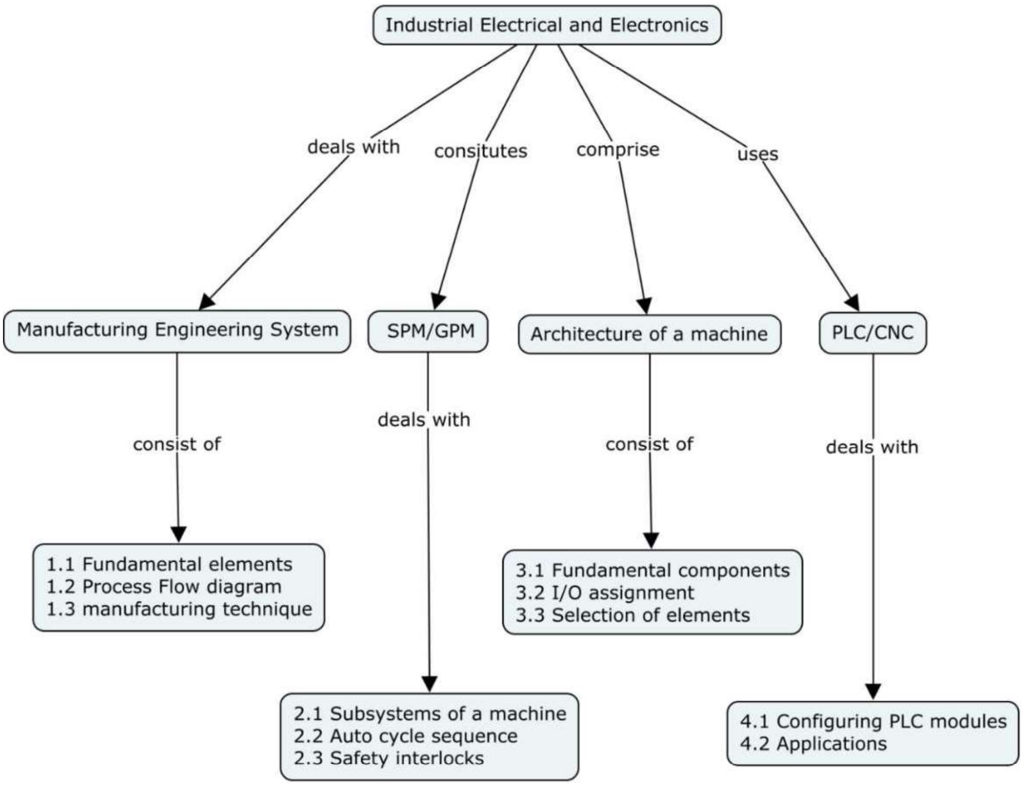
1. You have two counters counting up-to 16, built from negative edge DFF , First circuit is synchronous and second is "ripple" (cascading), Which circuit has a less propagation delay? Why?
2. Analyse what will happen if there is setup time and hold time violation, how to overcome this?
3. Prepare the I/O list and write the ladder diagram considering the following statements. There are two cylinders available like main and small cylinders. Initially both the cylinders are at HOME (Back) condition. User has to actuate the main cylinder first from HOME to forward. By this time small cylinder will be in HOME. Then the small cylinder should be actuated forward for 5s. Then it has to come back to HOME. Finally main cylinder should come back to Home.
   Programmer is given following elements to design the ladder.
   - Main cylinder HOME proximity for its HOME position confirmation.
   - Main cylinder FWD proximity for its FWD position confirmation.
   - Small cylinder HOME proximity for its HOME position confirmation.
   - A push button for Cycle start.
   - Main Cylinder forward & reverse solenoid (Double coil solenoid)
   - Small Cylinder forward & reverse solenoid (Double coil solenoid)
   - Indication lamp for Home condition confirmation for both the cylinders.
   - Indication Lamp for small cylinder in forward condition.

**Course Outcome 6 (CO6)**

1. Distinguish between general PLC and safety PLC.
2. Construct PLC ladder diagram for the following Boolean logic equation.
3. An electrical panel has to be connected to an external 3-Φ, 415V, 50Hz AC supply. Through a 16Amps MCCB.A 3-Φ induction motor to be connected with the 50Hz power supply. The motor has to be fully protected from over current and short circuit. Draw the power circuit of the motor.
   The motor has to be switched on and off through a PLC using 2 push buttons - Motor On and Motor off. A lamp has to indicate that motor is on. Write down the suitable ladder logic.

$$Y1 = A.B.\overline{C}.X.\overline{Z} + D.\overline{C}.X.\overline{Z}$$
$$= (A.B + D).\overline{C}.X.\overline{Z}$$

## Concept Map




## Syllabus

**Manufacturing Engineering System:** Batch, Cell concept, Individual part flow, Takt time, Process Time, Lead time, Cycle time, OEE, Process Flow diagram, Lean manufacturing technique and Six sigma overview

**SPM/GPM:** Basic Subsystems of a machine - Base & Columns, Fixture, Tooling's, Spindle, Slide ways, Hydraulics, Pneumatics, Lubrication, Cladding & Auto door, Coolant & Chip tray. Electrical - Control Cabinet, Servo drives, Operator console, HMI/MMI/Panel PC.

Auto cycle sequence - Auto Door movement, component clamp/de-clamp, Slide feed, Axes interpolation in a CNC machine, Automatic Tool Change, Metal cutting at regulated rpm, Cutting coolant and bed coolant. Safety interlocks- Levels of safety, redundancy levels and poka yoke used in machining process & power saving techniques

**Architecture of machine controllers:** Sensors & transducers, Actuators, Relays, contactor, power supply, fuse, Isolator, ELCB, MCB, MPCB, Controlling Induction motor from VFD, Servomotor& Servo drives, Encoders, Operator panel elements (Push button, Selector switch, lamp, HMI etc), PLC & CNC controllers. I/O assignment - Addressing Digital I/O, Analogue I/O & counter inputs for a machine based on application. Selection of elements for application control - PLC/CNC controller, HMI/MMI, sensors, transducers, actuators, motors, drives, Circuit breakers, power supply, relays, cables etc, Earthing/shielding of measuring equipments, Techniques of electrical noise elimination while wiring, Symbols for electrical elements, design a control panel & operator panel using selected elements

**PLC/CNC:** Configuring PLC modules using ladder, Bit, Byte & words, addressing digital I/O signals, Concept of NO/NC elements, coils, flags, Boolean operation, AND/OR/NOT, Pulse triggered execution, serial, parallel and latch execution sequence, Relays, Counter, Timers, Registers, Mathematical and logical instructions, building tags. Addressing analogue I/Os in Ladder, Programming an analogue I/O block, Read/Write functions, Programming an encoder using counter block, Compare functions Examples of very commonly used safety logics/techniques, building poka yoke in ladder using peripheral sensors, power saving techniques.

## Learning resources


1. Srinivas Medida, "Pocket Guide on Industrial Automation For Engineers and Technicians" first edition, IDC Technologies.
2. W. Bolton, "Programmable Logic Controllers", Newnes imprint of Elsevier, 2006
3. Frank D.Petruzella, "Programmable Logic Controllers", Fourth Edition McGraw-Hill, 2011


## Course contents and Lecture schedule

| S. No. | Topics | No. of Hours | Course Outcome |
|---|---|---|---|
| 1 | **Manufacturing Engineering System** | | |
| 1.1 | Batch, Cell concept, Individual part flow, Takt time, Process Time, Lead time, Cycle time, OEE | 2 | CO1 |
| 1.2 | Process Flow diagram | 2 | CO1 |
| 1.3 | Lean manufacturing technique and Six sigma overview | 2 | CO1 |
| 2 | **SPM/GPM** | | |
| 2.1 | Basic Subsystems of a machine : Base & Columns, Fixture, Tooling's, Spindle, Slide ways, Hydraulics, Pneumatics, Lubrication, Cladding& Auto door, Coolant & Chip tray, Electrical : Control Cabinet, Servo drives, Operator console, HMI/MMI/Panel PC | 3 | CO2 |
| 2.2 | Auto cycle sequence : Auto Door movement, component clamp/de-clamp, Slide feed, Axes interpolation in a CNC machine, Automatic Tool Change, Metal cutting at regulated rpm, Cutting coolant and bed coolant, | 4 | CO2 |
| 2.3 | Safety interlocks: Levels of safety, redundancy levels and poka yoke used in machining process & power saving techniques | 3 | CO2 |
| 3 | **Architecture of machine controllers** | | |
| 3.1 | Sensors & transducers, Actuators, Relays, contactor, power supply, fuse, Isolator, ELCB, MCB, MPCB, Controlling Induction motor from VFD, Servomotor & Servo drives, Encoders, Operator panel elements(Push button, Selector switch, lamp, HMI etc),PLC & CNC controllers, | 5 | CO3 |
| 3.2 | I/O assignment: Addressing Digital I/O, Analogue I/O & counter inputs for a machine based on application. | 2 | CO4 |
| 3.3 | Selection of elements for application control : PLC/CNC controller, HMI/MMI, sensors, transducers, actuators, motors, drives, Circuit breakers, power supply, relays, cables etc, | 5 | CO5 |

| | | | |
|---|---|---|---|
| | Earthing/shielding of measuring equipments, Techniques of electrical noise elimination while wiring, Symbols for electrical elements,<br>design a control panel & operator panel using selected elements | | |
| 4 | **PLC/CNC** | | |
| 4.1 | Configuring PLC modules using ladder, Bit, Byte & words, addressing digital I/O signals, Concept of NO/NC elements, coils, flags, Boolean operation: AND/OR/NOT, Pulse triggered execution, serial, parallel and latch execution sequence, Relays, Counter, Timers, Registers, Mathematical and logical instructions, building tags, Addressing analogue I/Os in Ladder, Programming an analogue I/O block, Read/Write functions, Programming an encoder using counter block, Compare functions | 6 | CO6 |
| 4.2 | Examples of very commonly used safety logics/techniques, building poka yoke in ladder using peripheral sensors, power saving techniques | 4 | CO6 |
| | **Total** | **40** | |

**Course Designers**

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Dr. G. Sivasankar gsivasankar@tce.edu

| 18EERH0 | TESTING & CERTIFICATION OF AUTOMOTIVE ELECTRICAL & ELECTRONIC SYSTEMS | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**Preamble**

This course gives an exposure to Indian Test standards and Test methods for automotive Electrical & Electronic components and Test standards & Compliance requirements for EMCs. This course also focuses on the Test set-up &Test Methods for HIL testing and various environmental requirements.

**Prerequisite**

18EEPQ0 – Automotive Electronics

**Course Outcomes**

On successful completion of the course, students will be able to

| No | Course Outcomes | Weightage in %*** |
|---|---|---|
| CO1 | Explain Indian Test standards for homologation of 2W/3W. | 20 |
| CO2 | Explain Indian Test standards & Test methods for Electrical & Electronic components. | 25 |
| CO3 | Explain Indian Test standards & Compliance requirements for EMC | 25 |
| CO4 | Explain HIL testing and Indian Test standards for Environmental requirements | 10 |
| CO5 | Identify the category of vehicles for the given vehicle specifications and test specifications. | 10 |
| CO6 | Calculate the parameters involved in various vehicle performance tests. | 10 |

*** Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

| CO | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.3.1,3.2.3 |
| CO2 | TPS2 | Understand | Respond | | 1.3,2.3.1, 3.2.3, 3.2.5 |
| CO3 | TPS2 | Understand | Respond | | 1.3, 2.3.1, 3.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO4 | TPS2 | Understand | Respond | | 1.3, 2.3.1, 3.2.3 |
| CO5 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.4, 3.2.5, 4.3.1,4.4.1, 4.4.4 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.4, 3.2.5, 4.3.1,4.4.1, 4.4.4 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | L | | M |
| CO2 | M | L | | | | | | M | | M | | L | | M |
| CO3 | M | L | | | | | | M | | M | | | | M |
| CO4 | M | L | | | | | | M | | M | | | | M |
| CO5 | S | M | L | | L | | | M | | M | | | | M |
| CO6 | S | M | L | | L | | | M | | M | | | | M |

S- Strong; M-Medium; L-Low

## Assessment Pattern : Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 40 | 40 | 40 | - | - | - | 40 |
| Understand | 60 | 40 | 40 | 100 | 100 | 100 | 40 |
| Apply | - | 20 | 20 | - | - | - | 20 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. Mention any two global standards for 2WEmissions

2. Mention any four parameters in Indian homologation requirements.
3. What is meant by Type approval?

**Course Outcome 2 (CO2):**

1. Describe the Homologation test procedure for Lighting system of 2W.
2. Explain the Homologation test procedure for Horn of 2W
3. Describe the Homologation test procedure for Emission of 2W Motor Cycle.

**Course Outcome 3 (CO3):**

1. What is range of frequency band for radiated emission testing?
2. Describe the EMC test procedure in Open Air Test Site.
3. Describe Bulk Current Injection Test procedure.

**Course Outcome 4 (CO4):**

1. Mention any four standards used for environmental testing of electrical & Electronic parts.
2. Explain thermal cycle test.
3. Explain various applicable tests for wiring harness.

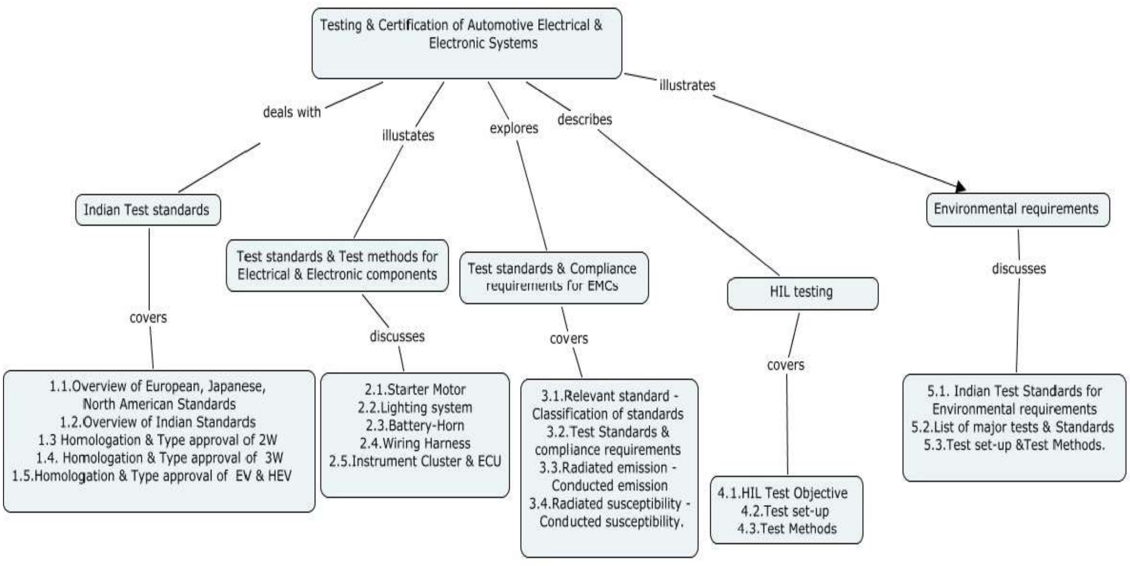
**Course Outcome 5 (CO5):**

1. Find out the grading of the vehicle if the piston displacement is above 50cm3 and maximum speed is above 50 kmph.
2. If the vehicle is used for carrying goods and having a mass exceeding 3.5t but not exceeding 12t , determine the category of the vehicle.
3. Find out the type of vehicle, if the horn decibel level is between 85 dB to 105 dB.

**Course Outcome 6 (CO6):**

1. In the acceleration performance test, if the time taken to achieve a speed of 40 km/h or 75% of maximum speed is observed, find out the maximum speed of the vehicle.
2. In evaluation of brake performance of a two wheeler, if the maximum control force applied during the test is 330 N or 33 kg, determine the operating type of the vehicle.
3. If the track is 4.2 km long with suitable banking at bends for speed up to 150 km/hr , determine the type of test track.

## Concept Map



## Syllabus

**Indian Test standards**

Overview of European, Japanese, North American Standards - Overview of Indian Standards -Homologation & Type approval of 2W & 3W, EV & HEV

**Test standards & Test methods for Electrical & Electronic components :** Test standards & Test methods for Electrical & Electronic components - Starter Motor, Lighting system, battery, Horn, Wiring Harness- Instrument Cluster & ECU

**Test standards & Compliance requirements for EMCs:** Relevant standard **-** Classification of standards – Test Standards & compliance requirements - Radiated emission - Conducted emission- Radiated susceptibility - Conducted susceptibility

**HIL testing :** HIL Test Objective- Test set-up - Test Methods

**Environmental requirements :** Indian Test Standards for Environmental requirements - List of major tests & Standards - Test set-up &Test Methods

## Learning Resources

1) Study Material supplied by 'The Automotive Research Association of India' (ARAI), Pune.

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 1.0 | **Indian Test Standards** | | |
| 1.1 | Overview of European, Japanese, North American Standards | 2 | CO1 |
| 1.2 | Overview of Indian Standards | 2 | CO1 |
| 1.3 | Homologation & Type approval of 2W | 2 | CO1 |
| 1.4 | Homologation & Type approval of 3W | 2 | CO5 |
| 1.5 | Homologation & Type approval of EV & HEV | 1 | CO1 |
| **2.0** | **Test standards & Test methods for Electrical & Electronic components** | | |
| 2.1 | Test standards & Test methods for Electrical components - Starter Motor | 3 | CO2 |
| 2.2 | Lighting system | 3 | CO2 |
| 2.3 | Battery-Horn | 2 | CO5 |
| 2.4 | Wiring Harness | 2 | CO2 |

| | | | |
|---|---|---|---|
| 2.5 | Test standards & Test methods for Electronic components - Instrument Cluster & ECU | 3 | CO6 |
| **3.0** | **Test standards & Compliance requirements for EMCs** | | |
| 3.1 | Relevant standard **-** Classification of standards | 1 | CO3 |
| 3.2 | Test Standards & compliance requirements | 2 | CO3 |
| 3.3 | Radiated emission - Conducted emission | 3 | CO3 |
| 3.4 | Radiated susceptibility - Conducted susceptibility | 3 | CO3 |
| **4.0** | **HIL testing** | | |
| 4.1 | HIL Test Objective | 1 | CO4 |
| 4.2 | Test set-up | 1 | CO4 |
| 4.3 | Test Methods | 1 | CO4 |
| **5.0** | **Environmental requirements** | | |
| 5.1 | Indian Test Standards for Environmental requirements | 1 | CO4 |
| 5.2 | Test set-up &Test Methods | 1 | CO4 |
| | Total | 36 | |

**Course Designer:**

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2.Ms.R.Suganya rsaeee@tce.edu

3)SrinivasaRagavan TVSmotors

| 18EERL0 | MANUFACTURING OF AUTOMOTIVE ELECTRICAL AND ELECTRONICS PARTS | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**Preamble:**

This course ‘Manufacturing of automotive electrical and electronics engineering, a departmental Elective course, is preceded by courses “Utilization of Electrical energy”, Basic Electrical and Electronics Engineering and ‘Basics of Mechanical Engineering’ The course mainly discusses the manufacturing process of different automotive electrical, Electronics and lighting parts and its implantation in the vehicle.

**Prerequisite**

Nil

**Course Outcomes**

| Sl. No | Course Outcomes | Weightage in % |
|---|---|---|
| CO1 | Explain the Vehicle Integration and Mounting methods. | **15** |
| CO2 | Explain the Routing methods, Fastening and Clearance/Interference fit | **10** |
| CO3 | Design the Process flow, process specifications and Inspection methodologies for Starter Motor, relay and horn, | **15** |
| CO4 | Design the Process flow, process specifications and Inspection methodologies for magneto, switches and wiring harness | **20** |
| CO5 | Design the process flow of PCB fabrication process | **25** |
| CO6 | Discuss the automotive lighting systems in the vehicle | **15** |

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 1.2 |
| CO2 | TPS2 | Understand | Respond | | 1.3, 2.1.1, 4.4.4 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.1, 4.4.4 |
| CO4 | TPS2 | Apply | Value | | 1.3, 2.1.1 |
| CO5 | TPS2 | Apply | Value | | 2.1.1, 4.4.4 |
| CO6 | TPS2 | Understand | Respond | | 1.3, 2.1.1 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| COs | PO | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | M | | M |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 2 | M | L | | | | | | M | | M | | M | | M |
| CO 3 | S | M | L | | | | | M | | M | | M | | S |
| CO 4 | M | M | L | | | | | M | | M | | M | | M |
| CO 5 | M | M | L | | | | | M | | M | | M | | M |
| CO 6 | M | L | | | | | | M | | M | | M | | M |

**Assessment Pattern: Cognitive Domain**

| **Cognitive Levels** | **Continuous Assessment Tests** | | | **Assignment** | | | **Terminal Examination** |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 40 | 40 | 40 | - | - | - | 40 |
| Understand | 40 | 40 | 40 | - | - | - | 40 |
| Apply | 20 | 20 | 20 | 100 | 100 | 100 | 20 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **Miniproject /Assignment/Practical Component** |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1) :**

1. Why is a rubber boot generally used for mounting an electronic unit on a vehicle frame?
2. How is a battery mounted on a vehicle frame?

