# B.E. Electrical and Electronics Engineering

## Regulations & Syllabi - R2019

## (Choice Based Credit System)

Leadership & Excellence

**Sri Eshwar**
**College of Engineering**
An Autonomous Institution

Accredited by NAAC with 'A' Grade

NBA NATIONAL BOARD OF ACCREDITATION For CSE, ECE, EEE, MECH

Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai
Kondampatti (Post), Kinathukadavu (Tk), Coimbatore – 641202

**REGULATIONS 2019**

**CHOICE BASED CREDIT SYSTEM (CBCS)**

**(Common to all B.E. / B.Tech. Programmes)**

As per the guidelines given by the University Grants Commission, All India Council for Technical Education and Affiliating University (Anna University - Chennai), Regulations 2019 (R-2019) have been prepared integrating the features of the Choice Based Credit System (CBCS). The Regulation 2019 is applicable to the candidates admitted to the first year Bachelor of Engineering (B.E.) / Bachelor of Technology (B.Tech.) Degree Programmes of the Institution from the academic year 2019 - 2020 onwards and academic year 2020 - 2021 for second year Lateral Entry students.

**Note:** The regulations, curriculum, syllabus and scheme of examinations are subjected to amendments as may be decided by the Academic Council of the Institution from time to time. Any or all such amendments will be effective from such date and to such batches of students as may be decided by the Academic Council.

## 1. PRELIMINARY DEFINITIONS AND NOMENCLATURE

In this Regulation,

1.1 **"Programme"** means Degree Programme (i.e) B.E. / B.Tech. Degree Programme.

2.1 **"Discipline"** means Branch or Specialization of B.E. / B.Tech. Degree Programme like Computer Science and Engineering, Mechanical Engineering, Information Technology etc.,

3.1 **"Course"** means a theory or practical subject that is normally studied in a semester like Mathematics, Physics, Engineering Graphics, etc.,

4.1 **"Head of the Institution"** means the Principal of the institution.

5.1 **"Head of the Department"** means the head of the department concerned.

6.1 **"Controller of Examinations"** means the authority of the Institution who is responsible for pertaining to Autonomous Examinations.

7.1 **"University"** means Anna University, Chennai.

8.1 **"Institution"** means Sri Eshwar College of Engineering, Coimbatore unless indicated otherwise by the context.

## 2. ADMISSION PROCEDURE

### 2.1. Regular Entry Admission

Candidates seeking admission to the first semester of the eight semesters of B.E. / B.Tech. Degree Programme:

i) Should have passed the Higher Secondary Examination (Academic stream, 10 + 2) Curriculum as prescribed by Government of Tamil Nadu with Mathematics, Physics and chemistry as three of the four subjects of study under part – III or any equivalent examination accepted by competent authority.

**(or)**

ii) Should have passed the Higher Secondary Examination of Vocational stream (Vocational groups in Engineering / Technology) as prescribed by the Government of Tamil Nadu.

They should also satisfy other eligibility conditions as prescribed by the Anna University, Chennai and Directorate of Technical Education, Chennai from time to time.

### 2.2 Lateral entry admission

i) The candidates who hold a Diploma in Engineering / Technology awarded by the State Board of Technical Education, Tamil Nadu or its equivalent are eligible to apply for Lateral entry admission to the third semester of BE / BTech in relevant branches of study, in their Diploma.

**(or)**

ii) The candidates who possess the Degree in Science (B.Sc.,) (10+2+3 stream) with Mathematics as a subject at the B.Sc. level are eligible to apply for Lateral entry admission to the third semester of B.E./B.Tech. Such candidates shall undergo two additional Engineering subjects in the third and fourth semesters as prescribed by the examination

committee. They should satisfy other eligibility conditions prescribed by the Anna University, Chennai and Directorate of Technical Education, Chennai from time to time.

## 3. PROGRAMMES OFFERED

The following branches of study approved by the University are offered by the Institution.

**Undergraduate Programmes:**

- B.E. Computer Science and Engineering
- B.E. Electrical and Electronics Engineering
- B.E. Electronics and Communication Engineering
- B.E. Mechanical Engineering
- B.E. Computer and Communication Engineering
- B.E. Computer Science and Engineering (AI – ML)
- B.Tech. Information Technology
- B.Tech. Artificial Intelligence and Data Science
- B.Tech. Computer Science and Business Systems

## 4. STRUCTURE OF PROGRAMMES

### 4.1. Categorization of Courses

Every B.E. / B. Tech. Programme will have a curriculum with syllabi consisting of theory and practical courses that shall be categorized as follows:

**Table 4.1 Categorization of Courses at UG Degree Programmes**

| S. No. | Category | Courses |
|---|---|---|
| 1. | Humanities and Social Sciences (HS) | Technical English, Foreign Language, Management & Engineering Ethics, Human Values and Engineering Economics |
| 2. | Basic Sciences (BS) | Mathematics, Physics and Chemistry |
| 3. | Engineering Sciences (ES) | Materials, Workshop, Drawing, Basics of Electrical / Electronics / Mechanical / Computer Engineering, etc., |
| 4. | Professional Core (PC) | Courses relevant to the chosen specialization / branch |
| 5. | Professional Electives (PE) | Courses relevant to the chosen specialization / branch |
| 6. | Open Electives (OE) | Courses from other technical and/or emerging subject areas |
| 7. | Project Work (PW) | Mini Project, Innovative/Multidisciplinary Project, Industry Project, Project Work |
| 8. | Employability Enhancement Courses (EEC) | Personality Development, Verbal & Soft Skills, Communication Skills, Aptitude, Seminar, Industry Oriented Courses and Internship in Industry or elsewhere. |
| 9. | Mandatory Courses (MC) | Environmental Science, Indian Constitution and Tradition |

### 4.2. Personality and Character Development

All students shall enroll in any one of the personality and character development activities (NCC / NSS /NSO/ YRC /UBA) and undergo the training for 40 hours during the first year.

**National Cadet Corps (NCC)** will have a number of parades/camps as specified by the NCC officer.

**National Service Scheme (NSS)** will have social service activities in and around the institution.

**National Sports Organization (NSO)** will have sports, Games, Drills and Physical exercises.

**Youth Red Cross (YRC)** society activity will include peacetime activities like health and hygiene, yoga, international friendship, awareness camps etc.,

**Unnat Bharat Abhiyan (UBA)** will have activities related to technical social services in villages around the institution. While the training activities will normally be during weekends, the camp will normally be held during vacation period.

**4.3. Number of courses per semester**

In each semester, the curriculum will normally have a blend of theory courses not exceeding SEVEN and practical/EEC courses not exceeding FOUR. However, the total number of courses per semester shall not exceed TEN (including EEC)

The courses that a student registers in a particular semester may include

- Courses of the current semester.
- Courses advanced to Semester V, VI and VII from Semester VIII

The maximum number of credits that can be registered in a semester is 36. However, this does not include the number of Re-appearance (RA) and Withdrawal (W) courses registered by the student for the appearance of Examination.

**4.4. Credit Assignment**

Each course is assigned certain number of credits based on the following:

| Contact period per week | Credits |
|---|---|
| 1 Lecture Period | 1 |
| 1 Tutorial Period | 1 |
| 2 Practical Periods (Laboratory / Seminar / Project Work / etc.) | 1 |

**4.5. Industrial Training / Internship**

The students may undergo industrial training / internship at industrial / research organizations / educational institutions for the prescribed period in the curriculum during summer vacation.

**4.6. Industry Oriented courses**

Students have to undergo Industry Oriented Courses with one credit of 30 hours duration which will be offered by experts from industry / faculty (internal as well as external) on specialized topics. Students have to complete such one credit courses during the semesters III to VII as and when these courses are offered by the department as specified in the Curriculum.

**4.7. Online courses**

**4.7.1.** Students can register and earn credits for only one online course of 3 credits during the fifth semester and sixth semester period, relevant to their programme approved by the Head of the Institution from time to time.

**4.7.2.** However, a student having “No standing arrears” is only eligible for credit transfer. A student can drop any one 3 credit course from PE or OE category of VII or VIII semester, if he/ she successfully completes online course with 3 credits (which are provided with certificates)

**4.7.3.** The entire online course offered by SWAYAM, Ministry of Human Resource Development (MHRD) portal and NPTEL Courses are approved. Other online courses are to be approved by the respective Board of Studies. Suitable Online courses relevant to PE/OE to be dropped shall be chosen from approved portal.

**4.7.4.** Students who undergo 12 weeks of Online courses can earn 3 credits for courses in NPTEL, AICTE - SWAYAM etc. Alternatively, students who undergo 45 hours of any other approved online courses can earn 3 credits.

**4.7.5.** Department Advisory Committee (DAC) shall monitor the progress of the student performance in the online course. The student may be exempted from undergoing one PE of OE only after successful completion of the online course

and submission of the certificate. Based on the marks obtained in the online certification exam an equivalent grade will be recommended by DAC.

**4.8. Flexibility to Register Courses**

4.8.1. In a semester, a student is permitted to add course registration for Two Electives (PE and / or OE) to a maximum of 30 credits from 5th Semester onwards with due approval from Head of the Institution through the Head of the Department and Dean (Academics).

4.8.2. However, a student having "No standing arrears" and a CGPA of 7.5 and above is only eligible. It is mandatory to satisfy the pre-requisites if any. The student shall register for the Project work in the VIII semester only. Total number of credits of such courses cannot exceed 8 per semester. No Fast Track course shall be offered by any department unless a minimum 10 students register for the course. However, if the students admitted in the associated branch and semester is less than 10, this minimum will not be applicable.

**4.9. Minimum Credits**

The total number of credits that a student earns during the period of study is called the total credits. For the successful completion of the B.E./B.Tech. Programme, a regular student must earn 160-162 credits (varies with the programme) in a minimum of eight Semesters, while a lateral-entry student must earn 114 - 116 credits in a minimum of six semesters.

**4.10. Flexibility to Add Credits**

**4.10.1.** A student has to earn the total number of credits specified in the curriculum of the respective Programme of study in order to be eligible to obtain the degree. However, if the student wishes, then the student is permitted to earn more than the total number of credits prescribed in the curriculum of the student's programme in the Course Category of Professional Elective (PE) and or Open Elective (OE) only.

**4.10.2.** For calculating the CGPA, the best out of the credits scores earned by the students will be taken in the PE and / or OE Category.

**4.10.3.** Flexibility to add credits is not permitted in other category of courses.

**4.11. Medium of Instruction**

The medium of instruction is English for all courses, examinations, seminar presentation / project / thesis / dissertation reports.

**5. DURATION OF THE PROGRAMME**

**5.1.** A student is ordinarily expected to complete the B.E. / B.Tech. Programme in 8 semesters (for HSC students) and six semesters (for Lateral Entry students) but in any case, not more than 14 Semesters for HSC (or equivalent) candidates and not more than 12 semesters for Lateral Entry candidates.

**5.2.** Each semester shall normally consist of 75 working days or 525 periods of 50 minutes each (including examination days). The Head of the Institution shall ensure that every teacher imparts instructions as per the number of periods specified in the syllabus covering the full content of the syllabus for the course being taught.

**5.3.** The semester end examinations will ordinarily follow immediately after the last working day of the semester as per the academic calendar prescribed from time to time.

**5.4.** The total period for completion of the programme reckoned from the commencement of the first semester to which the student was admitted shall not exceed the maximum period specified in clause 5.1 irrespective of the period of break of study (vide clause 11.9) in order that he/she may be eligible for the award of the degree (vide clause 11.11).

## 6. COURSE ENROLLMENT AND REGISTRATION

**6.1.** Each student, on admission shall be assigned to a Class Advisor (vide clause 7) who shall advice and counsel the student about the details of the academic programme and the choice of courses considering the student's academic background and career objectives.

**6.2.** Every student has to do course enrollment and registration within the stipulated time.

**6.3.** An elective course shall be offered only when a minimum of 20 students enrolls for the same.

**6.4.** After registering for a course, a student shall attend the classes, satisfy the attendance requirements, earn Continuous Internal Assessment marks and appear for the Semester End Examinations.

## 7. SEMESTER ABROAD PROGRAMME (SAP)

**7.1.1.** Students can travel to International Universities with the approval of Head of the Institution, Dean Academics and CoE for Semester Abroad (courses/ Project/ Research) Programme. University Level Courses (ULC) equivalent to the courses in the institution are permitted for credit transfer. ULC should match the courses in the specific programme of the institution satisfying AICTE/ AU norms.

**7.1.2.** Following are the eligibility conditions.

a) Two years must be completed with CGPA of 7.5

b) Have a good score in TOEFL, SAT, IELTS etc.

**7.1.3.** Semester Abroad Programme will be permitted for about 6-12 months duration only.

**7.1.4.** The medium of instruction under SAP must be in English only.

## 8. CLASS ADVISOR

Each class of students belonging to different sections of all the three years has a Class Advisor (CA) who is a regular faculty member of the department The Head of the Department (HOD) will appoint CAs for all the sections of the classes in their department. The CAs will hold the responsibility for three years of the same batch of students until the completion of the programme. The CAs will maintain all records of the class of students assigned to them and generally counsel them on maintaining good attendance, discipline and academic performance.

### 8.1. Tutor

In order to facilitate the students' progress and welfare, the Head of the Department will allocate a fixed number of students to a teaching faculty of the department who shall function as tutor for them throughout their period of study. Each tutor will have a maximum of 20 students allotted to him/her. The responsibilities of the tutor are:

**8.1.1.** Advice students in course registration, monitor their attendance and academic performance and counsel them periodically.

**8.1.2.** If necessary, the tutor may also discuss with, or inform the parents about the progress of the student concerned.

**8.1.3.** Tutor shall maintain a record of each of his/her wards, which shall contain information about the students' attendance, grades obtained in the Semester End Examinations, Continuous Internal Assessment Tests, achievements if any in Curricular, Co-curricular and Extra-curricular activities, medical history and disciplinary proceedings if any, taken against the student.

**8.1.4.** Tutors shall organize meetings with their wards in every semester, to keep track of their academic progress and to solve grievances if any and minute the same in the record.

**8.1.5.** Tutor shall coordinate with class advisor for close monitoring of their wards and to provide support to prepare academic records.

## 9. COURSE COMMITTEE FOR COMMON COURSES

Each common theory course offered to more than one discipline or group shall have a "Course Committee" comprising all the faculty members teaching the common course with one of them nominated as Course

Coordinator. The nomination of the Course Coordinator shall be made by the concerned course HoD depending upon whether all the faculty members teaching the common course belong to a single department or to several departments. The 'Course Committee' shall meet as often as necessary and ensure uniform evaluation of the tests through a common evaluation scheme. Wherever it is feasible, the Course Committee may also prepare a common question paper for the continuous internal assessments.