**Course Outcome 2 (CO2) :**

1. List the parts used for routing wiring harness along a vehicle frame.
2. Explain the process of fastening.

**Course Outcome 3 (CO3) :**

1. How is a Starter Motor mounted on an engine
2. Explain the inspection methodologies of relay.
3. Design the process flow of manufacturing a starter motor.

**Course Outcome 4 (CO4):**

1. Design the process flow of manufacturing a switches.
2. Design the process flow of manufacturing of magneto.
3. Why is a corrugated tube used in a wiring harness?

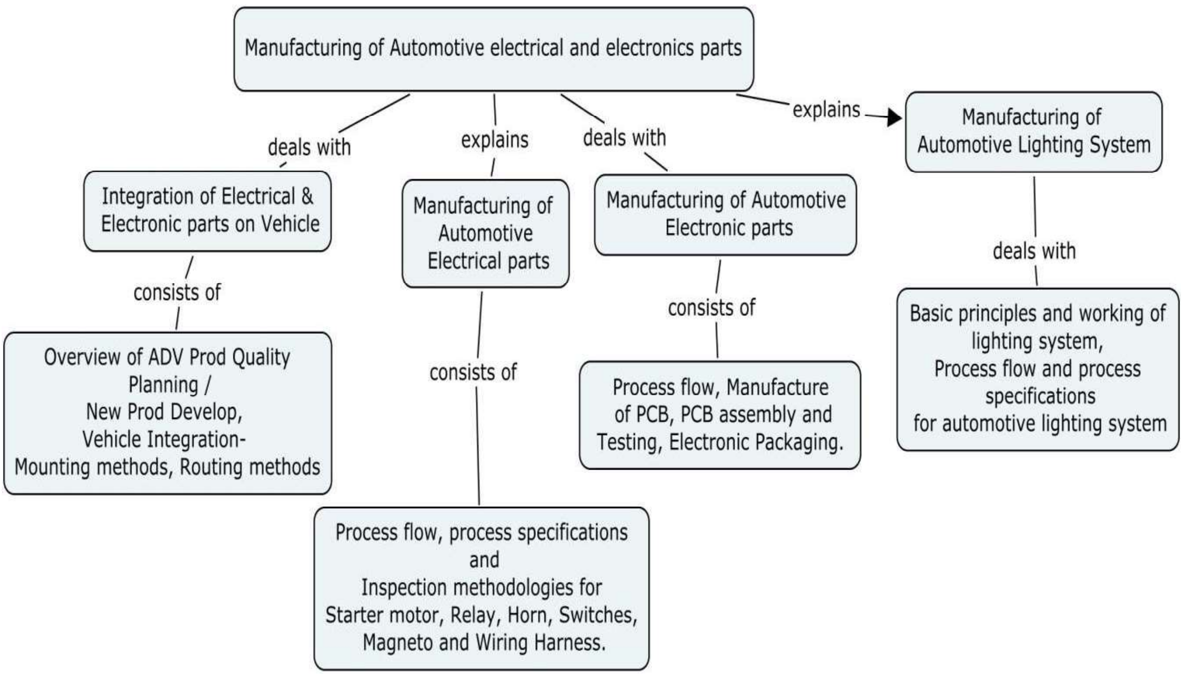
**Course Outcome 5 (CO5):**

1. Design the process reflows of soldering process? How is it different from wave soldering?
2. How are PCBs tested for correct assembly and soldering at end of line?

**Course Outcome 6 (CO6):**

1. Explain the process of manufacturing a vehicle headlamp?
2. What are the critical process parameters that affect light intensity in a vehicle headlamp? How do they affect the light intensity?
3. What are the critical process parameters that affect light intensity in a vehicle headlamp? How do they affect the light intensity?
4.

## Concept Map



## Syllabus

**Integration of Electrical & Electronic parts on Vehicle:** Overview of ADV Prod Quality Planning /New Prod Develop, Vehicle Integration- Mounting methods, Routing methods, Fastening, Clearance/Interference fit.

**Manufacturing of Automotive Electrical parts:** Process flow, process specifications and Inspection methodologies for Starter motor, Relay, Horn, Switches, Magneto and Wiring Harness.

**Manufacturing of Automotive Electronic parts:** Process flow, Manufacture of PCB, PCB assembly and Testing, Electronic Packaging.

**Manufacturing of Automotive Lighting System:** Basic principles and working of lighting system, Process flow and process specifications for automotive lighting system

## Learning Resources:

1. APQP Manual
2. Tom Denton,Automobile electrical and electronics systems,third edition, Elsevier Butterworth-Heinemann.

## Course Contents and lecture schedule

| S.No | Topic | No of Lectures | CO |
|---|---|---|---|
| 1. | **Integration of Electrical & Electronic parts on Vehicle** | | |
| 1.1 | Overview of APQP/NPD | 4 | CO1 |
| 1.2 | Vehicle Integration- Mounting methods | 2 | CO1 |
| 1.3 | Routing methods, Fastening, Clearance/Interference fit | 4 | CO2 |
| 2. | **Manufacturing of Automotive Electrical parts** | | |
| 2.1 | Process flow, process specifications and Inspection methodologies for Starter Motor | 2 | CO3 |
| 2.2 | Process flow, process specifications and Inspection methodologies for Relay | 2 | CO3 |
| 2.3 | Process flow, process specifications and Inspection methodologies for Horn | 2 | CO3 |
| 2.4 | Process flow, process specifications and Inspection methodologies for Switches | 2 | CO4 |
| 2.5 | Process flow, process specifications and Inspection methodologies for Magneto | 3 | CO4 |
| 2.6 | Process flow, process specifications and Inspection methodologies for Wiring Harness | 2 | CO4 |
| 3. | **Manufacturing of Automotive Electronic parts** | | |

| | | | |
|---|---|---|---|
| 3.1 | Process flow for manufacture of PCB | 2 | CO5 |
| 3.2 | Methods of manufacturing of PCB | 2 | CO5 |
| 3.3 | PCB assembly and Testing | 2 | CO5 |
| 3.4 | Electronic Packaging | 3 | CO5 |
| 4. | **Manufacturing of Automotive Lighting System** | | |
| 4.1 | Process flow for manufacturing automotive lighting system | 2 | CO6 |
| 4.2 | Process specifications and Inspection methodologies for automotive lighting system | 2 | CO6 |
| | Total | 36 | |

**Course designers:**

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2. Prof.R.Suganya -rsaeee@tce.edu

| 18EEPA0 | CONTROL SYSTEM DESIGN |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

**Preamble**

This course is to impart in students a good understanding of fundamental design principles in control engineering. The course covers design of continuous time and sampled data control systems using transfer function and state space based methods. A brief overview on digital implementation of PID controllers and common problems faced in the implementation are included. Emphasis is given for design using computer aided tools like MATLAB.

**Prerequisite**

- 18EE350 Signals and Systems
- 18EE440 Control Systems

**Course Outcomes**

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Design compensators/controllers using Root locus and for continuous time system to achieve given performance specifications | 15 |
| CO2 | Design compensators/controllers using Bode plot for continuous time system to achieve given performance specifications | 20 |
| CO3 | Analyse the time domain and frequency domain characteristics of a given sampled data system | 30 |
| CO4 | Design digital controllers/ compensators using root locus and Bode plot for a discrete time system using computer tools | 5 |
| CO5 | Calculate state feedback controller and observer gains using pole placement technique for continuous time and discrete time systems | 20 |
| CO6 | Explain tuning and digital implementation of PID Controllers | 10 |

*** Weightage depends on Bloom's Level, number of contact hours,

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.3,2.1.1, 2.1.4, 3.2.5, 4.3.1, 4.4.1, 4.4.4 |
| CO2 | TPS3 | Apply | Value | | 1.3,2.1.1, 2.1.4, 3.2.5, 4.3.1, 4.4.1, 4.4.4 |
| CO3 | TPS4 | Analyse | Organize | | 1.3,2.1.1, 2.1.2, 2.1.3, 4.3.1 4.3.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO4 | TPS3 | Apply | Value | | 1.3,2.1.1, 2.1.4, 3.2.5, 4.3.1, 4.4.1, 4.4.4 |
| CO5 | TPS3 | Apply | Value | | 1.3,2.1.1, 2.1.4, 4.3.1, 4.4.1, 4.4.4 |
| CO6 | TPS2 | Understand | Respond | | 1.3,2.1.1, 2.1.2, 2.1.3, 4.3.1 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | | L | | | M | | M | | | S | S |
| CO2 | S | M | L | | L | | | M | | M | | | S | S |
| CO3 | S | S | M | L | L | | | M | | M | | | S | S |
| CO4 | S | M | L | | L | | | M | | M | | | S | S |
| CO5 | S | M | L | | L | | | M | | M | | | S | S |
| CO6 | M | L | | | | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | - | - | - | 10 |
| Understand | 30 | 30 | 30 | - | - | - | 30 |
| Apply | 60 | 60 | 60 | 100 | 60 | 100 | 60 |
| Analyse | - | - | - | - | 40 | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

Note: CO4 to be evaluated only through assignments

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Mini project /Assignment/Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |

| | |
|---|---|
| Adaptation | |
| Origination | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1(CO1):**

1. Consider an unity feedback system with open loop transfer function $G(s) = \frac{K}{s(s+1)(s+2)}$. It is operating in closed with maximum peak overshoot of 16%. Calculate the gain and settling time corresponding to this overshoot. Design suitable compensator to reduce settling time to 80% of uncompensated system without changing overshoot.
2. Consider an unity feedback system with open loop transfer function $G(s) = \frac{10}{s(s+1)(s+2)}$. Design lag lead compensator using root locus to achieve
   a. Settling time $t_s \leq 4s$
   b. Max. Peak overshoot $M_p \leq 20\%$
   c. Velocity error constant $K_v \geq 20$

**Course Outcome 2(CO2):**

1. Consider a unity feedback system with plant transfer function $(s) = \frac{10K}{s(s+1)(s+10)}$ . Design lead compensator using Bode plot to achieve velocity error constant $K_v \geq 20$ and Phase margin $\phi_m \geq 30°$
2. Consider a unity feedback system with plant transfer function $G(s) = \frac{e^{-s}}{s(s+1)}$. Design lag lead compensator using Bode plot to achieve velocity error constant $K_v \geq 20$ and Phase margin $\phi_m \geq 30°$

**Course Outcome 3(CO3):**

1. Using Jury's stability criterion determine the number of poles outside |z|=0.5 circle in the z-plane $\Delta(z) = 2z^4 + 7z^3 + 10z^2 + 4z + 1$
2. A unit impulse sequence $\delta_k = \{1,0,0,\cdots\}$ is applied to a system and the output is obtained as $y_k = \{0,0.5,1,1,\cdots\}$

   a. Calculate the z transform of signal y(k)
   b. Determine the pulse transfer function of the system $G(z) = \frac{Y(z)}{U(z)}$ and difference equation governing the system
   c. Calculate the response of the system for unit step sequence.

**Course Outcome 4 (CO4):**

1. Consider a continuous time system G(s)=1/s(s+1)(s+2). Choose suitable time period and discretize the system. Design suitable control scheme using Root locus in MATLAB to achieve following specifications
   a. Settling time = 4s
   b. Maximum peak overshoot < 16%
   c. Velocity error constant $Kv \geq 20$

2. Consider a continuous time system $G(s) = \frac{e^{-s}}{s+1}$. Sampling period is 0.5s. Design suitable control scheme using Bode in MATLAB to achieve following specifications
   a. Phase margin $\geq 45°$
   b. Velocity error constant $Kv \geq 20$

c. Bandwidth not less than 4rad/s

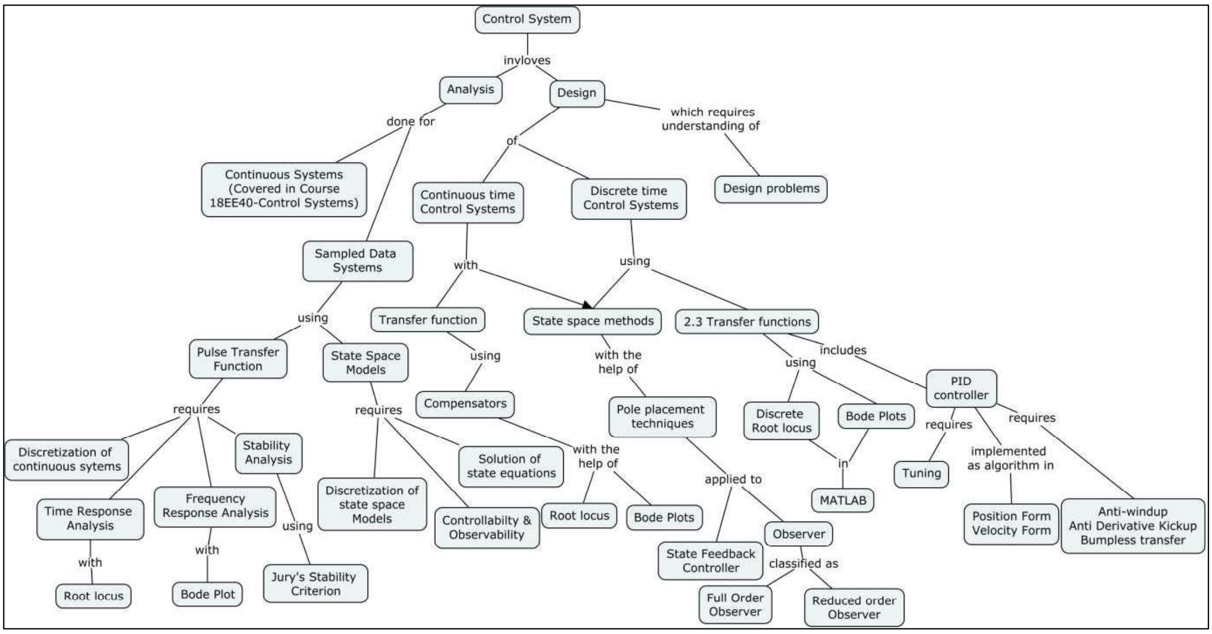
**Course Outcome 5 (CO5):**

1. Consider the system $\boldsymbol{F} = \begin{bmatrix} \mathbf{0} & \mathbf{1} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{1} \\ \mathbf{-1} & \mathbf{-2} & \mathbf{-3} \end{bmatrix}$ and $\boldsymbol{G} = \begin{bmatrix} \mathbf{0} \\ \mathbf{0} \\ \mathbf{1} \end{bmatrix}$ Design a state feedback controller to obtain dead beat response.
2. Consider the system with $\boldsymbol{A} = \begin{bmatrix} \mathbf{0} & \mathbf{1} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{1} \\ \mathbf{-1} & \mathbf{-2} & \mathbf{-3} \end{bmatrix}$ and $\boldsymbol{C} = [\mathbf{1} \quad \mathbf{0} \quad \mathbf{0}]$ Design a reduced order observer with observer poles at s=-10 & s=-20

**Course Outcome 6(CO6):**

**1.** Explain the velocity form of PID controller
**2.** Explain any one anti-windup scheme

**Concept Map**




**Syllabus**

**Design of continuous time control systems using Transfer functions:**
Design problem, Realization of lag, lead and lag-lead compensators – Root locus based design of cascade compensators - Frequency domain design of cascade compensators – Design using MATLAB

**Sampled Data Control Systems Analysis & Design:**
Introduction to Sample data control systems –Sampling, Structure of discrete control system, advantages & disadvantages over continuous control, Discretization of continuous systems Effect of sampling on poles and zeros, Stability Analysis using Jury's Stability Criterion, Time domain analysis of sampled data systems, Frequency domain analysis of sampled data systems, Discretization of state space models, State transition matrix, Solution of state equations, Effect of sampling period on controllability and observability

**Design of sampled data control systems in MATLAB:**
Digital compensator design using Root locus plots, Digital compensator Design using frequency response plots

**Design in State Space [Continuous & Discrete Systems]:**
Pole placement by state feedback, Full order Observers, Reduced order observers, State Space design using MATLAB

**PID Tuning, Digital Implementation and Practical Issues:**
Tuning of PID controllers using Ziegler-Nichols, Cohen Coon and Relay oscillation methods, Position and Velocity form of PID, Pseudo code of PID controller, Bump less transfer, Integral Windup and Anti-windup schemes, Derivative Kick up and methods to overcome them.

## Learning Resources


1. I.J. Nagrath and M.Gopal, "Control Systems Engineering", 6th Edition, New Age International, 2017.
2. M. Gopal, "Digital Control and State Variable Methods –Conventional and Intelligent Control Systems", 3rd edition, McGraw Hill Education, 2010.
3. Norman.S.Nise, "Nise's Control System Engineering – Wiley India Edition",Wiley India, 2018
4. Katsuhiko Ogata, "Discrete Time Control Systems", 2nd edition, Phi Learning, 2009.
5. B.C. Kuo, and F.Golnaraghi, Automatic Control Systems, 9th Edition. Wiley India, 2014. (Student edition)
6. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", Addison Wesley 12th Edition, 2014.
7. Jacqueline wilkie, Michael Johnson and Reza Katebi,"Control Engineering: An Introductory Course ", Palgrave Publishers, edition 2003.
8. Control Tutorials for MATLAB and Simulink: http://ctms.engin.umich.edu/CTMS/index.php?aux=Home


## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| **1** | **Design of continuous time control systems using Transfer functions:** | | |
| 1.1 | Design problem, Realization of lag, lead and lag-lead compensators | 1 | CO1 |
| 1.2 | Lead Compensator design using Root locus | 1 | CO1 |
| 1.3 | Lag compensator design using root locus | 1 | CO1 |
| 1.4 | Lag Lead compensator design using root locus | 2 | CO1 |
| 1.5 | Lead Compensator design using Bode plot | 2 | CO2 |
| 1.6 | Lag compensator design using Bode plot | 1 | CO2 |
| 1.7 | Lag Lead compensator design using Bode plot | 2 | CO2 |
| 1.8 | Feedback compensation | 1 | CO2 |
| 1.9 | Design using MATLAB | 1 | CO2 |
| **2** | **Analysis of Sampled Data Control Systems** | | |
| 2.1 | Introduction to Sample data control systems – Sampling, Structure of discrete control system, advantages & disadvantages over continuous control | 1 | CO3 |
| 2.2 | Discretization of continuous systems | 1 | CO3 |
| 2.3 | Effect of sampling on poles and zeros, Stability Analysis using Jury's Stability Criterion | 2 | CO3 |

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 2.4 | Time domain analysis of sampled data systems | 2 | CO3 |
| 2.5 | Frequency domain analysis of sampled data systems | 2 | CO3 |
| 2.6 | Discretization of state space models | 1 | CO3 |
| 2.7 | State transition matrix, Solution of state equations | 2 | CO3 |
| 2.8 | Effect of sampling period on controllability and observability | 1 | CO3 |
| **3** | **Design of sampled data control systems in MATLAB:** | | |
| 3.1 | Digital compensator design using Root locus plots | 1 | CO4 |
| 3.2 | Digital compensator design using frequency response plots | 1 | CO4 |
| **4** | **Design in State Space [Continuous & Discrete Systems]** | | |
| 4.1 | Pole placement by state feedback | 2 | CO5 |
| 4.2 | Full order Observers | 2 | CO5 |
| 4.3 | Reduced order observers | 1 | CO5 |
| 4.4 | State Space design using MATLAB | 1 | CO5 |
| | | | |
| **5** | **PID Tuning, Digital Implementation and Practical Issues:** | | |
| 5.1 | PID Tuning Methods | 2 | CO6 |
| 5.2 | Position and Velocity form of PID controller, Pseudo code of PID controller | 1 | CO6 |
| 5.3 | Bump less transfer, Integral Windup and Anti-windup schemes, Derivative Kick up and methods to overcome them | 1 | CO6 |
| | **Total** | **36** | |

**Course Designers:**

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| 18EEPB0 | OPERATIONS RESEARCH |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| PE | 3 | 0 | 0 | 3 |

**Preamble**

Operational Research (OR) is a course to aid decision making and improving efficiency of the system by applying advanced analytical methods. It becomes a professional course that deals with the application of scientific methods for decision-making, and especially to the allocation of scare resources.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Formulate real-world problems as a programming model | 10 |
| CO2 | Solve linear programming problems using graphical and simplex methods and perform sensitivity analysis | 20 |
| CO3 | Solve transportation and assignment problems by various methods | 15 |
| CO4 | Formulate inventory models and make optimal decisions | 20 |
| CO5 | Develop dynamic programming stages for real world problems and find optimal solution. | 15 |
| CO6 | solve Queuing models with infinite population | 15 |
| CO7 | Explain the application of game theory models to make decisions | 5 |

*** Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.4.3, 4.4.1 |
| CO2 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.1.3, 2.1.5, 2.4.4 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.1.3, 3.2.5 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.1.3, 2.4.7, 4.3.1 |
| CO5 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.1.3 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2, 2.1. |
| CO7 | TPS2 | Understand | Respond | | 1.3, 2.4.3, 2.4.6 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | S | M | L | | | | | M | | M | | | S | S |
| CO 2 | S | M | L | | | | | M | | M | | | S | S |
| CO 3 | S | M | L | | | | | M | | M | | | M | S |
| CO 4 | S | M | L | | | | | M | | M | | | S | S |
| CO 5 | S | M | L | | | | | M | | M | | | S | S |
| CO 6 | S | M | L | | | | | M | | M | | | S | S |
| CO 7 | M | L | | | | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

**AssessmentPattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | - | - | - | 10 |
| Understand | 30 | 30 | 30 | - | - | - | 30 |
| Apply | 60 | 60 | 60 | 100 | 100 | 100 | 60 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**AssessmentPattern: Psychomotor**

| Psychomotor Skill | Miniproject/Assignment/Practical Component |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

**Sample Questions for Course Outcome Assessment**

**Course Outcome1(CO1):**

1. A company produces two products, A and B. The sales volume for A is at least 80% of the total sales of both A and B. However, the company cannot sell more than 100 units of A per day. Both products use one raw material, of which the maximum daily availability is 240 lb. The usage rates of the raw material are 2 lb per unit of A and 4 lb per unit of B. The profit units for A and Bare $20 and $50, respectively. Develop a linear programming model to optimize the product mix.
2. Show & Sell can advertise its products on local radio and television (TV). The advertising budget is limited to $10,000 a month. Each minute of radio advertising costs $15 and each minute ofTY commercials $300. Show & Sell likes to advertise on radio at least twice as much as on TV. In the meantime, it is not practical to use more

than 400 minutes of radio advertising a month. From past experience, advertising on TV is estimated to be 25 times as effective as on radio. Determine the OR model for the optimum allocation of the budget to radio and TV advertising.