## 10. CLASS COMMITTEE

Every class shall have a Class Committee constituted by the respective Head of the Department. The class committee comprises of class advisor, tutor, faculty members handling the class concerned, student representatives and a chairperson who is not teaching the respective class. It is formed with the overall goal of improving the teaching-learning process. The functions of the Class Committee include

**10.1.** Solving problems experienced by students in the class room and in the laboratories.

**10.2.** Clarifying the regulations of the degree programme and the details of rules therein.

**10.3.** Informing the student representatives about the academic schedule including the dates of assessments and the syllabus coverage for each assessment.

**10.4.** Informing the student representatives, the details of regulations regarding weightage used for each assessment. In the case of practical courses (Laboratory experiments / Engineering drawing/project work/seminar/Internship etc.), the breakup of marks for each experiment/exercise/ module of work, should be clearly discussed in the Class Committee meeting and informed to the students.

**10.5.** Analyzing the performance of the students of the class after each test and finding the ways and means of solving problems, if any.

**10.6.** Identifying slow learning students, if any, and requesting the faculty members concerned to provide some additional help or guidance or coaching to such students.

**10.7.** The Class Committee for a class under a particular branch is normally constituted by the concerned Head of the Department.

**10.8.** The Class Committee shall be constituted within the first week of each semester.

**10.9.** At least 6 student representatives (usually 3 boys and 3 girls) shall be included in the Class Committee.

**10.10.** The Chairperson (a senior faculty member from the department) of the class committee shall invite the class Advisor, tutors and the HoD to the meeting of the Class Committee.

**10.11.** The Head of the Institution may participate in any class Committee meeting of the institution.

**10.12.** The Chairperson is required to prepare the minutes of every meeting, submit the same to Head of the Institution within two days of the meeting and arrange to circulate it among the students and faculty members concerned. If there are any points requiring support and action from the management, the same shall be brought to the notice of the management by the Head of the Institution.

**10.13.** Two subsequent meetings may be held in a semester at suitable intervals. During these meetings, the student members representing the entire class shall meaningfully express the opinions and suggestions of the other students of their class to improve the effectiveness of the teaching-learning process.

## 11. DEPARTMENT ADVISORY COMMITTEE (DAC)

All departments shall constitute a Department Advisory Committee (DAC) consisting of the HoD as Chairperson and 10% of senior faculties.

The roles and responsibilities of the DAC is as follows,

**i)** Study and suggest improvement in all the academic activities of the department.

**ii)** Suggest initiatives to enhance employability skill sets.

**iii)** To review and approve industries or other organizations identified for industrial training, internship or project work of students.

**iv)** Approve online/elective courses selected by students for the content and quality.

**v)** Introduce best practices for the attainment of POs/PEOs

**vi)** Suggest the equivalence of courses (addition/deletion of courses) to be studied for the transfer students from different regulations.

## 12. SYSTEM OF EXAMINATION

**12.1.** The system of examination is semester pattern.

Performance in each course of study shall be evaluated based on

- Continuous Internal Assessment (CIA) throughout the semester
- Semester End Examination (SEE) at the end of the semester

A student has to compulsorily register for the entire regular courses and all the arrear courses (if any) for appearing in the semester end examinations.

**12.2.** Each course, both theory and practical (including project work / viva voce examinations) shall be evaluated for a maximum of 100 marks as shown below:

**Table 12.1 Evaluation pattern of various courses**

| S. No | Category of course | Weightage for | |
|---|---|---|---|
| | | Continuous Internal Assessment | Semester End Examinations |
| 1. | Theory | 40 Marks | 60 Marks |
| 2. | Laboratory | 60 Marks | 40 Marks |
| 3. | Project Work | 60 Marks | 40 Marks |

**12.3.** The semester end examination of 3 hours duration shall be conducted for 100 marks as the maximum.

**12.4.** For the semester end examinations in both theory and practical courses including project work, the internal and external examiners shall be appointed by the Controller of Examinations.

## 13. PROCEDURE FOR AWARDING MARKS FOR CONTINUOUS INTERNAL ASSESSMENT (CIA)

### 13.1. Theory Courses

- For theory courses specified in the curriculum, out of 100 marks, the maximum mark for Continuous Internal Assessment is 40 and the Semester End Examinations are 60.
- The continuous internal assessment marks are awarded as per the procedure as follows.
- Continuous Internal Assessments comprises of three internal assessment tests, Assignment, Quizzes / Online Test / Case Study and Presentation / Tutorial. The Corresponding weightage is shown in the following table.

**Table 13.1 Evaluation components for Internal Assessment for Theory Courses**

| Particulars | Syllabus | Duration | Maximum Mark | Weightage (Marks reduced to) |
|---|---|---|---|---|
| Continuous Internal Assessment 1 | 1.5 Module | 1 hr 45 minutes | 60 | 8 |
| Continuous Internal Assessment 2 | 1.5 Module | 1 hr 45 minutes | 60 | 8 |
| Continuous Internal Assessment 3 | 2 Module | 2hrs 15 minutes | 80 | 8 |
| Assignment | 3 assignments covering all COs | | 50 (15+15+20) | 5 |
| Quiz / Online Test | | | 60 | 6 |
| Presentation / Tutorial / Case studies, etc., | | | 50 | 5 |
| | | | Total Marks | 40 |

**13.1.1.** In case a student has not appeared for the Continuous Internal Assessment due to medical reasons (hospitalization/ accident / specific illness) or due to participation in State / National/ International level Sports

events with prior permission from the HOD / Head of the Institution, a reassessment for any one of the Continuous Internal Assessment shall be given at the end of the semester through the concerned course handling faculty.

**13.2. Laboratory Courses**

**13.2.1.** For laboratory courses specified in the curriculum, out of 100 marks, the maximum mark for Continuous Internal Assessments is 60 and the Semester End Examinations is 40.

**13.2.2.** Every laboratory exercise / experiment shall be evaluated based on the student performance during the laboratory class and the student's laboratory records. The corresponding weightage is shown in the following table.

**Table 13.2 Evaluation components for Internal Assessment for Practical Courses**

| Parameter | Marks |
|---|---|
| Pre lab preparation | 30 |
| Conduct of experiment | 30 |
| Calculations, Result | 30 |
| Viva-voce | 10 |
| Total | 100 |
| Average of all Experiments | To be scaled down to 50 Marks |
| Model Practical Examination | 100<br>(To be scaled down to 10 Marks) |
| Continuous Internal Assessment Marks | 50+10 = 60 Marks |

**13.3. Project Work**

**13.3.1.** For Project Work, out of 100 marks, the maximum mark for continuous internal assessments is 60 and the Semester End Examinations is 60.

**13.3.2.** The Head of the Department shall constitute a review committee for project work for each branch of study.

**13.3.3.** Project work may be assigned to a single student or to a group of students not exceeding 4 per group. The student(s) is expected to follow the instructions of the project coordinator and Head of the department. The student(s) is expected to submit the project report on or before the last working day of the semester

**13.3.4.** The corresponding weightage for Mini Project / Innovative Project / Project Work Phase I/II shall be distributed as indicated in the following table.

**Table 13.3 Continuous Internal Assessment for Project Work**

**1. Innovative Project Work / Mini Project**

| **Review I (20 Marks)** | | **Review II (20 Marks)** | | **Report Evaluation (20 Marks)** | |
|---|---|---|---|---|---|
| Review Committee | Supervisor | Review Committee | Supervisor | Supervisor | Project Coordinator |
| 10 | 10 | 10 | 10 | 10 | 10 |

**2. Project Work Phase I**

| **Review I (15 Marks)** | | **Review II (15 Marks)** | | **Review III (15 Marks)** | | **Report Evaluation (15 Marks)** | |
|---|---|---|---|---|---|---|---|
| Review Committee | Supervisor | Review Committee | Supervisor | Review Committee | Supervisor | Supervisor | Project Coordinator |
| 10 | 5 | 10 | 5 | 10 | 5 | 5 | 10 |

**3. Project Work Phase II**

| Review I (10 Marks) | | Review II (10 Marks) | | Review III (10 Marks) | | Publications in Conference or Journals (10 Marks) | Report Evaluation (20 Marks) | |
|---|---|---|---|---|---|---|---|---|
| Review Committee | Supervisor | Review Committee | Supervisor | Review Committee | Supervisor | | Supervisor | Project Coordinator |
| 7 | 3 | 7 | 3 | 7 | 3 | 10 | 10 | 10 |

**13.4. Summer Internship / Industrial Training / Technical Seminar / Industry Oriented Courses (one credit) / Employment Enhancement (EEC) Courses (one credit)**

**13.4.1. Summer Internship**

**a)** After completion of the IV Semester, the student may undergo Summer Internship / Industrial Training after getting prior permission from HoD.

**b)** Internship and in-plant training in relevant organization / institutions shall be provided to the students in line with the course they go through in the curriculum.

**c)** Duration of the training will be two weeks during summer vacation.

**d)** Proof for the participation along with satisfactory completion certificate obtained from the organization concerned is mandatory.

**e)** Continuous Internal Assessment procedure for the summer internship and industrial training specified in curriculum is described below and reappearance is mandatory, in case of failure.

**f)** Summer internship and industrial training will be treated as non- credit courses and will be assessed as a qualitative measure of achievement based on Assessment Scale:

1. Evaluation of report given by the student (40%)
2. Student's presentation (40%)
3. Oral Examination (20%)

Assessment Scale: Below 45 % - Not Satisfactory, 45 % to 59 % - Satisfactory, 60 % to 74 % - Good, 75 % to 89 % - Very Good, 90 % to 100 % - Excellent

**g)** The final evaluation will be made based on the student report and a Viva - Voce Examination, conducted internally by a three-member panel constituted by the Head of the Department, in which at least one member has not less than three years of teaching experience. The final evaluation report of these courses shall be submitted by HoD to Head of the Institution for approval and forwarded to Controller of Examinations for entry in grade sheet.

**13.4.2. Technical Seminar**

**a)** Continuous Internal Assessment procedure for the Technical Seminar specified in curriculum is described below and reappearance is mandatory, in case of failure.

**b)** The Head of the Department will identify a faculty member as a coordinator for the course. A committee consisting of the Head of the Department, faculty handling the course and course coordinator will evaluate the students and assign grades based on their performance. The assessment procedure is given below.

**Table 13.4 Continuous Internal Assessment for Technical Seminar**

| Seminar Presentation – I (50 Marks) | | Seminar Presentation – II (50 Marks) | | Total (100 Marks) |
|---|---|---|---|---|
| Oral Presentation | Report | Oral Presentation | Report | |

| | | | | |
|---|---|---|---|---|
| 30 | 20 | 30 | 20 | 100 |

**13.4.3. Industry Oriented Course (one credit course)**

**a)** Continuous Internal Assessment procedure for the Industry Oriented Courses specified in curriculum is described below and reappearance is mandatory, in case of failure

**b)** The Head of the Department may identify a faculty member as a coordinator for the course. A committee consisting of the Head of the Department, faculty handling the course and course coordinator will evaluate the students and assign marks based on their performance. The assessment procedure is given below.

**Table 13.5 Evaluation Components for Internal Assessment for Industry Oriented Courses**

| Internal Assessment – I (Online Test / Quiz / Written Test / Oral Tests /Assignment / Tool test) | Internal Assessment – II (Online Test / Quiz / Written Test / Oral Tests /Assignment / Tool test) | Total |
|---|---|---|
| 50 | 50 | 100 |

**13.4.4. Employment Enhancement Course (EEC)**

Employment Enhancement Courses (EEC) will be continuously assessed internally as per the following assessment procedure.

**Table 13.6 Evaluation Components for Internal Assessment for Employment Enhancement Courses EEC (one credit)**

| Internal Assessment – I (Online Test / Quiz / Written Test / Oral Tests /Assignment / Tool test) | Internal Assessment – II (Online Test / Quiz / Written Test / Oral Tests /Assignment / Tool test) | Total |
|---|---|---|
| 50 | 50 | 100 |

**13.4.5. Non-Credit Courses**

**a)** Mandatory courses include Environmental Science and Engineering / Indian Constitution and Tradition / Technical Report Writing / Life Skills / Awareness on Competitive Examinations etc.,

**b)** For these courses, comments like Excellent, Very Good, Good, Satisfactory and Not-Satisfactory will be given as qualitative measures of achievement.

Assessment Scale: (fixed by the respective HODs to a maximum of 100 marks). Below 45 %- Not Satisfactory, 45 % to 59 %- Satisfactory, 60 %to 74 %- Good, 75 % to 89 %- Very Good, 90 % to 100 %- Excellent

**13.4.6. Design Thinking Laboratory**

The End Semester Examination for the Design Thinking Laboratory shall consist of an evaluation of the final report submitted by the student or students of the group (of not exceeding 4 students) by the panel of examiners consisting of faculty coordinator, supervisor and a common examiner from another programme nominated by the Head of the Institution.

**10.6 Continuous Internal Assessment Marks and Attendance Record**

10.6.1. Continuous Internal Assessment marks approved by the Head of the Department shall be displayed in the respective departments within 5 days from the last working day of the semester.

10.6.2. Every Faculty is required to maintain an “ATTENDANCE AND ASSESSMENT RECORD" which consists of attendance marked in each lecture or practical or project work class, the test marks and the record of class work (topic covered), separately for each course. This shall be submitted to the Head of the Departments periodically

(at least three times in a semester) for checking the syllabus coverage and the records of test marks and attendance. At the end of the semester, after due verification, the HoD will approve this. This record shall be verified by the Head of the Institution and kept in safe custody for 3 years.

10.6.3. The Practical classes for all the Practical /Lab component subjects will be assessed continuously and marks will be entered in the assessment record. If a student is absent for a laboratory class, then the student will be permitted to perform experiments based on the recommendation of the HoD during repeat classes conducted at the end of completion of all the experiments.

## 11. External Assessment

### 11.1 External Assessment for Theory Courses and Laboratory Courses

The Semester End Examinations for theory and laboratory courses will be of 3 hours duration and shall normally be conducted in the month of November/ December during the odd semesters and the month of April/May during the even semesters. Semester End Examination is a mandatory requirement for passing the course and every student should appear for the examination for theory courses and laboratory courses.

### 11.2 External Assessment for Project Work

11.2.1. Project work may be assigned to a single student or to a group of students not exceeding 4 per group. The student(s) is expected to submit the project report on or before the last working day of the semester.