**Course Outcome2(CO2):**

1. An airline offers coach and first-class tickets. For the airline to be profitable, it must sell a minimum of 25 first-class tickets and a minimum of 40 coach tickets. The company makes a profit of \$225 for each coach ticket and \$200 for each first-class ticket. At most, the plane has a capacity of 150 travelers. How many of each ticket should be sold in order to maximize profits? Use graphical method.
2. Maximize z= $x_1+3x_2$
   Subject to the constraints $-x_1+x_2 <=20$
   $-2x_1+x_2 <=50$
   $x_1,x_2 >=0$. Use simplex method.

**Course Outcome3(CO3):**

1. Three electric power plants with capacities of 25, 40, and 30 million kWh supply electricity to three cities. The maximum demands at the three cities are estimated at 30, 35, and 25 million kWh.The price per million kWh at the three cities is given in Table 5.6. During the month of August, there is a 20% increase in demand at each of the three cities, which can be met by purchasing electricity from another network at a premium rate of \$1000 per million kWh. The network is not linked to city 3, however. The utility company wishes to determine the most economical plan for the distribution and purchase of additional energy. (a) Formulate the problem as a transportation model. (b) Determine an optimal distribution plan for the utility company. (c) Determine the cost of the additional power purchased by each of the three cities.
2. JoShop needs to assign 4 jobs to 4 workers. The cost of performing a job is a function of the skills of the workers. The following table summarizes the cost of the assignments. Worker 1 cannot do job 3 and worker 3 cannot do job 4. Determine the optimal assignment using the Hungarian method.

| | | Job 1 | Job 2 | Job 3 | Job 4 |
|---|---|---|---|---|---|
| Worker | 1 | \$50 | \$50 | — | \$20 |
| | 2 | \$70 | \$40 | \$20 | \$30 |
| | 3 | \$90 | \$30 | \$50 | — |
| | 4 | \$70 | \$20 | \$60 | \$70 |

**Course Outcome 4 (CO4):**

1. Acme Manufacturing Company has contracted to deliver horne windows over the next 6 months. The demands for each month are 100,250,190,140,220, and 110 units, respectively. Production cost per window varies from month to month depending on the cost of labor, material, and utilities. Acme estimates the production cost per window over the next 6 months to be \$50, \$45, \$55, \$48, \$52, and \$50, respectively. To take advantage of the fluctuations in manufacturing cost, Acme may elect to produce more than is needed in a given month and hold the excess units for delivery in later months. This, however, will incur storage costs at the rate of \$8 per window per month assessed on end-of-month inventory. Develop a linear program to determine the optimum production schedule.

**Course Outcome 5 (CO5):**

1. A company has 8 salesman, who have to be allocated to four marketing zones. The return of profits from each zone depends upon the number of salesmen working in that zone. The expected returns for different number of salesmen in different zones, as

estimated from the past records, are given below. Determine the optimal allocation policy.

| No of salesmen | Marketing zones | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 0 | 45 | 30 | 35 | 42 |
| 1 | 58 | 45 | 45 | 54 |
| 2 | 70 | 60 | 52 | 60 |
| 3 | 82 | 70 | 64 | 70 |
| 4 | 93 | 79 | 72 | 82 |
| 5 | 101 | 90 | 82 | 95 |
| 6 | 108 | 98 | 93 | 102 |
| 7 | 113 | 105 | 98 | 110 |
| 8 | 118 | 110 | 100 | 110 |

2. Maximize $Y= 3x_1+5x_2$
   Subject to the constraints $3x_1+2x_2 <=18$
   $x_1<=4$
   $x_2 <=6$
   $x_1,x_2 >=0$. Use dynamic programming.

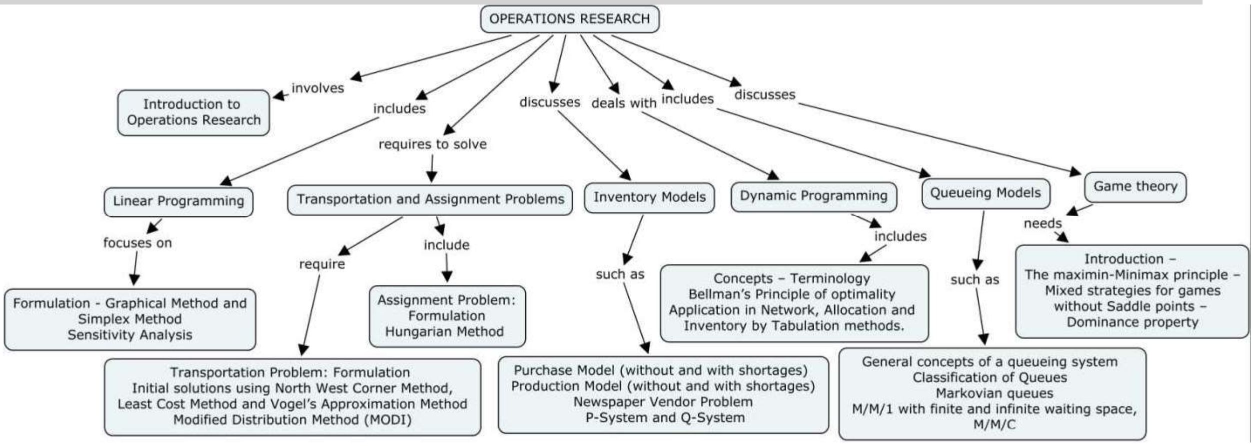
**Course Outcome 6(CO6):**

1. A person repairing radios finds that the time spent on the radio sets has an exponential distribution with mean 20 minutes. If the radios are repaired in the order in which they come in and their arrival is approximately Poisson with an average rate of 15 for 8-hour day, what is the repairman's expected idle time each day? How many jobs are ahead of the average set just brought in?
2. Car arrive at a toll gate according to Poisson distribution with mean 90 per hour. Average time for passing through the gate is 38 seconds. Drivers complain of long waiting time. Authorities are willing to decrease the passing time through the gate to 30 seconds by introducing new automatic devices. This can be justified only if under the old system, the number of waiting cars exceeds 5. In addition, the percentage of the gate's idle time under the new system should not exceed 10%.Can the new device be justified?

**Course Outcome 7(CO6):**

1. Explain the different steps in Decision theory approach.
2. Compare Hurwicz criterion with Minimax criterion.

## Concept Map




## Syllabus

Introduction to Operations Research

**Linear Programming**

Linear Programming: Formulation - Graphical Method and Simplex Method – Sensitivity Analysis

**Transportation and Assignment Problems**

Transportation Problem: Formulation - Initial solutions using North West Corner Method, Least Cost Method and Vogel's Approximation Method - Modified Distribution Method (MODI)
Assignment Problem: Formulation - Hungarian Method

**Inventory Models**

Purchase Model (without and with shortages) - Production Model (without and with shortages) - Newspaper Vendor Problem - P-System and Q-System

**Dynamic Programming**

Concepts – Terminology – Bellman's Principle of optimality – Application in Network, Allocation and Inventory by Tabulation methods.

**Queueing Models**

General concepts of a queueing system - Classification of Queues – Markovian queues-M/M/1 with finite and infinite waiting space, M/M/C

**Game theory**

Introduction – The maximin-Minimax principle – Mixed strategies for games without Saddle points – Dominance property

## Learning Resources


1. Hamdy A. Taha, "Operations Research - An Introduction", MacMillan Co.,
2. Harvey M. Wagner, "Principles of Operations Research with Applications to Managerial Decisions", Prentice Hall international,
3. SingiresuS.Rao, "Engineering Optimization-Theory and Practice", New Age International,
4. Hiller / Lieberman, "Introduction to Operations Research" Tata McGraw Hill

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 0 | Introduction: Operations Research | 1 | CO1 |
| 1 | **Linear Programming** | | |
| 1.1 | Linear Programming (LP): Formulation | 2 | CO1 |
| 1.2 | Graphical Method for LP problems | 2 | CO2 |
| 1.3 | Simplex and Dual Simplex Methods for LP problems | 4 | CO2 |
| 1.4 | Sensitivity Analysis | 2 | CO2 |
| 2. | **Transportation and Assignment Problems** | | |
| 2.1 | Transportation Problem(TP): LP Formulation | 1 | CO1 |
| 2.2 | Initial Basic Feasible solutions | 1 | CO3 |
| 2.3 | Optimal solution for TP using Modified Distribution Method | 2 | CO3 |
| 2.4 | Assignment Problem (AP): Formulation | 1 | CO3 |
| 2.5 | Hungarian Method for AP | 1 | CO3 |
| **3** | **Inventory Models** | | |
| 3.1 | Inventory models | 1 | CO4 |
| 3.2 | Purchase Model (with and without shortages) | 2 | CO4 |
| 3.3 | Production Model (with and without shortages) | 2 | CO4 |
| 3.4 | Newspaper Vendor Problem | 1 | CO4 |
| 3.5 | P-System and Q-System | 1 | CO4 |
| **4** | **Dynamic Programming** | | |
| 4.1 | Concepts – Terminology – Bellman's Principle of optimality | 2 | CO5 |
| 4.2 | Application in Network, Allocation and Inventory by Tabulation methods | 2 | CO5 |
| 5 | **Queueing Models** | | |
| 5.1 | General concepts of a queueing system - Classification of Queues | 1 | CO6 |
| 5.2 | Markovian queues- M/M/1 with finite and infinite waiting space | 3 | CO6 |
| 5.3 | M/M/C | 1 | CO6 |
| 6 | **Game theory** | | CO7 |
| 6.1 | Introduction – The maximin-Minimax principle | 1 | |
| 6.2 | Mixed strategies for games without Saddle points | 1 | CO7 |
| 6.3 | Dominance property | 1 | CO7 |
| | **Total** | 36 | |

**Course Designers:**


1. Prof.S.Siva Kumar siva@tce.edu
2. Dr. D.Kavitha dkavitha@tce.edu

| 18EEPR0 | AUTOMOTIVE FUNDAMENTALS AND MANUFACTURING | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**Preamble**

This course aims to provide knowledge on the construction and working of automobile subsystems, performance calculations, dynamics, vibration behaviour, process capabilities, process parameters, limitations and applications of various manufacturing processes.

**Prerequisite**

- Nil

**Course Outcomes**

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain construction and working of transmission, braking, steering and suspension systems of an automobile | 20 |
| CO2 | Determine performance calculations such as acceleration, gradeability, gear ratios | 15 |
| CO3 | Determine center of gravity, reactions, dynamics of two wheeled and four wheeled vehicle | 15 |
| CO4 | Determine vibration behaviour of an automobile | 15 |
| CO5 | Explain the various manufacturing process that are used for Automotive Parts manufacturing | 20 |
| CO6 | Select suitable material and process for the given Automotive part | 15 |

*** Weightage depends on Bloom's Level, number of contact hours.

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.1, 3.2, 4.1.2 |
| CO2 | TPS3 | Apply | Value | | 1.3, 2.1, 3.2, 4.3.2, 4.3.3 |
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1, 3.2, 4.3.2, 4.3.3 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1, 3.2, 4.3.2, 4.3.3 |
| CO5 | TPS2 | Understand | Respond | | 1.3, 2.1, 3.2, 4.1.2 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1, 3.2, 4.3.2, 4.3.3 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | |
| CO2 | S | M | L | | | | | M | | M | | | S | |
| CO3 | S | M | L | | | | | M | | M | | | S | |
| CO4 | S | M | L | | | | | M | | M | | | S | |
| CO5 | M | L | | | | | | M | | M | | | M | |
| CO6 | S | M | L | | | | | M | | M | | | S | |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 10 | 10 | 10 | - | - | - | 20 |
| Understand | 40 | 20 | 40 | - | - | - | 30 |
| Apply | 50 | 70 | 50 | 100 | 100 | 100 | 50 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Mini project /Assignment/Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

## Sample Questions for Course Outcome Assessment

### Course Outcome 1 (CO1):

1. Explain construction and working of single plate diaphragm clutch with neat

sketches.

2. What is double de-clutching?
3. Narrate the construction and working of fixed calliper disc brake system, with diagrams.

**Course Outcome 2 (CO2):**

1. The coefficient of rolling resistance for a truck weighing 62293.5 N is 0.018 and the coefficient of air resistance is 0.0276 in the formula R= KW + $K_a AV^2$, where A is in $m^2$ of frontal area, V the speed in km/h and R is in Newton. The transmission efficiency in top gear of overall gear ratio 6.2:1 is 90% and that in the second gear of 15:1 is 80%. The frontal area is 5.574 $m^2$. If the truck has to have a maximum speed of 88 km/h in top gear, calculate:
   i) the engine BP required ii) the engine speed if the driving wheels have an effective diameter of 0.8125 m; iii) the maximum grade the truck can negotiate at the above engine speed in second gear iv) The maximum drawbar pull available on level at the above engine speed in second gear.
2. A motor car which weighs 17795 N including the four road wheels each of which has an effective diameter of 0.66 m, a radius of gyration of 0.28 m and a weight of 294 N has an engine developing 66 kW at 2400 RPM. The parts which rotate at engine speed weigh 1069 N, with a radius of gyration 0.115 m. The transmission efficiency is 90% and the total road and air resistance at this engine speed in top gear of 3.84:1 is 873 N on level. Calculate the acceleration in $m/s^2$, under those conditions and assuming the acceleration to be uniform the time required to increase the speed by 32 km/h.

3. A motor car with wheel base 2.75 m with a centre of gravity 0.85 m above the ground 1.15 m behind the front axle has a coefficient of adhesion 0.6 between the tyre and the ground. Calculate the maximum possible acceleration when the vehicle is
   (a) Driven on four wheels
   (b) Driven on the front wheels only
   (c) Driven on rear wheels only

**Course Outcome 3 (CO3:**

1. Explain how center of gravity of a two wheeler is determined experimentally.
2. With neat sketch, show the forces and moments acting on a vehicle taking turn.
3. With mathematical expression discuss the stability of a vehicle on a slope, on a banked track.

**Course Outcome 4 (CO4):**

1. Define “Degree of freedom”. Give examples for single degree of freedom system and two degree of freedom system.
2. Obtain expressions for natural frequencies of undamped, combined bouncing and pitching. Also discuss on pitch and bounce centre.
3. The springs of a motor vehicle carry a total load of 11280 N with equal springing at front and rear. The combined spring rate is 88300 N/m. Calculate the frequency of vertical natural vibration with the dampers removed. If the dampers are adjusted to give a total damping force of 4415 N-s/m, calculate the frequency of damped vibrations

and the ratio of the second downward movement to the first downward movement.

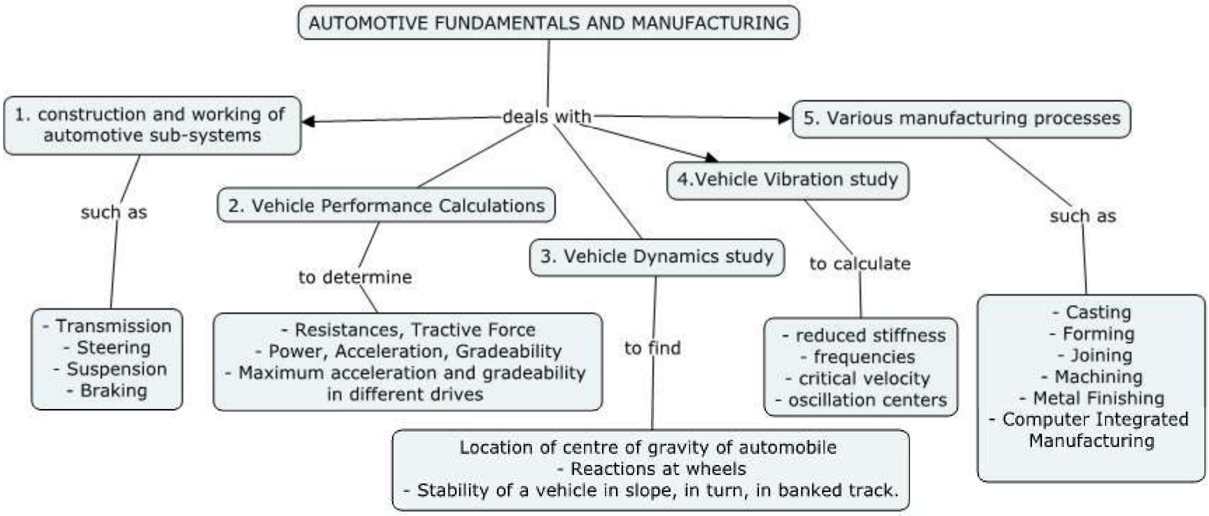
**Course Outcome 5 (CO5):**

1. Mention the types of Metal Forming processes.
2. List the process that can be performed in a Lathe.
3. Discuss about the significance of Computer integrated manufacturing.

**Course Outcome 6 (CO6):**

1. Suggest suitable material and process along with justification for manufacturing of Connecting Rod.
2. Suggest suitable material and process along with justification for manufacturing of Helical Gears.
3. Suggest suitable material and process along with justification for manufacturing of Front Axles.

## Concept Map




## Syllabus

**Construction and working of automotive systems –** Construction and working of single plate and multi-plate clutch, sliding mesh, constant mesh and synchromesh gear box, Epicyclic Gear Train. CVT, Propeller shaft, final drive and differential, steering linkages, steering mechanism, leaf spring and coil spring suspension, mechanical, hydraulic brakes, drum and disc brakes.

**Vehicle performance calculations** - Determination of resistance, tractive force, power, acceleration, gradeability, gear ratios for an automobile, maximum acceleration, gradeability for different drives.

**Vehicle Dynamics –** Determination of centre of gravity of automobile, reactions at wheels, stability of a vehicle in slope, in turn, in banked track.

**Vehicle Vibration -** Front and rear suspension, reduced stiffness, preload, models with one, two and four degrees of freedom, modes of vibration in the plane, Determination of frequencies and critical velocity, oscillation centres.

**Manufacturing processes - Casting –** Sand Casting, Die Casting, **Forming –** Rolling, Forging, Extrusion, Sheet metal forming, **Joining –** Fusion and Solid state Welding, **Machining –** Lathe, Milling, Gear hobbing, **Metal Finishing –** Lapping, Honing, Coating.

**Case Studies for each process –** Automotive components such as drive shaft, gear box casing, piston, connecting rod, chassis frame, fuel tank,fasteners,etc.

**Computer integrated Manufacturing –** CAD,CAM,CAPP.

## Learning Resources


1. N.K.Giri, "**Automobile Mechanics**", 8th Edition, Khanna Publishers, Delhi, 2013.
2. Kirpal Singh, "**Automobile Engineering**", Volume-1&2, 13th Edition, Standard Publishers Distributers, Delhi, 2017.
3. S.K.Hajra Choudury, Nirjhar Roy, A.K. Hajra Choudury, "Elements of workshop Technology", Vol-II, Machine Tools, Media Promoters and Publishers Pvt. Ltd, 2009.
4. Serope Kalpakjan and Steven R.Schmid, "Manufacturing Engineering and Technology", sixth edition, PHI, 2010.
5. Mikell P.Grover, "Fundamentals of Modern Manufacturing ", Wiley India Third Edition Re-print, 2012.


## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1. | **Construction and working of automotive sub-systems** | | |
| 1.1 | Construction and working of single plate | 1 | CO1 |
| 1.2 | Construction and working of multi-plate clutch. | 1 | CO1 |
| 1.3 | Working of sliding mesh gear box. | 1 | CO1 |
| 1.4 | Working of constant mesh and synchromesh gear box. Epicyclic Gear Train | 1 | CO1 |
| 1.5 | Working, merits and demerits of CVT. | 1 | CO1 |
| 1.6 | Construction of propeller shaft with universal joints, final drive and differential. | 1 | CO1 |
| 1.7 | steering linkages, steering mechanism, | 1 | CO1 |
| 1.8 | Functions and construction of leaf spring and coil spring suspension. | 1 | CO1 |
| 1.9 | Working of mechanical, hydraulic brakes, drum and disc brakes. | 1 | CO1 |
| 2. | **Vehicle performance calculations** | | |
| 2.1 | Determination of resistance, tractive force, power | 2 | CO2 |
| 2.2 | Determination of acceleration, gradeability | 1 | CO2 |
| 2.3 | Determination of gear ratios for an automobile gear box | 1 | CO2 |
| 2.4 | Calculation of maximum acceleration, gradeability for different drives | 1 | CO2 |
| 3. | **Vehicle Dynamics** | | |

| | | | |
|---|---|---|---|
| 3.1 | Determination of centre of gravity of automobile | 2 | CO3 |
| 3.2 | Calculation of reactions at wheels for three wheeled and four wheeled vehicle | 1 | CO3 |
| 3.3 | Stability of a vehicle in slope, in banked track | 1 | CO3 |
| 3.4 | Stability of a vehicle in turn | 1 | CO3 |
| 4. | **Vehicle vibration** | | |
| 4.1 | Determination of reduced stiffness of front and rear suspension of two wheeled vehicles | 2 | CO4 |
| 4.2 | Effect of pre-load in suspension, progressive suspension | 1 | CO4 |
| 4.3 | models with one, two and four degrees of freedom, modes of vibration in the plane | 1 | CO4 |
| 4.4 | Determination of frequencies and critical velocity for single and two degree of freedom system and oscillation centers. | 2 | CO4 |
| 5. | **Manufacturing processes** | | |
| 5.1 | **Casting –** Sand Casting, Die Casting , case studies | 2 | CO5,CO6 |
| 5.2 | **Forming –** Rolling, Forging, Extrusion, Sheet metal forming, case studies | 2 | CO5,CO6 |
| 5.3 | **Joining –** Fusion and Solid state Welding, case studies | 2 | CO5,CO6 |
| 5.4 | **Machining –** Lathe, Milling, Gear hobbing, case studies | 2 | CO5,CO6 |
| 5.5 | **Metal Finishing –** Lapping, Honing, Coating, case studies | 2 | CO5,CO6 |
| 5.6 | **Computer integrated Manufacturing –** CAD,CAM,CAPP | 2 | CO5,CO6 |
| | **TOTAL** | **36** | |

**Course Designers:**

1. Dr. A.Samuel Raja samuel1973@tce.edu (AUTOMOTIVE FUNDAMENTALS)
2. Mr. M.Balamurali balacim82@tce.edu (MANUFACTURING)

| 18EERF0 | INDUSTRIAL INSTRUMENTATION | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**Preamble**

Instrumentation is the science of automated measurement and control. It is a collective term for measuring instruments used for indicating, measuring and recording physical quantities. Applications of this science abound in modern research, industry, and even in household. From automobile engine control systems to home thermostats to aircraft autopilots to the manufacture of pharmaceutical drugs, automation surrounds us. This course covers some of the fundamental principles of industrial instrumentation.

**Prerequisite**

Nil

**Course Outcomes**

On the successful completion of the course, students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the principle and operating characteristics of Force and torque measuring techniques | 10% |
| CO2 | Explain the principle and operating characteristics of Acceleration and Vibration measuring techniques | 10% |
| CO3 | Apply suitable technique for measurement of Flow and Level for a given application | 30% |
| CO4 | Explain the principle and operating characteristics of Viscosity measuring techniques | 10% |
| CO5 | Apply suitable technique for measurement of high temperature for a given application | 20% |
| CO6 | Apply suitable technique for measurement of Pressure for a given application | 20% |

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | -- | 1.3 |
| CO2 | TPS2 | Understand | Respond | -- | 1.3 |
| CO3 | TPS3 | Apply | Value | -- | 1.3, 2.1.1, 2.1.5, 2.3.1 |
| CO4 | TPS2 | Understand | Respond | -- | 1.3 |
| CO5 | TPS3 | Apply | Value | -- | 1.3, 2.1.1, 2.1.5, 2.3.1 |

| | | | | | |
|---|---|---|---|---|---|
| CO6 | TPS3 | Apply | Value | -- | 1.1, 1.2, 2.1.1, 2.1.5, 2.3.1 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| Cos | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | M | L | | | | | | M | | M | | | | M |
| CO 2 | M | L | | | | | | M | | M | | | | M |
| CO 3 | S | M | L | | | | | M | | M | | | | S |
| CO 4 | M | L | | | | | | M | | M | | | | M |
| CO 5 | S | M | L | | | | | M | | M | | | | S |
| CO 6 | S | M | L | | | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 80 | 50 | 50 | - | - | - | 50 |
| Apply | - | 30 | 30 | 100 | 100 | 100 | 30 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Assessment Pattern : Psychomotor

| **Psychomotor Skill** | **Miniproject /Assignment/Practical Component** |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |

| | |
|---|---|
| Adaptation | - |
| Origination | - |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

10. Explain the operation of pneumatic load cell with neat diagram.
11. Explain the types of Mechanical load cells.
12. Explain the principle of rotating torque measurement

**Course Outcome 2 (CO2)**:

1. Draw the general block diagram of accelerometer.
2. Explain the principle and operation of piezoelectric Accelerometer.
3. What are the different methods used commonly for calibrations of vibration pickups?

**Course Outcome 3 (CO3)**:

1. A venturi tube of throat diameter 10cm is placed in a pipe of diameter 20cm to measure the volumetric flow. The volumetric flow rate through venturi tube is 0.02 $\frac{m^3}{sec}$.Water has the viscosity of $10^{-3}$pas. Determine the Reynolds number and the upstream to throat differential pressure developed.
2. An incompressible fluid is flowing through an orifice plate with a flow coefficient of 0.6 causing a pressure drop of 400mm of water column. Calculate the fluid velocity.
3. Calculate the buoyancy force on an object that displaces $3\ m^3$ of water at 20°C.

**Course Outcome 4 (CO4)**:

1. Define viscosity.
2. Explain the operation of Saybolt viscometer.
3. List the three physical principles used in Instruments for measuring viscosity.

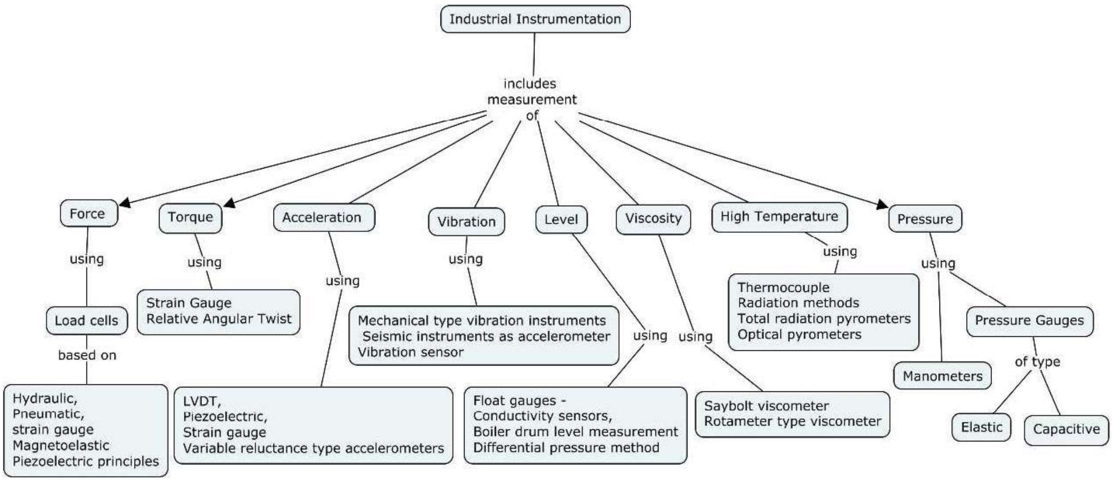
**Course Outcome 5 (CO5)**:

1. In a temperature measuring system with Chromel-Alumel thermocouple, the reference junction is maintained at 50°C.Find out the millivolt available as output if the hot junction temperature is 900°C.
2. A furnace wall 12 ft2 in area and 6-in thick has a thermal conductivity of 0.14 BTU/h ft°F. Estimate the heat loss if the furnace temperature is 1100°F and the outside of the wall is 102°F?
3. A total radiation pyrometer is used to measure furnace refractory wall temperature. The fumes and smoke along the path absorbs at 5% of radiant heat energy. The pyrometer reads 1100°C, what will be the actual wall temperature?

**Course Outcome 6 (CO6)**:

1. The liquid in a well manometer has a specific weight of 40 lb/ft3. How far will the liquid rise in the smaller leg, if the pressure in the larger leg is 1.5 lb/ft2 higher than in the smaller leg?
2. Recommend the type of manometer for measuring the pressure inside a reheating furnace. Justify the same
3. In the U-tube manometer assume that filled liquid is mercury and h=500mm for all the cases, find out
   a) The pressure difference p1-p2 in $\frac{kg}{cm^2}$
   b) The pressure p1 in gauge and absolute scale if p2 is open to atmosphere in mmWG
   c) The pressure p1 in gauge and absolute scale if p2 is evacuated and sealed in mmHg.

## Concept Map




## Syllabus

**MEASUREMENT OF FORCE, TORQUE**

Different types of load cells - Hydraulic, Pneumatic, strain gauge- Magneto-elastic and Piezoelectric load cells - Different methods of torque measurement: - Strain gauge-Relative angular twist

**MEASUREMENT OF ACCELERATION & VIBRATION**

Accelerometers LVDT, Piezoelectric, Strain gauge and Variable reluctance type accelerometers - Mechanical type vibration instruments - Seismic instruments as accelerometer - Vibration sensor - Calibration of vibration pickups

**FLOW MEASUREMENTS**

Orifice plate different types of orifice plates , Difference between area flow and mass flow meters, Venturi tube — Flow nozzle -- Principle and construction and details of Electromagnetic flow meter — Ultrasonic flow meters

**LEVEL MEASUREMENT**

Float gauges - Electrical types: Conductivity sensors, Boiler drum level measurement - Differential pressure method,

**VISCOSITY MEASUREMENT**

Viscosity — Saybolt viscometer-Rotameter type viscometer

**HIGH TEMPERATURE MEASUREMENTS:**

Special techniques for measuring high temperature using thermocouple -Radiation fundamentals - Radiation methods of temperature measurement - Total radiation pyrometers -Optical pyrometers

**PRESSURE MEASUREMENT**

Units of pressure - Manometers, different types, Elastic type pressure gauges Capacitive type pressure gauge

## Learning Resources

1. Patranabis, D. Principles of Industrial Instrumentation, 3rd Edition, Tata McGraw Hill, New Delhi, 2010.
2. Doebelin, E.O.andManik,D.N., Measurement Systems Application and Design, Special Indian Edition, Tata McGraw Hill Education Pvt. Ltd., 2007.
3. Liptak, B.C., Instrumentation Engineers Handbook (Measurement), CRC Press, 2005.
4. Singh,S.K., Industrial Instrumentation and Control, 3rd edition, McGrawHill Education., New Delhi, 2015.
5. Jain, R.K., Mechanical and Industrial Measurements, 12th edition, Khanna Publishers, Delhi, 2011.

6. A. K. Sawhney, PuneetSawhney Course in Mechanical Measurements and Instrumentation and Control, Dhanpat Rai & Sons, New Delhi, 1997.

**Course Contents and Lecture Schedule**

| Module No. | Topic | No. of Lectures |
|---|---|---|
| 1 | **MEASUREMENT OF FORCE, TORQUE:** | |
| 1.1 | Different types of load cells, Hydraulic, Pneumatic, strain gauge- Magneto-elastic and Piezoelectric load cells | 3 |
| 1.3 | Different methods of torque measurement:- Strain gauge-Relative angular twist | 2 |
| 2 | **MEASUREMENT OF ACCELERATION, VIBRATION:** | |
| 2.1 | Accelerometers: - LVDT, Piezoelectric, | 1 |
| 2.2 | Strain gauge and Variable reluctance type accelerometers | 1 |
| 2.3 | Mechanical type vibration instruments - Seismic instruments as accelerometer | 2 |
| 2.4 | Vibration sensor - Calibration of vibration pickups | 1 |
| 3 | **FLOW MEASUREMENTS:** | |
| 3.1 | Orifice plate different types of orifice plates | 3 |
| 3.2 | Difference between area flow and mass flow meters | 1 |
| 3.3 | Venturi tube — Flow nozzle | 2 |
| 3.4 | Principle and constructional details of Electromagnetic flow meter | 2 |
| 3.5 | Ultrasonic flow meters | 1 |
| 4 | **LEVEL MEASUREMENT :** | |
| 4.1 | Float gauges - Displacer type, DIP methods | 1 |
| 4.2 | Bubbler system-Load cell Electrical types: Conductivity sensors | 1 |
| 4.3 | Boiler drum level measurement - Differential pressure method | 1 |
| 5 | **MEASUREMENT OF VISCOSITY:** | |
| 5.1 | Viscosity | 1 |
| 5.2 | Saybolt viscometer | 1 |
| 5.3 | Rotameter type viscometer | 1 |
| 6.1 | **HIGH TEMPERATURE MEASUREMENTS:** | |
| | Special techniques for measuring high temperature using thermocouple | 2 |
| 6.2 | Radiation fundamentals: Radiation methods of temperature measurement - | 3 |
| 6.3 | Total radiation pyrometers , Optical pyrometers | 2 |
| **7** | **PRESSURE MEASUREMENT:** | |
| 7.1 | Units of pressure - Manometers, different types, | 2 |
| 7.2 | Elastic type pressure gauges | 1 |
| 7.3 | Capacitive type pressure gauge | 1 |
| | Total | 36 |

**Course Designers:**

1. Dr.V.Prakash vpeee@tce.edu
2. Prof. R. Suganya rsaeee@tce.edu

| 18EERJ0 | QUALITY ENGINEERING | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

This course covers the foundations of modern methods of quality control and improvement that are used in the manufacturing and service industries. Quality is the key to surviving tough competition. Consequently, business needs technically competent people who are well-versed in statistical quality control and improvement. This course starts with the philosophy and fundamentals of quality control. It then deals with the statistical foundations of quality control. Statistical Process Control and acceptance sampling are then covered. This course also deals with product and process design including quality assurance, reliability and environmental requirements and introduces experimental design techniques. This course also demonstrates the use of computer software package, Minitab, for quality control and improvement exercises and R tools for statistical simulation.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course students will be able to

| CO Number | Course Outcome Statement | Weightage*** in % |
|---|---|---|
| CO1 | Explain the Philosophy behind Quality Engineering | 10 |
| CO2 | Explain the fundamental concepts and standards of Quality Engineering | 10 |
| CO3 | Estimate Quality characteristics using statistical concepts and techniques | 20 |
| CO4 | Determine suitable control chart for a given statistical process control | 30 |
| CO5 | Illustrate the basics of product quality in terms of Electrical and Electronics systems | 15 |
| CO6 | Explain the basics of process quality in terms of Electrical, Electronics and software systems | 15 |

*** Weightage depends on Bloom's Level, number of contact hours,

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| | | | | | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.1.1 |
| CO2 | TPS2 | Understand | Respond | | 1.3, 2.1.1 |

| | | | | | |
|---|---|---|---|---|---|
| CO3 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.2 |
| CO5 | TPS2 | Apply | Value | | 1.3 |
| CO6 | TPS2 | Understand | Respond | | 1.3 |
| | | | | | |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | M | L | L | | | | M | | M | | | M | |
| CO2 | S | M | L | | | | | M | | M | | | M | |
| CO3 | S | M | M | L | | | | M | | M | | | M | |
| CO4 | S | M | L | L | | | | M | | M | | | M | |
| CO5 | S | M | L | | | | | M | | M | | | M | |
| CO6 | M | L | | | | | | M | | M | | | M | |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 50 | 50 | 80 | - | - | - | 50 |
| Apply | 30 | 30 | **-** | 100 | 100 | 100 | 30 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

**Assessment Pattern: Psychomotor**

| **Psychomotor Skill** | **Miniproject /Assignment/Practical Component** |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

**Course Outcome 1(CO1):**

1. Define Quality according to Juran and Deming's view.
2. Discuss Juran's Triology.
3. Explain Deming's 14 points of management

**Course Outcome 2(CO2):**

1. List the evaluation process of Quality control from 1920 to 1970 according to Feigenbaum.
2. Discuss the types of measurements scales used to classify data
3. List the features of 6 sigma quality standard.

**Course Outcome 3(CO3):**

1. Construct Cause and effect diagram for Edge flaws problem.
2. The % cost of quality for 12 projects are given below. Calculate the chance that a project's % cost of quality will be within 15 ± 6 %

| | | | | | |
|---|---|---|---|---|---|
| 15.35 | 13.90 | 15.11 | 13.02 | 11.67 | 14.15 |
| 8.07 | 15.95 | 17.45 | 14.53 | 11.73 | 16.89 |

3. A study is undertaken to reduce the cost of quality to 0.2. During brainstorming, one of the team members suggested that wherever the rework effort / total effort < 0.07, those projects have cost of quality generally lower than 0.2. The data on cost of quality of projects with rework effort / total effort < 0.07 is given below. Validate the suggestion?

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.15 | 0.22 | 0.12 | 0.21 | 0.12 | 0.19 | 0.33 |
| 0.11 | 0.22 | 0.3 | 0.18 | 0.31 | 0.19 | 0.27 |

**Course Outcome 4 (CO4)**

1. The data given below are surface Finish values of 30 jobs after chromium plating. Construct an Individual X & Moving Range chart to monitor the process.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0.078 | 0.079 | 0.077 | 0.076 | 0.074 | 0.072 | 0.069 | 0.075 | 0.078 | 0.077 |
| 0.075 | 0.078 | 0.08 | 0.081 | 0.08 | 0.079 | 0.082 | 0.073 | 0.078 | 0.074 |
| 0.072 | 0.075 | 0.068 | 0.073 | 0.074 | 0.081 | 0.076 | 0.08 | 0.074 | 0.07 |

2. For the given data's
    - Calculate Control Limits
    - Plot Control Chart
    - Calculate Process Capability Indices (Pp/Ppk).
    - Monitor Process through plotting control chart.

| Sample No. | Hour | x1 | x2 | x3 | x4 |
|---|---|---|---|---|---|
| 1 | 8:00 | 5.00 | 5.01 | 4.98 | 5.00 |
| 2 | 9:00 | 5.01 | 4.98 | 5.00 | 5.00 |
| 3 | 10:00 | 5.02 | 5.01 | 5.00 | 5.00 |
| 4 | 11:00 | 5.00 | 5.00 | 5.00 | 5.00 |
| 5 | 12:00 | 4.98 | 4.98 | 5.01 | 4.99 |

| | | | | | |
|---|---|---|---|---|---|
| 6 | 13:00 | 5.02 | 4.99 | 5.00 | 4.98 |
| 7 | 14:00 | 4.99 | 4.99 | 4.98 | 4.98 |
| 8 | 15:00 | 5.00 | 5.01 | 5.02 | 5.00 |
| 9 | 16:00 | 4.98 | 5.00 | 5.01 | 4.98 |

3. 20 data on acid content (mm) is given in the table below. If the specification on acid content is 0.70 ± 0.2 mm. Check whether the process has the potential to meet the customer requirement.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0.85 | 0.75 | 0.80 | 0.65 | 0.75 | 0.60 | 0.80 | 0.70 | 0.75 | 0.60 |
| 0.80 | 0.75 | 0.70 | 0.70 | 0.75 | 0.75 | 0.85 | 0.60 | 0.50 | 0.65 |

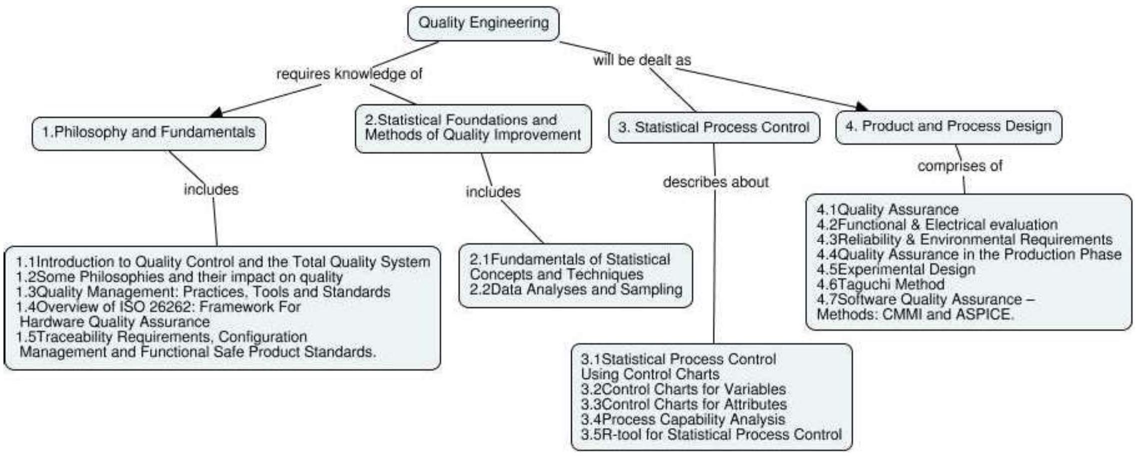
**Course Outcome 5 (CO5)**

1. Write the purpose of evaluation in Product design.
2. Explain the Philosophy behind APQP
3. Explain the electrical and electronics evaluation in terms of PCB.