11.2.2. The Semester End Examination for project work shall consist of evaluation of the final project report submitted by the student or students of the project group by an external examiner followed by a viva-voce examination conducted separately for each student by a committee consisting of the external examiner and an internal examiner.

11.2.3. If the project report is not submitted on or before the specified deadline, an extension of the time up to a maximum limit of 10 days may be given for the submission of project work by paying additional fee to conduct separate viva voce examination with due approval obtained from the Head of the Department. If the project report is not submitted even beyond the extended time, then the student(s) is deemed to have failed in the Project Work. The failed student(s) shall reappear for the same in the subsequent semester.

11.2.4. All answer books shall be preserved for six consecutive semesters in the strong room of CoE office.

### 11.3 Eligibility for Appearing in Semester End Examination

A student who has fulfilled the following conditions shall be deemed to have satisfied the attendance requirements for appearing for the semester end examination of a particular course.

11.3.1. Ideally every student is expected to attend all periods and earn 100% attendance. However, the student shall secure not less than 75% (after rounding off to the nearest integer) of the overall attendance.

11.3.2. If a student secures attendance between 65% and less than 75% in any course in the current semester, due to medical reasons (hospitalization / accident / specific illness) or due to participation in the College / University / State / National / International level Sports events, with prior permission from the Head of the Institution and Head of the Department concerned, the student shall be given exemption from the prescribed attendance requirement and the student shall be permitted to appear for the semester end examination of that course. In all such cases, the students should submit the required documents on joining after the absence to the Head of the Department through the Class Advisor.

11.3.3. A student shall normally be permitted to appear for the semester end examination of the course if the student has satisfied the attendance requirements (vide Clause 11.3.1 & 11.3.2) and has registered for the examination in those courses of that semester by paying the prescribed fee.

11.3.4. Students who do not satisfy clause 11.3.1 and 11.3.2 and who secure less than 65% attendance will not be permitted to write the Semester End Examination and will not be permitted to move to the next semester. They are required to repeat the incomplete semester in the next academic year, as per the norms prescribed.

11.3.5. The Continuous Internal Assessment marks obtained by the student in the first appearance shall be retained and considered valid only for THREE attempts. For further attempts, the student should secure minimum 50 marks exclusively from the Semester End Examinations conducted for 100 marks for passing the course.

11.3.6. A student who has already appeared for a course in a semester and passed the examination is not entitled to reappear for the same course for improvement of letter grades / marks.

**11.4 Passing Requirements**

11.4.1. Passing minimum for each theory, practical courses and project work is

a) 50% in the Semester End Examinations

b) Minimum 50% of the grand total of Continuous Assessment marks and Semester End Examinations marks put together.

11.4.2. For students scoring less than the passing minimum marks in the semester end examinations, the term “U” against the concerned course will be indicated in the grade sheet. The student has to reappear in the subsequent examinations for the concerned course as arrears.

11.4.3. For a student who is absent for theory / practical / project viva- voce, the term “AB” will be indicated against the corresponding course. The student should reappear for the semester end examination of that course as arrear in the subsequent semester.

11.4.4. The letter grade “W” will be indicated for the courses for which the student has been granted authorized withdrawal (refer clause 11.9).

**11.5 Arrear Examinations**

Students who fail in the semester end examinations with RA grade and absentees can appear for the exam in the subsequent semesters. Arrear examinations shall be conducted along with the regular examinations.

**11.6 Revaluation**

11.6.1. A student when not satisfied with the evaluation can apply for revaluation after consulting with the course faculty and HoD. Revaluation can be applied only for theory courses.

11.6.2. The student should pay the prescribed fee for getting photocopy of the answer script / revaluation.

11.6.3. Candidates who apply for photocopy of answer scripts only will be eligible for applying for revaluation.

11.6.4. Students can get the photocopy of the valued theory answer scripts after the publication of semester examination results (not for practical courses, project work, all one credit courses). It can be revalued and based on the same, the grade can get changed and if there is no change, the status NC grade shall be maintained. The grade that is obtained from the revaluation process is found to be better, then that grade will be retained as the final grade, else the earlier grade shall be retained as the final grade.

11.6.5. The entire revaluation process must be completed within four weeks from the date of publication of results.

**11.7 Review Revaluation**

Candidates not satisfied with Revaluation can apply for Review of the revaluation within the prescribed date on payment of a prescribed fee through proper application to Controller of Examinations.

**11.8 Withdrawal from Examination**

11.8.1. A student may, for valid reasons, and on prior application, may be granted permission to withdraw from appearing for one or more consecutive examinations in a semester. Such withdrawal shall be permitted only once during the entire period of study of the degree programme based on the recommendations given by the Head of the Department and Head of the Institution with required documents.

11.8.2. Withdrawal from examination will be permitted only if a student has nil arrear upto the previous semester.

11.8.3. Withdrawal application is valid only if it is submitted within TEN days prior to the commencement of the examinations as recommended by the Head of the Institution and approved by the Dean Academics and Controller of Examinations.

11.8.4. In extraordinary conditions, the TEN days requirement stated above shall be waived at the discretion of the Head of the Institution based on the merit of the case.

11.8.5. Withdrawal essentially requires the student to register for the course/courses. In the case of withdrawal, the same will be appropriately reflected in the Grade Sheets.

**11.9 Provision for Authorized Break of Study**

11.9.1. A student is permitted to opt for break of study for a maximum period of one year only in a single spell.

11.9.2. Break of Study shall be granted only once for valid reasons during the entire period of study of the degree programme. If a candidate intends to temporarily discontinue the programme in the middle of the semester for valid reasons, and to rejoin the programme in a subsequent year, permission may be granted based on the merits of the case provided he / she applies to the DOTE, Affiliating University, through the Head of the Institution stating the reasons thereof and the probable date of rejoining the programme. However, if the candidate has not completed the first semester of the programme, Break of Study will be considered only on valid medical reasons.

11.9.3. The candidates permitted to rejoin the programme after break of study, shall be governed by the Curriculum and Regulations in force at the time of rejoining. Students rejoining in new Regulations should appear for additional courses if any, as prescribed by Department Advisory Committee so as to bridge the curriculum in-force and the old curriculum.

11.9.4. The authorized break of study would not be counted towards the overall duration for completing the degree.

11.9.5. All the norms are liable to change upon the terms of the affiliated university.

**11.10 Eligibility for Awarding Grades**

11.10.1. A student who appears for the Semester End Examination and Continuous Internal Assessment Tests in any particular course only will be treated as eligible for the award of the grade in the course.

11.10.2. All assessment of a course will be done on mark basis. The letter grade and the grade point are awarded based on percentage of marks secured by a candidate in individual course as detailed below.

**Table 11.1 Grade Point**

| Range of Percentage of Total Marks | Letter Grade | Grade Point |
|---|---|---|
| 90 to 100 | O (Outstanding) | 10 |
| 80 to 89 | A+ (Excellent) | 9 |
| 70 to 79 | A (Very Good) | 8 |
| 60 to 69 | B+ (Good) | 7 |
| 50 to 59 | B (Above Average) | 6 |
| 0 to 49 | U | 0 |
| SA (Shortage of Attendance) | SA | 0 |
| Withdrawal from the final examination | W | 0 |

After the completion of the programme, the Cumulative Grade Point Average / Semester Grade Point average is calculated using the formula

$$\text{GPA / CGPA} = \frac{\sum_{i=1}^{n} C_i GP_i}{\sum_{i=1}^{n} C_i}$$

Where $C_i$ = Number of Credits assigned to the course

$GP_i$ = Point corresponding to the grade obtained for each course

n = Number of all courses successfully cleared during the particular semester in the case of SGPA and during all the semesters in the case of CGPA

11.10.3. After the results are declared, grade cards will be issued to each student which contains the list of registered courses with grades obtained.