**Course Outcome 6 (CO6)**

1. Outline electrical evaluation carried out in industrial automotive field.
2. Explain the functionality of Quality Assurance team activities.
3. Write the purpose of evaluation in Process design

## Concept Map




## Syllabus

**Philosophy and Fundamentals**

Introduction to Quality Control and the Total Quality System, Some Philosophies and their impact on quality, Quality Management: Practices, Tools and Standards, Overview of ISO 26262: Framework For Hardware Quality Assurance - Traceability Requirements, Configuration Management and Functional Safe Product Standards.

**Statistical Foundations and Methods of Quality Improvement**

Fundamentals of Statistical Concepts and Techniques, Data Analyses and Sampling.

**Statistical Process Control**

Statistical Process Control Using Control Charts, Control Charts for Variables, Control Charts for Attributes, Process Capability Analysis. R-tool for Statistical Process Control.

**Product and Process Design**

Quality Assurance, Functional & Electrical evaluation, Reliability & Environmental Requirements, Quality Assurance in the Production Phase, Experimental Design and the Taguchi Method, Software Quality Assurance – Methods: CMMI and ASPICE.

## Learning Resources


1. A.Mitra, "Fundamentals of Quality Control and Improvement", Wiley, Fourth Edition, 2016
2. W.Fleischammer, "Quality by Design for Electronics", Chapman & Hall, First Edition, 1996
3. H.M.Wadsworth, K.S.Stephens and A.B.Godfrey, "Modern Methods for Quality Control and Improvement", John Wiley & Sons. 2nd Edition, 2004
4. M.S. Phadke, "Quality Engineering using Robust Design", Pearson, 2008.


## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1. | **Philosophy and Fundamentals** | | |
| 1.1 | Introduction to Quality Control and the Total Quality System | 2 | CO1 |
| 1.2 | Some Philosophies and their impact on quality | 2 | CO1 |
| 1.3 | Quality Management: Practices, Tools and Standards | 2 | CO2 |
| 1.4 | Overview of ISO 26262: Framework For Hardware Quality Assurance | 1 | CO2 |
| 1.5 | Traceability Requirements, Configuration Management and Functional Safe Product Standards. | 2 | CO2 |
| 2. | **Statistical Foundations and Methods of Quality Improvement** | | |
| 2.1 | Fundamentals of Statistical Concepts and Techniques | 2 | CO3 |
| 2.2 | Data Analyses and Sampling | 3 | CO3 |
| 3 | **Statistical Process Control** | | |
| 3.1 | Statistical Process Control Using Control Charts | 1 | CO4 |
| 3.2 | Control Charts for Variables | 1 | CO4 |
| 3.3 | Control Charts for Attributes | 2 | CO4 |
| 3.4 | Process Capability Analysis | 2 | CO4 |
| 3.5 | R-tool for Statistical Process Control | 3 | CO4 |
| 4 | **Product and Process Design** | | |
| 4.1 | Quality Assurance | 1 | CO5 |
| 4.2 | Functional & Electrical evaluation | 2 | CO5 |
| 4.3 | Reliability & Environmental Requirements | 2 | CO5 |

| Module No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 4.4 | Quality Assurance in the Production Phase | 2 | CO6 |
| 4.5 | Experimental Design | 2 | CO6 |
| 4.6 | Taguchi Method | 2 | CO6 |
| 4.7 | Software Quality Assurance – Methods: CMMI and ASPICE. | 2 | CO6 |
| **Total** | | **36** | |

**Course Designers:**

1. Dr. S. Charles Raja charlesrajas@tce.edu
2. Dr.R.Medeswaran medes@tce.edu

| 18EERK0 | RELIABILITY ENGINEERING | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

This course is designed to provide an introduction to reliability engineering. Reliability engineering fulfils the need for a time-based concept of quality. Competition, the pressure of schedules and deadlines, the cost of failures, the rapid evolution of new materials, methods and complex systems, the need to reduce product costs, and safety considerations all increase the risks of product development. Reliability engineering has developed in response to the need to control these risks. Understanding of reliability engineering principles and methods is now an essential ingredient of modern engineering. This course starts by explaining the fundamental concepts of reliability engineering. It demonstrates how reliability engineering methods can be applied to design and development to control the level of risk. Reliability of electrical and electronic systems is dealt in detail. This course explains reliability testing and analysis covering environmental and stress testing and the integration of reliability and other development testing. This course also demonstrates reliability prediction using failure rate database including an introduction to computer simulation tools to predict electrical and electronic product and system reliability.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course, students will be able to

| CO | Course Outcomes | Weightage in %*** |
|---|---|---|
| CO1 | Explain the basic concepts of Reliability Engineering | 15 |
| CO2 | Identify the reliability of Electrical systems | 20 |
| CO3 | Illustrate the reliability prediction of Electronic systems | 20 |
| CO4 | Classify reliability testing and data analysis | 20 |
| CO5 | Estimate the reliability of electrical and electronic systems using failure rate database | 15 |
| CO6 | Explain the importance of reliability in electric vehicles | 10 |

*** Weightage depends on Bloom's Level, number of contact hours

## CO Mapping with CDIO Curriculum Framework

| CO | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.3.1,3.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO2 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 4.5.3 |
| CO3 | TPS2 | Understand | Respond | | 1.3, 2.3.1, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 4.5.3 |
| CO5 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 4.5.3 |
| CO6 | TPS2 | Understand | Respond | | 1.3, 2.3.1,3.2.3 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | M |
| CO2 | S | M | L | | | | | M | | M | | | S | S |
| CO3 | M | L | | | | | | M | | M | | | M | M |
| CO4 | S | M | L | | | | | M | | M | | | S | S |
| CO5 | S | M | L | | | | | M | | M | | | S | S |
| CO6 | M | L | | | | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

## Assessment Pattern- Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 50 | 30 | 30 | - | - | - | 30 |
| Apply | 30 | 50 | 50 | 100 | 100 | 100 | 50 |
| Analyse | - | - | - | - | - | - | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. Discuss why engineering products fail.
2. Define reliability. What is its relation to probability of failure?
3. Suppose that the scores in an examination are normally distributed with mean μ= 76, standard deviation=15, the top 15% of students are A grade, bottom 10% are F grade. Find the minimum score to receive A Grade.

**Course Outcome 2 (CO2):**

1. In a normal domestic kitchen containing a fluorescent light fitting and a washing machine, list the EMI sources you may find and how as a designer you may mitigate these effects.

2. Write down the importance of Computer Aided Engineering and Environments in reliability design.
3. Write down the stress effects of current.

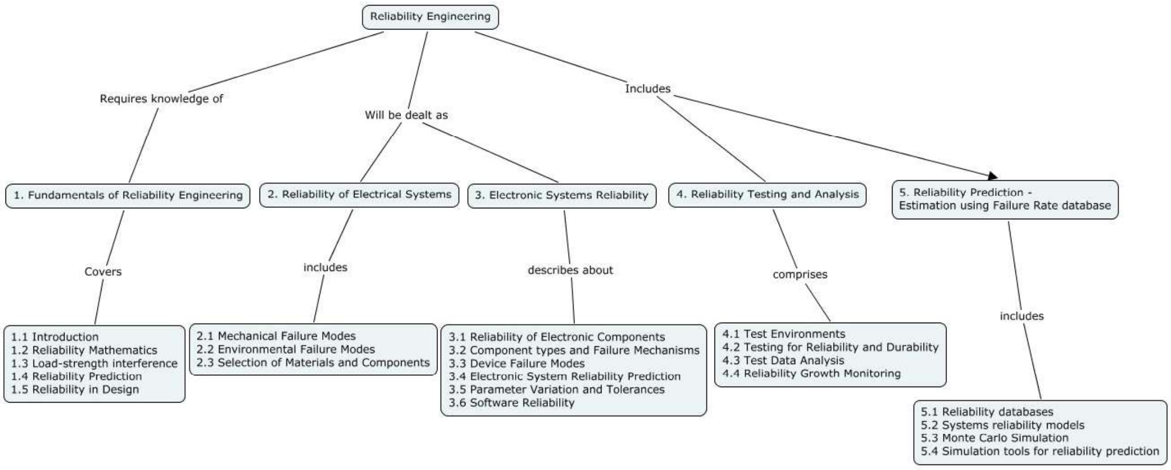
**Course Outcome 3 (CO3):**
1. You are designing an electronic unit that will be used on an agricultural machine. What failures might be caused by the vibration environment? What steps would you take to minimize these?
2. Describe three methods for analyzing the effects of component parameter variations on the performance of an electronic circuit. For each, describe how the variations and their effects can be minimized by the designer.
3. For a small plastic transistor operating at 120mW, estimate Tj if ϴ=0.4°C mW-1 above 25°C, if the ambient temperature is 50°C. If the maximum junction temperature is 150°C, estimate what power the transistor will dissipate at an ambient temperature of 60°C

**Course Outcome 4 (CO4)**
1. Explain the Highly Accelerated Life Testing.
2. Write down the main principles of effective vibration testing.
3. The first reliability qualification test on a new electronic test equipment generates 11 failures in 600h, with no one type of failure predominating. The requirement set for the production standard equipment is an MTBF of not less than 500h in service. How much more testing should be planned, assuming values for α of 0.3 and 0.5?

**Course Outcome 5 (CO5)**
1. Suppose that you have run a Monte Carlo analysis (m samples) and wish to cut the standard deviation in half. How many samples do you need to run?
2. Test the hypothesis that whenever several random variables are added together, the resulting sum tends to normal regardless of the distribution of the variables being added. Sample the sum of 10 random variables from different statistical distribution and test the normality of this sum by constructing the histogram or using other statistical tools.
3. An electric circuit current was modelled with 1000 experiments. The mean value of the outputs is 25 amps with the standard deviation of 8 amps. Estimate the number of runs required to achieve 1 % accuracy with 95 % confidence.

**Course Outcome 6 (CO6):**
1. Discuss the importance of reliability in Electric Vehicles.
2. What are the requirements of an EV battery to be reliable?
3. State the effects of failure of electric drive reliability in EV.

## Concept Map




## Syllabus

**Fundamentals of Reliability Engineering**
Introduction, Reliability Mathematics, Load-strength Interference, Reliability Prediction, Reliability in Design

**Reliability of Electrical Systems**
Mechanical Failure Modes, Environmental Failure Modes, Selection of Materials and Components.

**Electronic Systems Reliability**
Reliability of Electronic Components, Component types and Failure Mechanisms, Device Failure Modes, Electronic System Reliability Prediction, Parameter Variation and Tolerances, Software Reliability.

**Reliability Testing and Analysis**
test Environments, Testing for Reliability and Durability, Test Data Analysis, Reliability Growth Monitoring.

**Reliability Prediction – Estimation using Failure rate database**
Reliability databases, systems reliability models, Monte Carlo Simulation, simulation tools for reliability prediction.

**Reliability of Electric Vehicle components**
Importance of reliability in Electric Vehicle components - batteries - electric drives.

## Learning Resources

1. Patrick D. T. O'Connor, "Practical Reliability Engineering", Fourth Edition, Wiley- India, 2006
2. E.E. Lewis, "Introduction to Reliability Engineering", Wiley, 1987
3. E. Balaguruswamy, "Reliability Engineering", Tata McGraw-Hill Publishing Co. Ltd., 1984
4. B.S. Dhillion, C. Singh, "Engineering Reliability", John Wiley & Sons, 1980

## Course Contents and Lecture Schedule

| No. | TOPIC | No. of Lectures | CO |
|---|---|---|---|
| 1 | **Fundamentals of reliability engineering** | | |
| 1.1 | Introduction | 1 | CO1 |
| 1.2 | Reliability Mathematics | 2 | CO1 |
| 1.3 | Load-strength Interference | 1 | CO1 |
| 1.4 | Reliability Prediction | 2 | CO1 |
| 1.5 | Reliability in Design | 2 | CO1 |
| 2. | **Reliability of Electrical Systems** | | |
| 2.1 | Mechanical Failure Modes | 2 | CO2 |
| 2.2 | Environmental Failure Modes | 2 | CO2 |
| 2.3 | Selection of Materials and Components | 2 | CO2 |
| 3 | **Electronic Systems Reliability** | | |
| 3.1 | Reliability of Electronic Components | 1 | CO3 |
| 3.2 | Component types and Failure Mechanisms | 2 | CO3 |
| 3.3 | Device Failure Modes | 2 | CO3 |
| 3.4 | Electronic System Reliability Prediction | 1 | CO3 |
| 3.5 | Parameter Variation and Tolerances | 1 | CO3 |
| 3.6 | Software Reliability | 1 | CO3 |
| 4 | **Reliability Testing and Analysis** | | |
| 4.1 | Test Environments | 2 | CO4 |
| 4.2 | Testing for Reliability and Durability | 2 | CO4 |
| 4.3 | Test Data Analysis | 2 | CO4 |
| 4.4 | Reliability Growth Monitoring | 1 | CO4 |
| 5. | **Reliability Prediction – Estimation using Failure rate database** | | |
| 5.1 | Reliability databases | 1 | CO5 |
| 5.2 | Systems reliability models | 1 | CO5 |
| 5.3 | Monte Carlo Simulation | 1 | CO5 |
| 5.4 | Simulation tools for reliability prediction | 1 | CO5 |
| 6 | **Reliability of Electric Vehicle Components** | | |
| 6.1 | Importance of reliability in Electric Vehicle components | 1 | CO6 |
| 6.2 | Reliability of batteries | 1 | CO6 |
| 6.3 | Reliability of electric drives | 1 | CO6 |
| | **Total** | **36** | |

## Course Designers:

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| 18EEPY0 | POWER QUALITY | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

**Preamble**

This course imparts knowledge about various electrical power quality issues and their origin and addresses the effects of power quality problems on electrical power system. It also emphasis need for PQ monitoring and measurement. The study on transient and power factor enables students to understand the characteristics and performance of the real system. The topic on introduction to mitigation devices gives solution for solving various PQ issues.

**Prerequisite**

18EE510 : Generation, Transmission and Distribution
18EE530 : Power Electronics

**Course Outcomes**

On the successful completion of the course, students will be able to :

| Course Outcome No. | Course Outcomes | Weightage*** in % |
|---|---|---|
| CO1 | Explain various power quality problems | 20 |
| CO2 | Discuss the root cause of power quality problems | 30 |
| CO3 | Determine the PQ indices in the given electrical system | 10 |
| CO4 | Assess the severity of PQ problems in distribution system | 10 |
| CO5 | Analyze various power quality issues and their solutions in residential / commercial / industrial facilities | 20 |
| CO6 | Develop an ability to analyse the measured data | 10 |

*** Weightage depends on Bloom's Level, number of contact hours

**CO Mapping with CDIO Curriculum Framework**

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 4.1.1, 4.1.2 |
| CO2 | TPS2 | Understand | Respond | - | 1.3, 2.1.1, 2.3.1, 4.1.1, 4.1.2 |
| CO3 | TPS3 | Apply | Value | - | 1.3, 2.1.1, 2.3.1, 2.3.2, 4.1.2, 4.3.1, 4.3.2 |
| CO4 | TPS3 | Apply | Value | - | 1.3,2.1.1, 2.3.1, 2.3.2, 4.1.2, 4.3.1, 4.3.2 |

| | | | | | |
|---|---|---|---|---|---|
| CO5 | TPS4 | Analyze | Organise | - | 1.3,2.1.5, 2.3.2, 2.3.3, 4.1.1, 4.1.2, 4.3.3, 4.3.4, 4.5.5 |
| CO6 | TPS3 | Apply | Value | - | 1.3,2.1.1, 2.3.1, 2.3.2, 4.1.2, 4.3.1, 4.3.2 |

## Mapping with programme outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | M |
| CO2 | M | L | | | | | | M | | M | | | M | M |
| CO3 | S | M | L | | | | | M | | M | | | M | M |
| CO4 | S | M | L | | | | | M | | M | | | M | M |
| CO5 | S | M | M | | | | | M | | M | | | M | M |
| CO6 | S | M | M | | | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 10 | 10 | - | - | - | 10 |
| Understand | 40 | 40 | 40 | - | - | - | 40 |
| Apply | 40 | 30 | 30 | 100 | 50 | 50 | 30 |
| Analyze | - | 20 | 20 | - | 50 | 50 | 20 |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Mini project /Assignment/Practical Component |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |

| | |
|---|---|
| Adaptation | - |
| Origination | - |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1) :**

1. What is Power Quality?
2. What is the most common power quality Problem? Why has power quality only become an issue in recent years?
3. What are harmonics?
4. Define DC offset, Inter harmonics
5. Define voltage unbalance
6. What are the major power quality issues? Explain in detail

**Course Outcome 2 (CO2) :**
1. What are the root causes of voltage sag?
2. List few sources that cause harmonics.
3. Name any two IEEE standards that define power quality.
4. Discuss about long and short duration voltage variations.
5. Discuss in detail about transients
6. Explain the following: a) Total harmonic distortion b) Total demand distortion

**Course Outcome 3 (CO3) :**

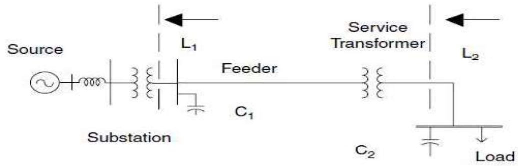
1. A highly inductive non linear load consumes 400 kW and 192 Kvar. The current THD is 27 %. Find the true power factor.
2. Illustrate the impact of voltage sag on efficiency of the industrial equipments.
3. Illustrate various factors affecting the sag magnitude and when does voltage sag lead to interruption?

**Course Outcome 4 (CO4) :**
1. Suppose that a capacitor bank installed for reactive power compensation at a six pulse power converter applications to be tuned to fifth harmonic. Compute the required reactor size and verify whether capacitor bank operation fall within IEEE limits.
2. A waveform contains 50 Hz fundamental, plus $5^{rd}$, $9^{th}$, $11^{th}$, $13^{th}$ harmonics with their magnitudes 0.3, 0.1, 0.05 and 0.01respectively. CalculateTHD.
3. Calculate the *k* rating of a transformer required to carry a load consisting of 1000 A of fundamental, 120 A of third harmonics, 80 A of fifth harmonics, and 40 A of seventh harmonics.

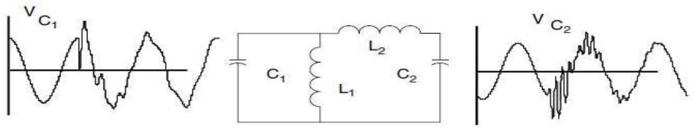
**Course Outcome 5 (CO5) :**
1. Investigate the filter requirement to attenuate the 5th, 7th, and 11th harmonics. Also design such that each filter section is tuned 4 percent below the filtered harmonic.
2. Examine the harmonic currents drawn from the line and design a filter to comply with IEEE-519, where the source is 277 V, line-to-neutral. The fundamental load current at 50 Hz is 100 A. This load also draws fifth-harmonic current $I_5$ = 20 A and seventh-harmonic current $I_7$ = 15 A.
3. Examine the capacitor bank requirement to improve the power factor from the present level to typically 0.9 to 0.95. Determine whether capacitor operating parameters fall within IEEE maximum recommended limits.