11.10.4. The Semester Grade Point Average (SGPA) for each semester will be calculated and reflected in the grade sheet.

11.10.5. Similarly, Cumulative Grade Point Average (CGPA) up to current semester will be calculated and reflected in the grade sheet.

### 11.11 Award of Degree

#### 11.11.1 First Class with Distinction

A student who satisfies the following conditions shall be declared to have passed the examination in First class with Distinction:

a) Should have secured a CGPA of not less than 8.5.

b) Should have passed the examination in all the courses of all the 8 semesters/ 6 semesters in the case of Lateral Entry in the student's First Appearance. Withdrawal from examination will not be considered as an appearance.

c) One-year authorized break of study (if availed) is included in the five years/ four years in the case of lateral entry for award of First class with Distinction.

#### 11.11.2 First Class

A student who satisfies the following conditions shall be declared to have passed the examination in First class:

a) Should have secured a CGPA of not less than 7.0.

b) Should have passed the examination in all the courses of all the 8 semesters/6 semesters in the case of Lateral Entry. Withdrawal from examination will not be considered as an appearance.

c) One-year authorized break of study (if availed) is included in the five years/ four years in the case of lateral entry for award of First class.

#### 11.11.3 Second Class

Students who have passed in all courses and obtained CGPA below 7.0 and completed the course within the maximum prescribed period will be declared to have passed in second class.

### 11.12 Consolidated Statement of Grades

At the end of the programme, every successful student will be issued with consolidated statement of grades which contains the following particulars:

a) Grades in the courses of all the semesters (SGPA)

b) Cumulative Grade Point Average (CGPA)

### 11.13 Degree Classification

First class with Distinction / First class / Second class

### 11.14 Eligibility for Awarding Degree

A student shall be eligible for the award of the degree only if he/she:

11.14.1. Has undergone the prescribed programme of study by earning the minimum total number of credits specified in the curriculum of the relevant programme of study within the maximum duration prescribed.

11.14.2. Should have no disciplinary action pending against him/her including malpractices in examinations.

11.14.3. Should have successfully completed all Mandatory Courses.

### 11.15 Malpractice

The Head of the Institution shall refer the cases of malpractices in continuous internal assessment tests and semester-end examinations, to the Malpractice Enquiry Committee, constituted by him/her for the purpose. Such committee shall follow the approved scales of punishment. The Head of the Institution shall take necessary action, against the erring students based on the recommendations of the committee.

Any action on the part of candidate at an examination like possession of incriminating materials, cheat sheets, trying to get undue advantage in the performance or trying to help another, or derive the same through unfair means is punishable according to the provisions of the institution.

### 11.16 Transitory Regulation

11.16.1. A candidate, who is detained or discontinued the semester, on re- admission shall be required to pass all the courses in the curriculum prescribed for such batch of students in which the student joins subsequently and the academic regulations be applicable to him/her which are in force at the time of his/her re-admission.

11.16.2. However, exemption will be given to those candidates who have already passed in such courses in the earlier semester(s) and additional courses are to be studied as approved by Head of the Department, Dean Academics and Head of the Institution.

### 11.17 Discipline

Every student is required to observe discipline and decorous behavior both inside and outside the college and not to indulge in any activity which will tend to bring down the reputation of the College. The Head of Institution shall constitute a disciplinary committee consisting of Head of Institution, two Heads of Department of which one should be from the faculty of the student, to enquire into acts of indiscipline and notify about the disciplinary action recommended for approval. In case of any serious disciplinary action which leads to suspension or dismissal, then a committee shall be constituted including one representative from Anna University, Chennai. In this regard, the member will be nominated by the University on getting information from the Head of the Institution.

### 11.18 Revision of Regulation, Curriculum and Syllabus

11.18.1. The curriculum and syllabi under this regulation will be for four years. The college may from time-to-time revise, amend or change the Regulations, Curriculum, Syllabus and Scheme of examinations through the Board of Studies and Academic Council with the approval of the Governing Body of the college.

11.18.2. In the event of any clarification in the interpretation of the above rules and regulations, they shall be referred to the Standing Committee. The Standing Committee will offer suitable interpretations / clarifications/amendments required for the special case on such references and get them ratified in the next meeting of the Academic Council. The decision of the Academic Council will be final.

**B.E. – ELECTRICAL AND ELECTRONICS ENGINEERING**

**Courses of Study and Scheme of Assessment**

| Sl. No. | Course Code | Course Title | Periods / week | | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| | | **SEMESTER I** | | | | | | | | | |
| **THEORY** | | | | | | | | | | | |
| | | Induction Program | - | - | - | - | - | - | - | - | - |
| 1 | U19HS101 | Technical English | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19MA101 | Matrix Algebra and Calculus | BS | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 3 | U19PH101 | Engineering Physics | BS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19CS101 | Problem Solving using C | ES | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19ME101 | Engineering Graphics | ES | 5 | 1 | 0 | 4 | 3 | 40 | 60 | 100 |
| **PRACTICALS** | | | | | | | | | | | |
| 6 | U19PH111 | Physics Laboratory | BS | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 7 | U19GE111 | Engineering Practices Laboratory | ES | 4 | 0 | 0 | 4 | 2 | 60 | 40 | 100 |
| 8 | U19CS111 | Problem Solving using C Laboratory | ES | 4 | 0 | 0 | 4 | 2 | 60 | 40 | 100 |
| 9 | U19EM101 | Soft Skills | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| | | **Total** | | **30** | **13** | **1** | **16** | **22** | **480** | **420** | **900** |
| | | **SEMESTER II** | | | | | | | | | |
| **THEORY** | | | | | | | | | | | |
| 1 | U19HS11X | Language Elective | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19MA102 | Advanced Calculus and Complex Variables | BS | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 3 | U19CY101 | Engineering Chemistry | BS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19PH102 | Semiconductor Physics | BS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19EE103 | Circuit Theory | ES | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 6 | U19CS103 | Data Structures and Algorithms | ES | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **PRACTICALS** | | | | | | | | | | | |
| 7 | U19CY111 | Chemistry Laboratory | BS | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 8 | U19CS113 | Data Structures and Algorithms Laboratory | ES | 4 | 0 | 0 | 4 | 2 | 60 | 40 | 100 |
| 9 | U19EE111 | Electric Circuits and Electronic Devices Laboratory | ES | 2 | 0 | 0 | 2 | 1 | - | - | - |
| | | **Total** | | **28** | **18** | **2** | **8** | **24** | **360** | **440** | **800** |

| | | | | | |
|---|---|---|---|---|---|
| CAT | Category of Course | BS | Basic Sciences | PW | Project Work |
| CP | Contact Periods | HS | Humanities and Social Sciences | EM | Employability Enhancement Course |
| L | Lecture Hours | ES | Engineering Sciences | NC | Non-Credit Course |
| T | Tutorial Hours | PC | Professional Core | MC | Mandatory Course |
| P | Practical Hours | PE | Professional Elective | CIA | Continuous Internal Assessment |
| C | Credits | OE | Open Elective | SEE | Semester End Examination |

**B.E. – ELECTRICAL AND ELECTRONICS ENGINEERING**

**Courses of Study and Scheme of Assessment**

| Sl. No. | Course Code | Course Title | Periods / week | | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| | | **SEMESTER III** | | | | | | | | | |
| **THEORY** | | | | | | | | | | | |
| 1 | U19MA201 | Transforms and Partial Differential Equations | BS | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 2 | U19EE201 | Field Theory | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 3 | U19EE202 | DC Machines and Transformers | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 4 | U19EE203 | Linear and Digital Electronics | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 5 | U19EE204 | Measurements and Instrumentation | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19MC201 | Environmental Science | MC | 1 | 1 | 0 | 0 | NC | - | - | - |
| **PRACTICALS** | | | | | | | | | | | |
| 7 | U19EE211 | DC Machines and Transformers Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 8 | U19EE212 | Linear and Digital Electronics Circuits Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 9 | U19ICXXX | Industry Oriented Course I | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| | | **Total** | | **30** | **13** | **1** | **16** | **22** | **480** | **420** | **900** |
| | | **SEMESTER IV** | | | | | | | | | |
| **THEORY** | | | | | | | | | | | |
| 1 | U19MA205 | Statistics and Numerical Methods | BS | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 2 | U19EE205 | AC Machines | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 3 | U19EE206 | Control Systems | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 4 | U19EE207 | Generation, Transmission and Distribution | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 5 | U19XXXXX | Open Elective I* | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19MC202 | Indian Constitution and Tradition | MC | 1 | 1 | 0 | 0 | NC | - | - | - |
| **PRACTICALS** | | | | | | | | | | | |
| 7 | U19EE213 | AC Machines Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 8 | U19EE214 | Control and Instrumentation Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | |
| 9 | U19EE281 | Mini Project | PW | 2 | 0 | 0 | 2 | 1 | 60 | 40 | |
| 10 | U19EM201 | Verbal and Soft Skills | EM | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| | U19EM202 | Summer Internship | EM | - | - | - | - | NC | - | - | - |
| | | **Total** | | **28** | **16** | **4** | **8** | **23** | **440** | **460** | **900** |

| | | | | | |
|---|---|---|---|---|---|
| CAT | Category of Course | BS | Basic Sciences | PW | Project Work |
| CP | Contact Periods | HS | Humanities and Social Sciences | EM | Employability Enhancement Course |
| L | Lecture Hours | ES | Engineering Sciences | NC | Non-Credit Course |
| T | Tutorial Hours | PC | Professional Core | MC | Mandatory Course |
| P | Practical Hours | PE | Professional Elective | CIA | Continuous Internal Assessment |
| C | Credits | OE | Open Elective | SEE | Semester End Examination |

**B.E. – ELECTRICAL AND ELECTRONICS ENGINEERING**

**Courses of Study and Scheme of Assessment**

| Sl. No. | Course Code | Course Title | Periods / week | | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| | | **SEMESTER V** | | | | | | | | | |
| **THEORY** | | | | | | | | | | | |
| 1 | U19EE301 | Power System Analysis | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 2 | U19EE302 | Power Electronics | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 3 | U19EE303 | Microprocessors and Microcontrollers | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EE5XX | Professional Elective I | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19XXXXX | Open Elective II* | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **PRACTICALS** | | | | | | | | | | | |
| 6 | U19EE311 | Power Electronics Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 7 | U19EE312 | Microprocessor and Microcontroller Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 8 | U19EM301 | Aptitude I | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| | | **Total** | | **23** | **15** | **2** | **6** | **20** | **420** | **380** | **800** |
| | | **SEMESTER VI** | | | | | | | | | |
| **THEORY** | | | | | | | | | | | |
| 1 | U19EE304 | Solid State Drives | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19EE305 | Power System Protection and Switchgear | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19EE306 | Special Electrical Machines | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EE5XX | Professional Elective II | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19XXXXX | Open Elective III* | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **PRACTICALS** | | | | | | | | | | | |
| 6 | U19EE313 | Power Systems Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 7 | U19EE381 | Innovative/ Multi-Disciplinary Project | PW | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 8 | U19ICXXX | Industry Oriented Course II | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 9 | U19EM302 | Aptitude II | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 10 | U19EM303 | Design Thinking Laboratory | EM | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| | | **Total** | | **25** | **15** | **0** | **10** | **20** | **580** | **420** | **800** |

| | | | | | |
|---|---|---|---|---|---|
| CAT | Category of Course | BS | Basic Sciences | PW | Project Work |
| CP | Contact Periods | HS | Humanities and Social Sciences | EM | Employability Enhancement Course |
| L | Lecture Hours | ES | Engineering Sciences | NC | Non-Credit Course |
| T | Tutorial Hours | PC | Professional Core | MC | Mandatory Course |
| P | Practical Hours | PE | Professional Elective | CIA | Continuous Internal Assessment |
| C | Credits | OE | Open Elective | SEE | Semester End Examination |

**B.E. – ELECTRICAL AND ELECTRONICS ENGINEERING**

**Courses of Study and Scheme of Assessment**

| Sl. No. | Course Code | Course Title | | Periods / week | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| | | **SEMESTER VII** | | | | | | | | | |
| **THEORY** | | | | | | | | | | | |
| 1 | U19HS401 | Principles of Management and Professional Ethics | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19EE401 | Embedded Systems | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19EE5XX | Professional Elective III | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EE5XX | Professional Elective IV | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **PRACTICALS** | | | | | | | | | | | |
| 5 | U19EE481 | Project Work – Phase I | PW | 6 | 0 | 0 | 6 | 3 | 60 | 40 | 100 |
| | | **Total** | | **18** | **12** | **0** | **6** | **15** | **220** | **280** | **500** |
| | | **SEMESTER VIII** | | | | | | | | | |
| **THEORY** | | | | | | | | | | | |
| 1 | U19EE5XX | Professional Elective V | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19XXXXX | Open Elective IV* | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **PRACTICALS** | | | | | | | | | | | |
| 3 | U19EE482 | Project Work – Phase II | PW | 16 | 0 | 0 | 16 | 8 | 60 | 40 | 100 |
| | | **Total** | | **22** | **6** | **0** | **16** | **14** | **140** | **160** | **300** |

**Total Number of Credits: 160**

| | | | | | |
|---|---|---|---|---|---|
| CAT | Category of Course | BS | Basic Sciences | PW | Project Work |
| CP | Contact Periods | HS | Humanities and Social Sciences | EM | Employability Enhancement Course |
| L | Lecture Hours | ES | Engineering Sciences | NC | Non-Credit Course |
| T | Tutorial Hours | PC | Professional Core | MC | Mandatory Course |
| P | Practical Hours | PE | Professional Elective | CIA | Continuous Internal Assessment |
| C | Credits | OE | Open Elective | SEE | Semester End Examination |