**Course Outcome 6 (CO6) :**

1. A nonlinear industrial load has a rated power factor of 0.9, but the measuring device reads power factor as 0.81. Identify the reason and determine the root cause of the issue.
2. Calculate the following from the data given below:
   a) kvar required to improve PF to 0.95 lag
   b) Cost of additional capacitor
   c) Reduction in kVA demand
      Rating of transformer = 2000 kVA
      Average loading on the transformer = 1200 kVA
      Present power factor (old pf) = 0.7 (lag)
      Unit cost of Capacitor/Kvar = Rs. 300
3. Identify the reasons for voltage magnification at the consumer end due to energizing capacitor on utility system. State the harmful impact of this scenario.

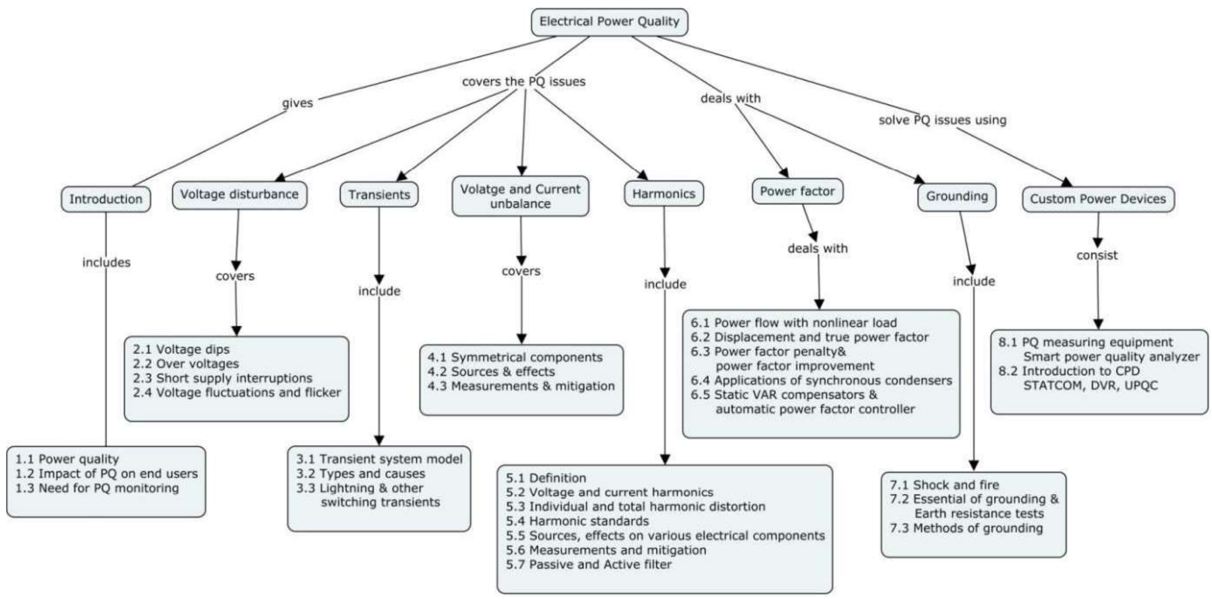


(a) Voltage magnification at customer capacitor due to energizing capacitor on utility system



(b) Equivalent circuit

## Concept Map




## Syllabus

### Introduction

Power quality - Impact of PQ on end users, Need for PQ monitoring, Various PQ problems

### Voltage disturbances

Voltage dips, over voltages, short supply interruptions, voltage fluctuations and flicker - sources, effects, measurement and mitigation

**Transients**
Transient system model, examples of transient models and their response, power system transient model, types and causes of transients, lightning, other switching transients.

**Voltage and Current Unbalance**
Symmetrical components of currents and voltages, sources, effects, measurements and mitigation

**Harmonics**
Definition, odd and even harmonics, harmonic phase sequence, voltage and current harmonics, individual and total harmonic distortion, harmonic standards, sources, effects on various electrical components, measurements and mitigation, passive and active filters (Case Studies)

**Power factor**
Active and reactive power flow with nonlinear load, displacement and distortion power factor, power factor penalty, power factor improvement, applications of synchronous condensers and static VAR compensators, automatic power factor controller (Case Studies)

**Effect of Grounding**
Shock and fire hazards, essential of a grounded system, earth resistance tests, methods of grounding, effect of poor grounding on power quality.

**Solving power quality problems using CPD**
Power quality measuring equipment-Smart power quality analyzers, Introduction to custom power devices (CPD) – STATCOM, DVR, UPQC.

## Learning Resources


1. Sankaran C,"Power Quality", CRC Press special Indian edition 2009.
2. Angelo Baggini, "Handbook of Power Quality" John Wiley & Sons Ltd, 2008.
3. Roger .C. Dugan, Mark F.Mcgranaghan & H.Wayne Beaty," Electrical power system Quality" McGraw-Hill Newyork Second edition 2003.
4. Barry W.Kennedy, "Power Quality Primer", McGraw-Hill, New York, 2000.
5. Math H.J.Bollen, « Understanding Power Quality Problems : Voltage Sags and Interruptions », IEEE Press, New York, 2000.
6. Arrillaga.J, Watson.N.R and Chen.S, « Power System Quality Assessment », John Wiley & Sons Ltd., England, 2000
7. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad: Power Quality: Problems and Mitigation Technique, Wiley Publications, 2015
8. Arindam Ghosh and Gerald Ledwich: Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers, 2002.
9. G.T.Heydt: Electric Power Quality, 2nd edition, Stars in a Circle Publications, 1994.
10. Math H.J.Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions", IEEE Press, New York, 2000.


## Course contents and Lecture schedule

| Sl No. | Topic | No. of Hours | Course Outcome |
|---|---|---|---|
| 1 | **Introduction** | | |

| | | | |
|---|---|---|---|
| 1.1 | Power quality | 1 | CO1 |
| 1.2 | Impact of PQ on end users | 1 | CO2 |
| 1.3 | Need for PQ monitoring | 1 | CO6 |
| 2 | **Voltage disturbances** | | |
| 2.1 | Voltage dips | 1 | CO3 |
| 2.2 | Over voltages | 1 | CO3 |
| 2.3 | Short supply interruptions | 1 | CO2 |
| 2.4 | Voltage fluctuations and flicker | 1 | CO2 |
| 3 | **Transients** | | |
| 3.1 | Transient system model, examples of transient models and their response, power system transient model | 2 | CO1 |
| 3.2 | Types and causes of transients | 1 | CO1 |
| 3.3 | Lightning, other switching transients | 1 | CO2 |
| 4 | **Voltage and Current Unbalance** | | |
| 4.1 | Symmetrical components of currents and voltages, | 1 | CO3 |
| 4.2 | Sources & effects | 1 | CO2 |
| 4.3 | Measurements and mitigation | 1 | CO3 |
| 5 | **Harmonics** | | |
| 5.1 | Definition, odd and even harmonics, harmonic phase sequence | 1 | CO1 |
| 5.2 | Voltage and current harmonics | 1 | CO1 |
| 5.3 | Individual and total harmonic distortion | 1 | CO4 |
| 5.4 | Harmonic standards | 1 | CO4 |
| 5.5 | Sources, effects on various electrical components | 1 | CO2 |
| 5.6 | Measurements and mitigation | 1 | CO6 |
| 5.7 | Passive and Active filter | 1 | CO5 |
| 6 | **Power factor** | | |
| 6.1 | Active and reactive power flow with nonlinear load | 1 | CO2 |
| 6.2 | Displacement and distortion power factor | 1 | CO2 |
| 6.3 | Power factor penalty, power factor improvement | 1 | CO5 |
| 6.4 | Applications of synchronous condensers | 1 | CO5 |
| 6.5 | Static VAR compensators, automatic power factor controller | 2 | CO5 |
| 7 | **Grounding** | | |
| 7.1 | Shock and fire | 1 | CO1 |
| 7.2 | Essential of grounding, Earth resistance tests | 1 | CO6 |
| 7.3 | Methods of grounding | 1 | CO5 |
| 7.4 | Effect of poor grounding on power quality | 1 | CO5 |
| 8 | **Solving power quality problems using CPD** | | |
| 8.1 | Power quality measuring equipment, Smart power quality analyzer | 2 | CO6 |
| 8.2 | Introduction to custom power devices –STATCOM, DVR, UPQC | 3 | CO5 |
| | **Total** | **36** | |

**Course Designers**

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| 18EEPZ0 | SPECIAL MACHINES AND DRIVES | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

This course aims to impart in students, a good understanding of fundamental principles of different types of special machines. The course includes constructional details, operating principles, motor characteristics, microprocessor based controllers and applications of various types of special machines.

## Prerequisite

- 18EE320 - DC Machines and Transformers
- 18EE420- AC Machines

## Course Outcomes

On the successful completion of the course, students will be able to

| Course OutcomeNo. | Course Outcomes | Weightage in % |
|---|---|---|
| CO1. | Illustrate the basic construction and operating principle of Synchronous Reluctance Motor, SRM, Stepper motor, PMSM, PMBLDC Motor and Linear Induction Motor. | 25 |
| CO2. | Explain the motor characteristics, power input and torque developed for Synchronous Reluctance Motor, SRM, Stepper motor, PMSM and PMBLDC Motor. | 25 |
| CO3. | Develop the drive systems and control schemes for Stepper motors, SRM,PMSM and PMBLDC Motor. | 20 |
| CO4. | Develop a suitable special purpose motor drive for the specific application | 10 |
| CO5. | Explain the Microprocessor/ DSP based control of Stepper motors, SRM,PMSM and PMBLDC Motor. | 10 |
| CO6. | Analyse the performance of a drive system using Matlab-Simulink | 10 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4,3.2.3 |
| CO2 | TPS2 | Understand | Respond | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO3 | TPS3 | Apply | Value | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO4 | TPS3 | Apply | Value | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO5 | TPS2 | Understand | Respond | | 1.2.5, 2.1.1, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO6 | TPS5 | Analyze | Organise | Complex Overt Responses | 1.2.7, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |

**Mapping with Programme Outcomes and Programme Specific Outcomes**

| COs | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 | PSO 1 | PSO 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | |
| CO2 | M | L | | | | | | M | | M | | | M | |
| CO3 | S | M | L | | | | | M | | M | | | S | |
| CO4 | S | M | L | | | | | M | | M | | | S | |
| CO | M | L | | | | | | M | | M | | | M | |
| CO6 . | S | S | M | M | S | | | M | | M | | | S | |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 10 |
| Understand | 60 | 50 | 50 | - | - | - | 60 |
| Apply | 20 | 30 | 30 | - | - | - | 30 |
| Analyse | - | - | - | 100 | 100 | 100 | - |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

Note: Assignment topics are based on analysis of the performance of special purpose motor drives using Matlab-Simulink.

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1):**

1. Illustrate the construction and working principle of a synchronous reluctance motor.
2. Explain the working principle of Linear Induction motor.
3. Explain the various operating modes of SR motor with neat diagrams.

**Course Outcome 2 (CO2):**

1. How do you obtain the current-flux linkage characteristics of a SRM?
2. Explain the torque-speed characteristics of a BLDC motor.
3. Derive the expression for power input and torque of a PMSM.

**Course Outcome 3 (CO3)**

1. Design an open loop controller for a four phase VR stepper motor.
2. Explain the closed loop speed control system for a SRM drive.
3. Illustrate a low cost three phase BLDC motor drive.

**Course Outcome 4 (CO4)**

1. Select the suitable special purpose motor drive for the following applications:

(a) PC based scanning equipment (b) Traction (c) Fan and also justify your choice.
2. Find a suitable special purpose motor drive system for optical disk drive head driving mechanism. Illustrate the schematic of the motor drive.
3. Illustrate the closed loop drive system suitable for industrial process control where variable speed, precise motion control and stable operation are critical.

**Course Outcome 5 (CO5)**

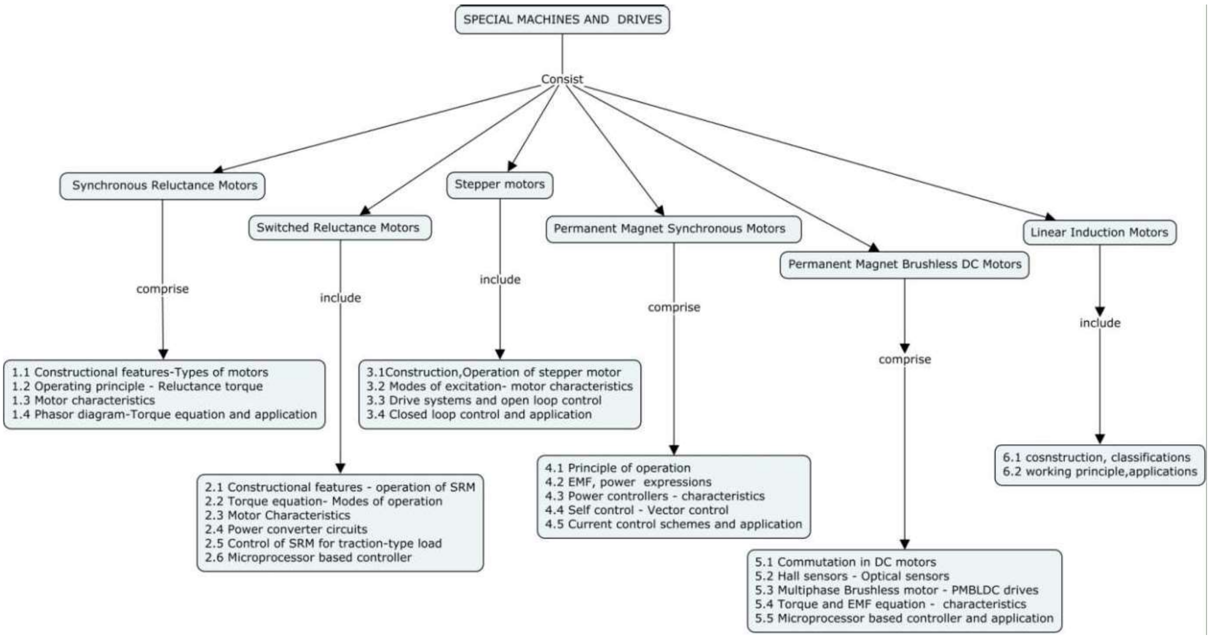
1. Explain the role of microprocessor in the design of closed loop variable reluctance stepper motor drive.
2. Discuss the implementation of vector control in PMSM using DSP.
3. Illustrate the microprocessor based BLDC motor drive.

**Course Outcome 6 (CO6)**

1. Model and Analyse a closed loop speed controlled SRM drive for the following cases: (a) Increase the reference speed (b) Increase the load torque. Use Matlab-Simulink.
2. Develop a Matlab-Simulink model for analysing the current and torque waveforms of a variable speed BLDC motor drive.

Design a self controlled PMSM using Matlab-Simulink.

## Concept Map




## Syllabus

**Synchronous Reluctance Motors**

Constructional features-Types-Cage rotor-Cageless rotor-Axial and Radial air gap Motors - Operating principle - Reluctance torque- Motor characteristics-Torque-angle characteristics-Speed-torque characteristics - Phasor diagram-Torque equation-Applications.

**Switched Reluctance Motors**

Constructional features - Principle of operation and control requirements- Torque equation - Modes of operation - Motor Characteristics –Current-Flux linkage Characteristics-Torque-Speed Characteristics-Power converter circuits – Control of SRM for traction-type load-Microprocessor based controller- Applications.

**Stepper motors**
Constructional features - Principle of operation - Torque production in Variable Reluctance (VR) stepper motor - Modes of excitation - Dynamic characteristics - Drive systems and Circuit for open loop control of stepper motor - Closed loop control of stepper motor- Applications.
**Permanent Magnet Synchronous Motors**
Principle of operation - EMF, power input and torque expressions - Phasor diagram - Power controllers - Torque speed characteristics - Self control - Vector control - Current control schemes- Applications.
**Permanent Magnet Brushless DC Motors**
Commutation in DC motors - Difference between mechanical and electronic commutators - Hall sensors - Optical sensors - Multiphase Brushless motor - Square wave permanent magnet brushless motor drives - Torque and EMF equation - Torque-speed characteristics – Microprocessor based controller- Applications.
**Linear Induction Motors**
Construction-Classifications-Working Principle-Applications.

## Learning Resources


1. Bimal K.Bose, “Modern Power Electronics and AC Drives”, Prentice Hall, New Delhi, 2005.
2. Gopal K.Dubey, ”Fundamentals of Electrical Drives”, Narosa Publishing House Pvt. Ltd.,New Delhi, Second edition, 2015.
3. R. Krishnan, Permanent Magnet Synchronous and Brushless DC Motor Drives, Prentice Hall of India, 2009.
4. T.J.E.Miller ,”Brushless Permanent Magnet and Reluctance DC Motor Drives”, Clarendon Oxford Press, 1989.
5. T. Kenjo, “Stepping Motors and their Microprocessor Controls”, Clarendon Oxford Press, 1994.
6. T. Kenjo and S. Naganori, “Permanent Magnet and Brushless DC motors”, Clarendon Oxford Press,1989.
7. T. Kenjo, “Power Electronics for the Microprocessor Age”, Oxford Press Publications, 1994.
8. J R Hendershot and T.J.E.Miller, “Design of Brushless Permanent Magnet Motors”, Oxford University Press,1995.
9. K.Venkataratnam, “Special Electrical Machines”,University Press(India) Pvt. Ltd.,2009.
10. I.Boldea and S.A.Nasar, “Linear motion electromagnetic systems”, Wiley Interscience,1985.
11. Ion Boldea, “Linear Electric Machines, Drives and MAGLEVs Handbook”, CRC Press, Taylor& Francis Group, 2013.


## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 1. | **Synchronous Reluctance Motors** | | |
| 1.1 | Constructional features-Types-Cage rotor-Cageless rotor-Axial and Radial air gap Motors | 1 | CO1 |
| 1.2 | Operating principle – Reluctance torque | 1 | CO1 |
| 1.3 | Motor characteristics-Torque-angle characteristics- Speed-Torque characteristics | 2 | CO2 |
| 1.4 | Phasor diagram-Torque equation- Applications | 2 | CO2 |

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 2. | **Switched Reluctance Motors** | | |
| 2.1 | Constructional features – Principle of operation and control requirements | 2 | CO1 |
| 2.2 | Torque equation- Modes of operation | 2 | CO2 |
| 2.3 | Motor Characteristics –Current-Flux linkage Characteristics-Torque-speed Characteristics | 2 | CO2 |
| 2.4 | Power converter circuits | 1 | CO3 |
| 2.5 | Control of SRM for traction-type load | 1 | CO3 |
| 2.6 | Microprocessor based controller- Applications | 1 | CO5 |
| 3. | **Stepper motors** | | |
| 3.1 | Constructional features – Principle of operation – Torque production in Variable Reluctance (VR) stepper motor | 2 | CO1 |
| 3.2 | Modes of excitation- Dynamic characteristics | 1 | CO2 |
| 3.3 | Drive systems and Circuit for open loop control of stepper motor | 2 | CO3 |
| 3.4 | Closed loop control of stepper motor- Applications | 1 | CO3 |
| 4 | **Permanent Magnet Synchronous Motors** | | |
| 4.1 | Principle of operation | 1 | CO1 |
| 4.2 | EMF, power input and torque expressions – Phasor diagram | 2 | CO2 |
| 4.3 | Power controllers – Torque speed characteristics | 1 | CO2 |
| 4.4 | Self control – Vector control | 2 | CO3 |
| 4.5 | Current control schemes- Applications | 1 | CO3 |
| 5 | **Permanent Magnet Brushless DC Motors** | | |
| 5.1 | Commutation in DC motors – Difference between mechanical and electronic commutators | 1 | CO1 |
| 5.2 | Hall sensors – Optical sensors | 2 | CO1 |
| 5.3 | Multiphase Brushless motor – Square wave permanent magnet brushless motor drives | 1 | CO2 |
| 5.4 | Torque and EMF equation – Torque-speed characteristics | 2 | CO2 |
| 5.5 | Microprocessor based controller- Applications | 1 | CO5 |
| 6 | **Linear Induction Motors** | | |
| 6.1 | Construction-Classifications | 1 | CO1 |
| 6.2 | Working Principle- Applications. | 2 | CO1 |
| | Total | 38 | |

**Course Designers:**

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2 Dr.S.Arockia Edwin Xavier saexeee@tce.edu

| 18EERA0 | POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 3 | 0 | 0 | 3 |

## Preamble

This course will cover the applications of power electronics for the control and conversion of electrical power with emphasis on renewable energy systems.

## Prerequisite

18EE530 : Power Electronics

## Course Outcomes

On the successful completion of the course, students will be able to

| Course Outcome No. | Course Outcomes | Weightage*** in % |
|---|---|---|
| CO1 | Explain contribution and impact of renewable energy sources | 20 |
| CO2 | Describe the features of power electronics and their role in renewable energy system | 30 |
| CO3 | Design converters for renewable energy systems | 20 |
| CO4 | Categorize various issues experienced during grid connection of wind generators | 10 |
| CO5 | Categorize various issues experienced during grid connection of PV systems | 10 |
| CO6 | Demonstrate the control aspects of converters used in wind generators and PV systems | 10 |

*** Weightage depends on Bloom's Level, number of contact hours

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | - | 1.3,2.1.1, 4.1.1, 4.1.2 |
| CO2 | TPS2 | Understand | Respond | - | 1.3,2.1.1, 2.3.1, 4.1.1, 4.1.2 |
| CO3 | TPS3 | Apply | Value | - | 1.3,2.1.1, 2.3.1, 2.3.2, 4.1.2, 4.3.1, 4.3.2 |
| CO4 | TPS4 | Analyze | Organise | - | 1.3,2.1.5, 2.3.2, 2.3.3, 4.1.1, 4.1.2, 4.3.3, 4.3.4 |
| CO5 | TPS4 | Analyze | Organise | - | 1.3,2.1.5, 2.3.2, 2.3.3, 4.1.1, 4.1.2, 4.3.3, 4.3.4 |
| CO6 | TPS3 | Apply | Value | - | 1.3,2.1.1, 2.3.1, 2.3.2, 4.1.2, 4.3.1, 4.3.2 |

## Mapping with Programme Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | M | M |
| CO2 | M | L | | | | | | M | | M | | | M | M |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C0 3 | S | M | L | | | | | M | | M | | | M | M |
| CO 4 | S | M | M | | | | | M | | M | | | M | M |
| CO 5 | S | M | M | | | | | M | | M | | | M | M |
| CO 6 | S | M | L | | | | | M | | M | | | M | M |

S- Strong; M-Medium; L-Low

## Assessment Pattern

| Bloom's Category | Continuous Assessment Tests | | | Assignment | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 40 | 10 | 10 | - | - | - | 10 |
| Understand | 40 | 40 | 40 | - | - | - | 40 |
| Apply | 20 | 30 | 30 | 100 | 50 | 50 | 30 |
| Analyze | - | 20 | 20 | - | 50 | 50 | 20 |
| Evaluate | - | - | - | - | - | - | - |
| Create | - | - | - | - | - | - | - |

## Assessment Pattern: Psychomotor

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | - |
| Set | - |
| Guided Response | - |
| Mechanism | - |
| Complex Overt Responses | - |
| Adaptation | - |
| Origination | - |

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. What is global warming?
2. List the various types of renewable energy sources.
3. Write the merits of renewable energy sources.

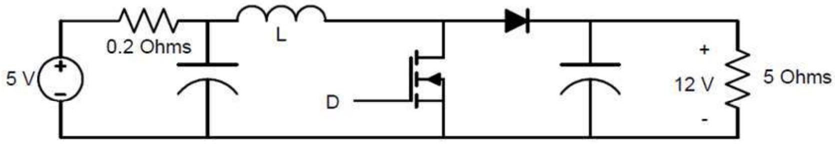
**Course Outcome 2 (CO2):**

1. What is the need for power converters in wind energy system?
2. Discuss the role of power electronics in renewable energy system.

3. Explain the merits and demerits of power electronics.

**Course Outcome 3 (CO3)**

1. Develop the design procedure of soft switching AC-link universal power converter,
2. Figure 3.1 shows a boost (up) converter supplying 12 V to a load of 5 Ω from a 5 V source having an internal resistance of 0.2 Ω. Determine the duty ratio D at which the converter operates. (You may neglect semiconductor device drops in your calculations.

9. 


10. Figure 3.1 Boost converter

3. Compare hard and soft switching converters.

**Course Outcome 4 (CO4)**

1. Figure 4.1 shows a circuit model for the utility supplying one phase of an ac induction motor. The motor system parameters are Rs = 0.08 Ω, Lls = 1 mH, Lm = 40 mH, Llr = 1 mH, Rr = 0.1 Ω, and Rx = 33 Ω. If the utility voltage is 170·cos(377t), i) what is the current into the motor? and ii) At what power factor is the motor operating?

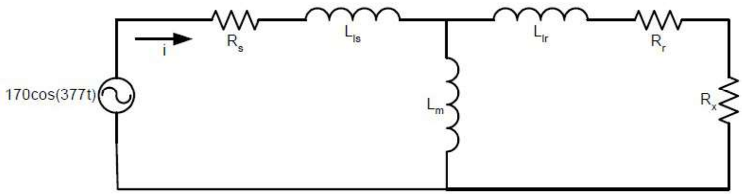



Figure 4.1 A Circuit model for one phase of an induction motor being driven by the utility

2. Consider a induction machine based wind energy conversion system. If induction machine is replaced by synchronous machine, what are the expected changes in the performance indices?

3. Consider synchronous machine based wind energy conversion system. If it is replaced by induction machine, analyse change in reactive power scenario.

**Course Outcome 5 (CO5)**

1. Which converter is best suitable for interfacing the PV array? Why?
2. Identify the issues related to grid connection of PV system.
3. Compare the issues related to grid connected mode and islanding mode operation of solar power system.
4. Compare the performance of various DC-DC converter topologies used in solar power conversion system.

**Course Outcome 6 (CO6)**

1. Demonstrate the role of pq theory in converter control.
2. Consider the circuit given in Figure 6.1. $V_d$ = 250V, Switching frequency is 30 kHz. The bridge is connected to a speed controlled dc machine. The armature inductance $L_a$=0.2mH. The armature resistance is negligible.

a) The bridge may be controlled by the use of unipolar or bipolar PWM. Describe the advantages and disadvantages of these control algorithms.

b) The bridge is controlled to provide an average output voltage, $V_o$=200V. Find the duty ration $D_1$ and $D_2$ and the ripple frequency of the two control principles Sketch $V_o(t)$ for the two control principles.

At the given speed, the back –emf $E_a$=200V. Unipolar PWM is used.

c) The armature current, $I_a$, is 1A, find the maximum and the minimum instantaneous armature current.

d) Sketch the armature current, $i_a(t)$.Inductance which of the power semiconductors are conducting, Also sketch $i_d(t)$.

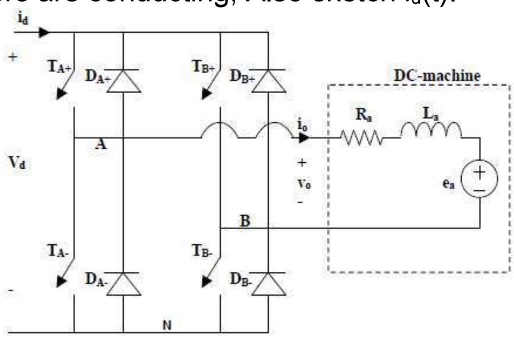
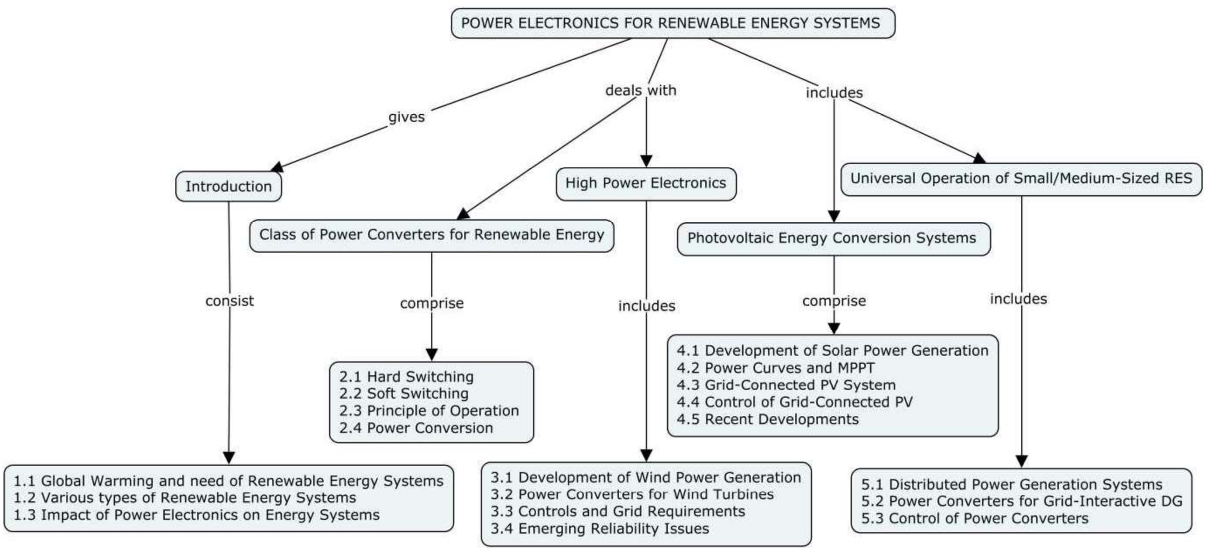



Figure 6.1

## Concept Map




## Syllabus

### Introduction

Environmental Pollution: Global Warming Problem, Impact of Power Electronics on Energy Systems, Challenges of the Current Energy Scenario: The Power Electronics Contribution, Renewable Energy Systems

### Class of Power Converters for Renewable Energy

Introduction, Hard Switching AC-Link Universal Power Converter, Soft Switching AC-Link Universal Power Converter, Principle of Operation of the Soft Switching AC-Link Universal Power Converter

**Wind Energy Conversion Systems**

Introduction, Development of Wind Power Generation, Power Converters for Wind Turbines, Controls and Grid Requirements for Modern Wind Turbines, Emerging Reliability Issues for Grid Connected Wind Power System

**Photovoltaic Energy Conversion Systems**

Introduction, Power Curves and Maximum Power Point of PV Systems, Grid-Connected PV System Configurations, Control of Grid-Connected PV Systems – Converters for domestic applications

**Hybrid Renewable Energy System**

Converters for hybrid renewable energy system - Recent Developments in Multilevel converters

## Learning Resources

1. Haitham Abu-Rub, Mariusz Malinowski & Hamal Al Haddad, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", IEEE Press and John Wiley Publications, First Edition, 2014.
2. Muhammad H.Rashid, "Power Electronics Circuits, Devices & Applications", Pearson Education India Publication, New Delhi, 7th Impression, 2009.
3. Ned Mohan, Tore Undeland & William Robbins, "Power Electronics: converters Applications and Design", John Willey and sons, 3rd Edition, 2003.
4. Ali Keyhani, M.N.Marwali & Min Dai, "Integration of green and renewable energy in electrical power systems", Wiley and sons, 2010.
5. Ewald F. Fuchs & Mohammad A.S. Masoum, "Power Conversion of Renewable Energy Systems" Springer New York Dordrecht Heidelberg London, 2011.

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| **1.** | **Introduction** | | |
| 1.1 | Global Warming and need of Renewable Energy Systems | 1 | CO1 |
| 1.2 | Various types of Renewable Energy Systems | 2 | CO1 |
| 1.3 | Impact of Power Electronics on Energy Systems | 1 | CO2 |
| **2.** | **Class of Power Converters for Renewable Energy** | | |
| 2.1 | Hard Switching AC-Link Universal Power Converter | 2 | CO2 |
| 2.2 | Soft Switching AC-Link Universal Power Converter | 1 | CO2 |
| 2.3 | Principle of Operation of the Soft Switching AC-Link Universal Power Converter | 2 | CO2 |

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 2.3.1 | Design Procedure and Analysis | 2 | CO3 |
| 2.4 | AC–AC,DC–AC and AC–DC Power Conversion | 2 | CO3 |
| **3.** | **Wind Energy Conversion Systems** | | |
| 3.1 | Development of Wind Power Generation | 2 | CO1 |
| 3.2 | Wind Generator Technologies | 1 | CO2 |
| 3.3 | Power Converters for Wind Turbines | 2 | CO2 |
| 3.4 | Controls and Grid Requirements for Modern Wind Turbines | 2 | CO6 |
| 3.5 | Emerging Reliability Issues for Grid Connected Wind Power System | 2 | CO4 |
| **4.** | **Photovoltaic Energy Conversion Systems** | | |
| 4.1 | Development of Solar Power Generation | 1 | CO1 |
| 4.2 | Power Curves and Maximum Power Point of PV Systems | 2 | CO3 |
| 4.3 | Grid-Connected PV System Configurations | 2 | CO5 |
| 4.4 | Control of Grid-Connected PV Systems | 2 | CO6 |
| 4.5 | Recent Developments in PV Systems | 1 | CO5 |
| 4.6 | Converters for domestic applications | 1 | CO3 |
| **5.** | **Hybrid Renewable Energy System** | | |
| 5.1 | Converters for hybrid renewable energy system | 2 | CO2 |
| 5.2 | Recent Developments in Multilevel converters | 2 | CO3 |
| | Total | 35 | |

**Course Designers:**

1. Dr. V. Suresh Kumar vskeee@tce.edu
2. Dr. G.Sivasankar gsivasankar@tce.edu

| 18EERB0 | SIMULATION OF POWER ELECTRONIC SYSTEMS (TCP) | Category | L | T | P | Credit |
|---|---|---|---|---|---|---|
| | | PE | 2 | 0 | 2 | 3 |

*Maximum strength of students per class is 40.

## Preamble

This Course enhances the students to analyze on various aspects of Power Electronic systems. The simulation of fundamental Power electronic circuits using Matlab-PLECS and PSPICE software is discussed. Using various simulation techniques, the output response of the systems for different conditions can be easily analyzed. The real power, reactive power, power factor & efficiency calculations are simplified using the simulation software. The Static, dynamic models and performance analysis of power electronics rectifier, inverter, chopper circuits and AC and DC motor drives are discussed.

## Prerequisite

- 18EE530: Power Electronics

## Course Outcomes

On the successful completion of the course, students will be able to

| Course Outcome No.f | Course Outcomes | Weightage |
|---|---|---|
| CO1 | Explain the concept of Matlab, PLECS and PSPICE simulation | 20 |
| CO2 | Analyse the Linear, Nonlinear, Sinusoidal, Nonsinusoidal circuits, Diode rectifiers, Phase Controlled Rectifiers using Matlab, PLECS and PSPICE simulation | 20 |
| CO3 | Analyse the DC-DC converters using Matlab, PLECS and PSPICE simulation | 20 |
| CO4 | Analyse the DC-AC converters using Matlab, PLECS and PSPICE simulation | 20 |
| CO5 | Analyse the State space models using Matlab, PLECS and PSPICE simulation | 10 |
| CO6 | Analyse the DC and AC motor drives using Matlab, PLECS and PSPICE simulation. | 10 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3 |

| | | | | | |
|---|---|---|---|---|---|
| CO2 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO3 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO4 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO5 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |
| CO6 | TPS4 | Analyse | Organise | Complex Overt Responses | 1.3, 2.1.1, 2.1.4, 2.1.5, 2.3.1, 2.4.4, 3.2.3 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | S | L | L | | S | | | M | | M | | L | | S |
| CO2 | S | S | S | M | S | | | M | L | M | | L | | S |
| CO3 | S | S | S | M | S | | | M | L | M | | L | | S |
| CO4 | S | S | S | M | S | | | M | L | M | | L | | S |
| CO5 | S | S | S | M | S | | | M | L | M | | L | | S |
| CO6 | S | S | S | M | S | | | M | L | M | | L | | S |

S- Strong; M-Medium; L-Low

## Assessment Pattern: Cognitive Domain

| Cognitive Levels | Continuous Assessment Tests | | | Practical Test# | Terminal Examination |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | | |
| Remember | 10 | - | - | - | - |
| Understand | 30 | 40 | 40 | - | 40 |
| Apply | 60 | 60 | 60 | 40 | 60 |
| Analyse | - | - | - | 60 | - |
| Evaluate | - | - | - | - | - |
| Create | - | - | - | - | - |

**#** Practical test using Matlab-PLECS & PSPICE.

## Sample Questions for Course Outcome Assessment

**Course Outcome 1 (CO1):**

1. Write any four general commands in Matlab.
2. Compare PLECS stand alone and PLECS block set.
3. What are the platforms for PSpice?

4. Explain the MATLAB While Structures.
5. Discuss the different types of analysis in PSpice.

**Course Outcome 2 (CO2):**

1. Draw a linear circuit with a nonsinusoidal source.
2. A 250V, 100W rated light bulb is connected to a 230V, 50Hz single phase supply. Plot the bulb voltage and current using PSpice.
11. A linear circuit supplied by a nonsinusoidal source is shown in Fig.1.

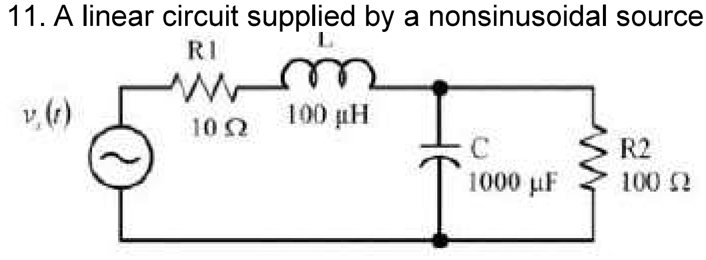



Fig.1

12. Find the average power absorbed by the circuit if the source voltage is expressed as $v_s(t)=100+50\cos(120\pi t)+25\cos(240\pi t)+15\cos(360\pi t)$.Write Matlab Script file.

5. Using PSpice simulate a three phase diode rectifier with source inductance. For RLE load plot the load voltage and current.The rectifier is supplied from a balanced three phase star connected 440V, 50Hz supply and the filter capacitance $C_f$=1μF,R=10Ω,L=5mH,E=2V and Source inductance is 0.5mH. Using transient analysis determine the fourier coefficients of the load current and input current under the following cases: (a) with out source inductance (b) with source inductance Ls=0.5mH (c) with source inductance Ls=1.5mH. Analyse the effect of source inductance.

**Course Outcome 3 (CO3):**

1. A buck converter has an inductance of 30μH, a load resistance of 5Ω and a source voltage of 24V DC and operates with a duty ratio 0.6. Plot the output voltage if the PWM switching frequency is 10kHz. Analyse the output voltage and current for RL load under continuous current mode and discontinuous current mode using PSpice and Matlab-PLECS.

2. Simulate a Voltage commutated Chopper that delivers power to RLE load for which R=1Ω and L=10mH.For a chopping frequency of 200Hz and dc source voltage of 400V, analyse the voltage, current output waveforms with respect to ripple.Plot the waveforms for the duty cycles 0.2 & 0.8.Use Matlab-PLECS.

3. Simulate the above circuit specified in question 2 using PSPICE software.

**Course Outcome 4 (CO4):**

1.Explain the simulation of the single phase PWM inverter using PSpice and Matlab-PLECS.

2.Simulate a single phase bridge inverter that feeds power to a load of R=10 Ω and L=0.04H from a 400V dc source. Analyse the power delivered for square wave operation and quasi-square wave operation with 60% on-period. Compare the voltage, current and power delivered for the inverter operating frequencies 50Hz & 1kHz.Use Matlab-PLECS.

3.Simulate and analyse the above circuit specified in question 2 using PSPICE software.

4.Simulate a 3-phase 120 degree mode bridge inverter that feeds a star-connected load of R=5Ω with dc source voltage=230V & f=50Hz.Compare the output voltage and current waveforms for square wave inverter operation and sine PWM operation. Use Matlab-PLECS and PSPICE.

**Course Outcome 5 (CO5)**

1. Develop a state space model for the following circuit shown in Fig.2

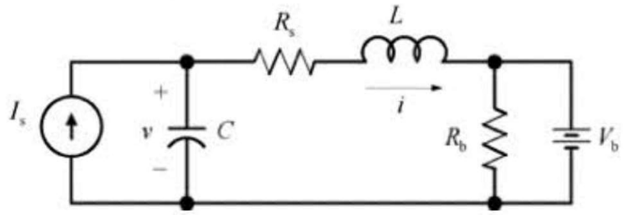



Fig.2

2.For the circuit shown in Fig.2, C=10μf, L=5mH, Is=10A and Rb=100Ω with proper time interval, simulate and plot the capacitor voltage.

3.Find out the state space model equation for the buck - boost converter.

4.Simulate a boost converter with the circuit parameter Vs=12V, Vo=28V, R=8Ω, L=150μH, C=100μF and f=5kHz using PSpice and Matlab-PLECS.

**Course Outcome 6 (CO6)**

1. Determine the transient response of a separately excited DC motor fed from a buck converter with respect to step change in load torque.Using PSpice and Matlab-PLECS plot the following:

(a)Armature current (b)Motor Speed (c)Developed motor torque.

2. Determine the PSpice schematic of the induction motor represented by its equivalent circuit as shown in Fig.3 and analyse the torque-speed characteristics for various slip values and various rotor resistance values.

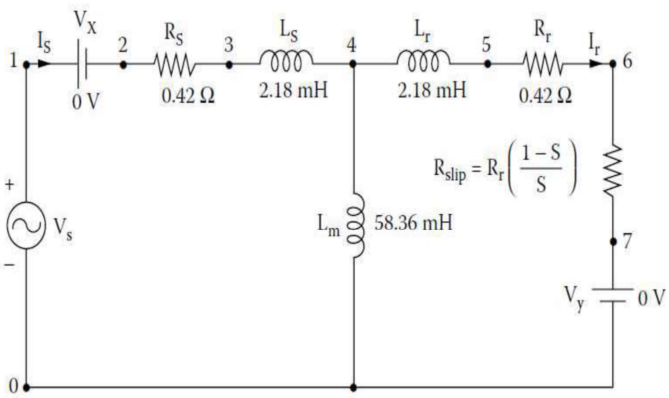
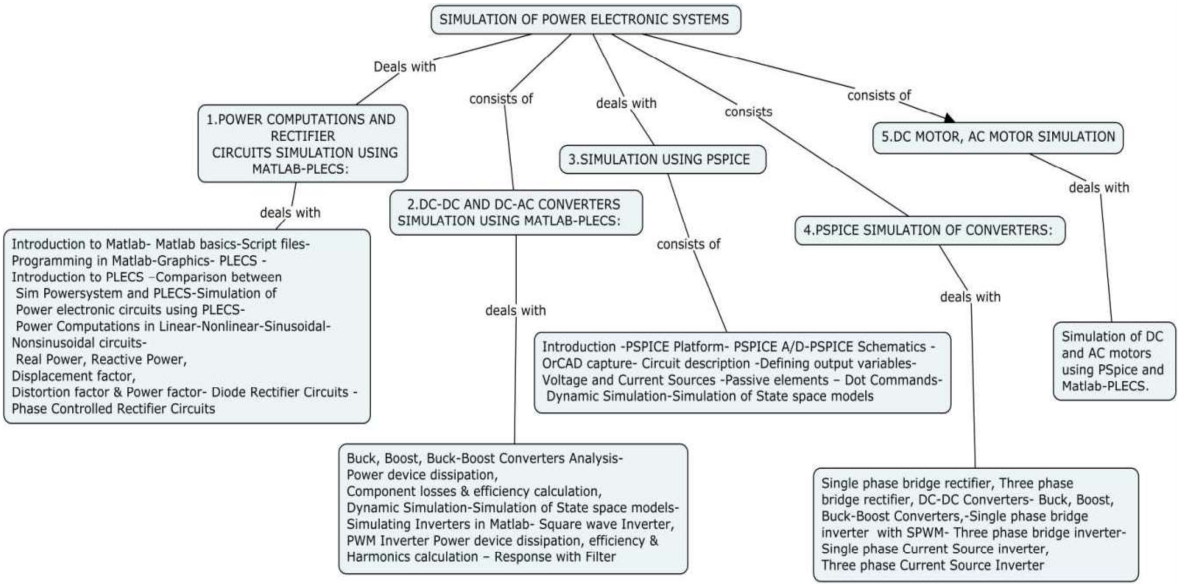



Fig.3

3. Analyse the torque-speed characteristics of the induction motor represented by its equivalent circuit as shown in Fig.3 for various slip values and various rotor resistance values using Matlab-PLECS.

## Concept Map




## Syllabus

**POWER COMPUTATIONS AND RECTIFIER CIRCUITS SIMULATION USING MATLAB-PLECS:**
Introduction to Matlab- Matlab basics-Script files-Programming in Matlab-Graphics.
**PLECS** -Introduction to PLECS –Comparison between Sim Power system and PLECS-Simulation of Power electronic circuits using PLECS- Power Computations in Linear-Nonlinear-Sinusoidal- Non sinusoidal circuits- Real Power, Reactive Power, Displacement factor, Distortion factor & Power factor- Diode Rectifier Circuits -Phase ControlledRectifierCircuits.

**SIMULATION OF DC-DC AND DC-AC CONVERTERS USING MATLAB-PLECS:** Buck, Boost, Buck-Boost Converters Analysis- Power device dissipation, Component losses & efficiency calculation, Dynamic Simulation-Simulation of State space models-Simulating Inverters in Matlab- Square wave Inverter, PWM Inverter Power device dissipation, efficiency & Harmonics calculation – Response with Filter

**SIMULATION USING PSPICE :**Introduction -PSPICE Platform- PSPICE A/D-PSPICE Schematics -OrCAD capture- Circuit description -Defining output variables-Voltage and Current Sources -Passive elements – Dot Commands- Dynamic Simulation-Simulation of State space models.

**SIMULATION OF CONVERTERS USING PSPICE:** Single phase bridge rectifier, Three phase bridge rectifier,
DC-DC Converters- Buck, Boost, Buck-Boost Converters,-Single phase bridge inverter with SPWM- Three phase bridge inverter- Single phase Current Source inverter, Three phase Current Source Inverter.

**SIMULATION OF DC MOTOR, AC MOTOR DRIVES :** Simulation of DC and AC motor drives using PSpice and Matlab-PLECS.

## Learning Resources


1. Muhammad H. Rashid and Hasan M. Rashid., "SPICE for Power Electronics and Electric Power" CRC Press 2006.
2. Randall Shaffer., "Fundamentals of Power Electronics with MATLAB" Charles River Media Boston Massachusetts, 2007.
3. Rao V.Dukkipati,."Analysis and Design of Control Systems using MATLAB" New age international, 2006.
4. Chee-Mun Ong, "Dynamic Simulation of Electric Machinery : Using MATLAB/ Simulink", Prentice Hall PTR, New Jersey, 1998.
5. Ned Mohan, "Power Electronics: Computer Simulation Analysis and Education using PSPICE", Minnesota Power Electronics Research and Education, USA, 1992.
6. Ramshaw E., Schuuram D. C., "PSpice Simulation of Power Electronics Circuits – An Introductory Guide", Springer, New York, 1996.
7. http://www.plexim.com/plecs.


## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 1. | **POWER COMPUTATIONS AND RECTIFIER CIRCUITS SIMULATION USING MATLAB-PLECS** | | |
| 1.1 | Introduction to Matlab- Matlab basics-Script files-Programming in Matlab-Graphics | 1 | CO1 |
| 1.2 | PLECS -Introduction to PLECS –Comparison between Sim Power system and PLECS | 1 | CO1 |
| 1.3 | Simulation of Power Electronics circuits using PLECS- Power Computations in Linear-Nonlinear-Sinusoidal- Nonsinusoidal circuits | 1 | CO2 |
| 1.4 | Real Power, Reactive Power, Displacement factor, Distortion factor & Power factor- Diode Rectifier Circuits - Phase Controlled Rectifier Circuits | 1 | CO2 |
| 2. | **DC-DC AND DC-AC CONVERTERS SIMULATION USING MATLAB-PLECS** | | |
| 2.1 | Buck, Boost, Buck-Boost Converters Analysis, Power device dissipation, Component losses & efficiency calculation | 1 | CO3 |
| 2.2 | Dynamic Simulation-Simulation of State space models | 1 | CO5 |
| 2.3 | Simulating Inverters in Matlab-PLECS-<br><br>Square wave Inverter, PWM Inverter | 1 | CO4 |
| 2.4 | Power device dissipation, Efficiency & Harmonics calculation – Response with Filter | 1 | CO3 |
| 3 | **SIMULATION USING PSPICE** | | |
| 3.1 | Introduction -PSPICE Platform- PSPICE A/D-PSPICE Schematics -OrCAD capture | 1 | CO1 |

| Module No. | Topic | No. of Lectures | Course Outcome |
|---|---|---|---|
| 3.2 | Circuit description -Defining output variables | 1 | CO1 |
| 3.3 | Voltage and Current Sources -Passive elements | 2 | CO1 |
| 3.4 | Dot Commands | 1 | CO! |
| 3.5 | Dynamic Simulation-Simulation of State space models. | 1 | CO5 |
| 4 | **PSPICE SIMULATION OF CONVERTERS** | | |
| 4.1 | Single phase bridge rectifier, Three phase bridge rectifier, | 1 | CO2 |
| 4.2 | DC-DC Converters- Buck, Boost, Buck-Boost Converters, | 1 | CO3 |
| 4.3 | Single phase bridge inverter with SPWM- | 1 | CO4 |
| 4.4 | Three phase bridge inverter- Single phase Current Source inverter Three phase Current Source Inverter., | 1 | CO4 |
| 5 | **DC MOTOR, AC MOTOR DRIVES SIMULATION** | | |
| 5.1 | Simulation of DC and AC motor drives using PSpice and Matlab-PLECS | 2 | CO6 |
| | Total | 20 | |

## Tentative List of Experiments (24 Hours)

**Simulation using PSpice and Matlab-PLECS**

1.Simulation of Diode Rectifier Circuits: Half wave, Full wave circuits with R, RL, RC loads &Battery charger applications.

2. Simulation of Phase Controlled Rectifier Circuits:Half wave phase controlled, Full wave phase controlled circuits with R, RL, RC loads &Battery charger applications.

3.Performance Analysis and Thermal Analysis of Single phase and Three phase Diode Rectifier Circuits, Phase Controlled Rectifier Circuits with filter –Analysis of Fourier coefficients of output voltage- Effects of Filter Capacitance.

4.Dynamic Simulation, Performance Analysis and Thermal Analysis :Simulation of State space models-Simulating Buck,Boost,Buck-Boost chopper circuits, Square wave Inverters-Single phase bridge inverter -Three phase bridge inverter- Single phase Current Source Inverter, Three phase Current Source Inverter, PWM Inverters with SPWM - Power device dissipation, efficiency & Harmonics calculation – Response with Filter.

5.Transient response analysis of DC motor and Induction motor drives.

## Course Designers:

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2. Dr.S.Arockia Edwin Xavier saexeee@tce.edu

| 18EEEA0 | INTERNET OF THINGS |
|---|---|

| Category | L | T | P | Credit |
|---|---|---|---|---|
| ES | 3 | 0 | 0 | 3 |

## Preamble

The objectives of this course are to provide in-depth understanding of the underlying concepts of Internet of things, building blocks, domain-specific IoTs, and Design methodology for IOT. Also the course provides knowledge on Python coding to embed the coding in various open source hardware such as Arduino, Raspberry Pi. Eventually the course extends the students knowledge upto the level of building cost effective IOT system for real world scenario with the open source hardware and software tool chains.

## Prerequisite

Nil

## Course Outcomes

On the successful completion of the course, students will be able to:

| COs No. | Course outcomes | Weightage in % |
|---|---|---|
| CO1 | Explain the architecture and functionality of IOT | 15 |
| CO2 | Identify the design methodologies and sensor networks for the IOT implementation | 20 |
| CO3 | Explain the logical design of IOT using python programming. | 15 |
| CO4 | Develop the Python Program for the Raspberry Pi. | 10 |
| CO5 | Choose the suitable hardware and software tools chains to fulfil the IOT requirements | 15 |
| CO6 | Develop the IOT system for the given scenario | 25 |

## CO Mapping with CDIO Curriculum Framework

| CO # | TCE Proficiency Scale | Learning Domain Level | | | CDIO Curricular Components (X.Y.Z) |
|---|---|---|---|---|---|
| | | Cognitive | Affective | Psychomotor | |
| CO1 | TPS2 | Understand | Respond | | 1.3, 2.3.1 |
| CO2 | TPS3 | Apply | Value | | 1.3, 2.3.1 |
| CO3 | TPS2 | Understand | Respond | | 1.3, 2.3.1 |
| CO4 | TPS3 | Apply | Value | | 1.3, 2.3.1, 2.4.3, 2.4.6 |
| CO5 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.1.5 |
| CO6 | TPS3 | Apply | Value | | 1.3, 2.1.1, 2.3.1, 2.4.3, 2.4.4 |

## Mapping with Programme Outcomes and Programme Specific Outcomes

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | | | | | | M | | M | | | | M |
| CO2 | S | M | L | | | | | M | | M | | | | S |
| CO3 | M | L | | | | | | M | | M | | | | M |
| CO4 | S | M | L | | | | | M | | M | | | | S |
| CO5 | S | M | L | | | | | M | | M | | | | S |
| CO6 | S | M | L | | | | | M | | M | | | | S |

S- Strong; M-Medium; L-Low

**Assessment Pattern: Cognitive Domain**

| Cognitive Levels | Continuous Assessment Tests | | | Assignment* | | | Terminal Examination |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | |
| Remember | 20 | 20 | 20 | - | - | - | 20 |
| Understand | 40 | 40 | 30 | - | - | - | 30 |
| Apply | 40 | 40 | 50 | 100 | 100 | 100 | 50 |
| Analyse | 0 | 0 | 0 | - | - | - | 0 |
| Evaluate | 0 | 0 | 0 | - | - | - | 0 |
| Create | 0 | 0 | 0 | - | - | - | 0 |

*Assignment mark is based on IoT Miniproject

**Assessment Pattern: Psychomotor**

| Psychomotor Skill | Miniproject /Assignment/Practical Component |
|---|---|
| Perception | |
| Set | |
| Guided Response | |
| Mechanism | |
| Complex Overt Responses | |
| Adaptation | |
| Origination | |

**Sample Questions for Course Outcome Assessment**

**Course Outcome 1 (CO1)**
1. Mention important benefits of IOT
2. Identify the components for weather reporting with IOT .
3. Describe and compare the network architectures of OSI model and TCP/IP Model.

**Course Outcome 2 (CO2)**
1. What are the advantages of having a switch rather than a hub to interconnect several machines?
2. Describe how an algorithm is used in configuring a IOT network.
3. How does OSHW support for IOT

**Course Outcome 3 (CO3)**
1. Identify the components of IOT.
2. Compare the roles of switch and router.
3. Suggest the sensors for IOT for the given application

**Course Outcome 4 (CO4)**
1. Explain how route optimization is done in IOT.
2. Develop pseudo code for accessing sensors in python
3. Develop an ardiuno code for accessing sensors and actuators

**Course Outcome 5 (CO5)**
1. Compute the propagation delay of an IOT system when an algorithm is running with a defined rate and networking delay
2. Analyse the criticality, implementation issues and constraint of the IOT system for the given real world scenario.

**Course Outcome 6 (CO6)**

1. Consider a point to point link 50 Km. in length. At what bandwidth would propagation delay equal transmit delay for 100 bytes packet? What about 512 byte packets?
2. Develop an IOT System with sensors for monitoring agriculture field
3. Develop an IOT System with sensors for street light monitoring and control

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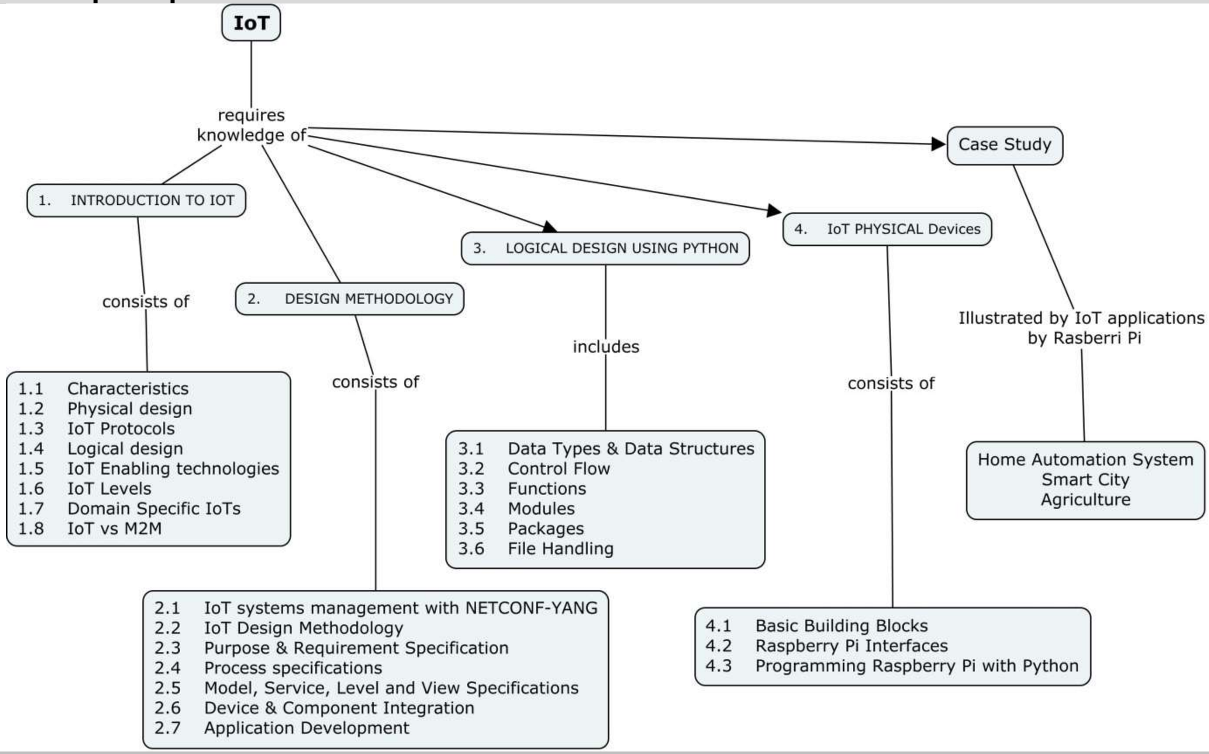
## Concept Map




## Syllabus

**INTRODUCTION TO IOT:** Characteristics, Physical design, IoT Protocols, Logical design, IoT Enabling technologies, IoT Levels, Domain Specific IoTs, IoT vs M2M, Cyber security, IPv 4.

**DESIGN METHODOLOGY:** IoT systems management with NETCONF-YANG, IoT Design Methodology - Purpose & Requirement Specification, Process specifications, Model, Service, Level and View Specifications, Device & Component Integration, Application Development. Sensor networks-Wireless Sensor Networks (WSN)

**LOGICAL DESIGN USING PYTHON:** Data Types & Data Structures, Control Flow, Functions, Modules, Packages, File Handling,

**IoT PHYSICAL Devices:** Basic Building Blocks, Raspberry Pi Interfaces, Cloud Computing**,** Building IoT applications using Arduino and Raspberry Pi.

**CASE STUDIES:** Home Automation, Smart city, Agriculture

## Learning Resources

1. ArshdeepBahga, Vijay Madisetti, “Internet of Things – A hands-on approach”,Universities Press, 2015

2. Peter Waher “Learning Internet of Things”, PacktPublishing,UK, 2015.
3. Miguel de Sousa”,Internet of Things with Intel Galileo” ”, PacktPublishing,UK, 2015
4. Marco Schwartz, “Internet of Things with the Arduino Yun”, Packt Publishing, 2014
5. Adrian McEwen, Hakim Cassimally “Designing the Internet of Things”,WileyPublishing, 2015
6. https://nptel.ac.in/courses/106105166/
7. https://www.coursera.org/specializations/iot

## Course Contents and Lecture Schedule

| Module No. | Topic | No. of Lecture Hours | Course Outcome |
|---|---|---|---|
| **1.** | **INTRODUCTION TO IOT** | | |
| 1.1 | Characteristics | 1 | CO1 |
| 1.2 | Physical design | 1 | CO1 |
| 1.3 | IoT Protocols | 1 | CO1 |
| 1.4 | Logical design | 1 | CO1 |
| 1.5 | IoT Enabling technologies | 1 | CO1 |
| 1.6 | IoT Levels | 1 | CO1 |
| 1.7 | Domain Specific IoTs | 1 | CO1 |
| 1.8 | IoT vs M2M, Cyber security, IPv 4 | 1 | CO1 |
| **2.** | **DESIGN METHODOLOGY** | | |
| 2.1 | IoT systems management with NETCONF-YANG | 1 | CO2 |
| 2.2 | IoT Design Methodology | 1 | CO2 |
| 2.3 | Purpose & Requirement Specification | 1 | CO2 |
| 2.4 | Process specifications | 1 | CO2 |
| 2.5 | Model, Service, Level and View Specifications | 1 | CO2 |
| 2.6 | Device & Component Integration | 1 | CO2 |
| 2.7 | Application Development | 1 | CO2 |
| 2.8 | Sensor networks-Wireless Sensor Networks (WSN) | 1 | CO2 |
| **3.** | **LOGICAL DESIGN USING PYTHON** | | |
| 3.1 | Data Types & Data Structures | 1 | CO3 |
| 3.2 | Control Flow | 1 | CO3 |
| 3.3 | Functions, Modules | 1 | CO3 |
| 3.4 | Packages | 1 | CO3 |
| 3.5 | File Handling | 1 | CO3 |
| **4.** | **IoT PHYSICAL Devices** | | |
| 4.1 | Basic Building Blocks | 1 | CO5 |
| 4.2 | Raspberry Pi Interfaces | 2 | CO5 |
| 4.3 | Cloud Computing | 1 | |
| 4.4 | Building IoT applications using Arduino and Raspberry Pi. | 3 | CO4 |
| 5 | **CASE STUDIES** | | |
| 5.1 | Home Automation | 2 | CO6 |
| 5.2 | Smart city | 3 | CO6 |

| | | | |
|---|---|---|---|
| 5.3 | Agriculture | 3 | CO6 |
| Total | | 36 | |

## CourseDesigners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