**SUMMARY**

| Sl. No. | Course Category | Credits per Semester | | | | | | | | Credits | Credit % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | | |
| 1 | **HS** | 3 | 3 | - | - | - | - | 3 | - | 9 | 5.6 |
| 2 | **BS** | 8 | 11 | 4 | 4 | - | - | - | - | 27 | 16.9 |
| 3 | **ES** | 10 | 10 | - | - | - | - | - | - | 20 | 12.5 |
| 4 | **PC** | - | - | 17 | 14 | 13 | 10 | 3 | - | 57 | 35.6 |
| 5 | **PE** | - | - | - | - | 3 | 3 | 6 | 3 | 15 | 9.4 |
| 6 | **OE** | - | - | - | 3 | 3 | 3 | - | 3 | 12 | 7.5 |
| 7 | **PW** | - | - | - | 1 | - | 1 | 3 | 8 | 13 | 8.1 |
| 8 | **EM** | 1 | - | 1 | 1 | 1 | 3 | - | - | 7 | 4.4 |
| 9 | **NC** | - | - | - | ✓ | - | - | - | - | - | - |
| 10 | **MC** | - | - | ✓ | ✓ | - | - | - | - | - | - |
| **Total** | | **22** | **24** | **22** | **23** | **20** | **20** | **15** | **14** | **160** | **100** |

**B.E. – ELECTRICAL AND ELECTRONICS ENGINEERING**

**Courses of Study and Scheme of Assessment**

| Sl. No. | Course Code | Course Title | Periods / week | | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| | | **HUMANITIES AND SOCIAL SCIENCES (HS)** | | | | | | | | | |
| 1 | U19HS101 | Technical English | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19HS11X | Language Elective | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19HS401 | Principles of Management and Professional Ethics | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **LANGUAGE ELECTIVES (HS)** | | | | | | | | | |
| 1 | U19HS111 | Business English | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19HS112 | Basic Japanese | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19HS113 | Basic German | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19HS114 | Basic French | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **BASIC SCIENCES (BS)** | | | | | | | | | |
| 1 | U19MA101 | Matrix Algebra and Calculus | BS | 5 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 2 | U19PH101 | Engineering Physics | BS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19PH111 | Physics Laboratory | BS | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 4 | U19MA102 | Advanced Calculus and Complex Variables | BS | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 5 | U19CY101 | Engineering Chemistry | BS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19PH102 | Semiconductor Physics | BS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19CY111 | Chemistry Laboratory | BS | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 8 | U19MA201 | Transforms and Partial Differential Equations | BS | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 9 | U19MA205 | Statistics and Numerical Methods | BS | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| | | **ENGINEERING SCIENCES (ES)** | | | | | | | | | |
| 1 | U19CS101 | Problem Solving using C | ES | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19ME101 | Engineering Graphics | ES | 5 | 1 | 0 | 4 | 3 | 40 | 60 | 100 |
| 3 | U19GE111 | Engineering Practices Laboratory | ES | 4 | 0 | 0 | 4 | 2 | 60 | 40 | 100 |
| 4 | U19CS111 | Problem Solving using C Laboratory | ES | 4 | 0 | 0 | 4 | 2 | 60 | 40 | 100 |
| 5 | U19EE103 | Circuit Theory | ES | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 6 | U19CS103 | Data Structures and Algorithms | ES | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19CS113 | Data Structures and Algorithms Laboratory | ES | 4 | 0 | 0 | 4 | 2 | 60 | 40 | 100 |
| 8 | U19EE111 | Electronic Devices and Circuits Laboratory | ES | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| | | **ROFESSIONAL CORE (PC)** | | | | | | | | | |
| 1 | U19EE201 | Field Theory | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 2 | U19EE202 | DC Machines and Transformers | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 3 | U19EE203 | Linear and Digital Electronics | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 4 | U19EE204 | Measurements and Instrumentation | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19EE211 | DC Machines and Transformers Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 6 | U19EE212 | Linear and Digital Electronics Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 7 | U19EE205 | AC Machines | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 8 | U19EE206 | Control Systems | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 9 | U19EE207 | Generation, Transmission and Distribution | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 10 | U19EE213 | AC Machines Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 11 | U19EE214 | Control and Instrumentation Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 12 | U19EE301 | Power System Analysis | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |
| 13 | U19EE302 | Power Electronics | PC | 4 | 3 | 1 | 0 | 4 | 40 | 60 | 100 |

| Sl. No. | Course Code | Course Title | Periods / week | | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| 14 | U19EE303 | Microprocessor and Microcontrollers | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 15 | U19EE311 | Power Electronics Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 16 | U19EE312 | Microprocessor and Microcontrollers Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 17 | U19EE304 | Solid State Drives | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 18 | U19EE305 | Power System Protection and Switchgear | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 19 | U19EE306 | Special Electrical Machines | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20 | U19EE313 | Power Systems Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 21 | U19EE401 | Embedded Systems | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **PROFESSIONALELECTIVES (PE)** | | | | | | | | | |
| | | **POWER SYSTEMS** | | | | | | | | | |
| 1 | U19EE501 | Energy Auditing and Management | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19EE502 | Power System Transients | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19EE503 | Power System Operation and Control | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EE504 | High Voltage Engineering | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19EE505 | HVDC and EHVAC Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19EE506 | Electrical Energy Utilization and Conservation | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19EE507 | Power System Planning and Reliability | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19EE508 | Restructured Power Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 9 | U19EE509 | Digital Protection of Power Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 10 | U19EE510 | AI Applications to Power System | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **ELECTRICAL MACHINES AND POWER ELECTRONICS** | | | | | | | | | |
| 11 | U19EE511 | Design of Electrical Machines | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 12 | U19EE512 | Electrical Machine Analysis | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 13 | U19EE513 | Advanced Power Semiconductor Devices | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 14 | U19EE514 | Modern Power Converters | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 15 | U19EE515 | Flexible AC Transmission Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 16 | U19EE516 | Power Quality | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 17 | U19EE517 | Application of Power Electronics to Power Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 18 | U19EE518 | Microprocessor Applications in Power Electronics | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 19 | U19EE519 | Micro Electro Mechanical Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 20 | U19EE520 | Switched Mode Power Conversion | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **RENEWABLE ENERGY SYSTEMS** | | | | | | | | | |
| 21 | U19EE521 | Non-conventional Energy Sources | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22 | U19EE522 | Solar and Wind Energy Conversion Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 23 | U19EE523 | Design of Solar Photovoltaic Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 24 | U19EE524 | Distributed Generation and Microgrid | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 25 | U19EE525 | Smart Grid | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 26 | U19EE526 | Electric Vehicles and Power Management | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 27 | U19EE527 | Solar and Energy Storage Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 28 | U19EE528 | Grid Integration of Renewable Energy Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 29 | U19EE529 | Power Electronics for Renewable Energy System | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 30 | U19EE530 | Energy Conservation Practices | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **CONTROL AND AUTOMATION** | | | | | | | | | |
| 31 | U19EE531 | Advanced Control Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 32 | U19EE532 | Advanced Microprocessors and Microcontrollers | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

| Sl. No. | Course Code | Course Title | Periods / week | | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| 33 | U19EE533 | Microcontroller Based System Design | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 34 | U19EE534 | PLC and SCADA | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 35 | U19EE535 | Virtual Instrumentation | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 36 | U19EE536 | Process Control and Instrumentation | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 37 | U19EE537 | Nano Electronics | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 38 | U19EE538 | Embedded Networked systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 39 | U19EE539 | Electric Vehicle Mechanics and Control | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 40 | U19EE540 | Control of Electrical Machines | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **SEMESTER V**<br>**PROFESSIONAL ELECTIVE I** | | | | | | | | | |
| 1 | U19EE501 | Energy Auditing and Management | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19EE502 | Power System Transients | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19EE511 | Design of Electrical Machines | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EE512 | Electrical Machine Analysis | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19EE521 | Non-conventional Energy Sources | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19EE522 | Solar and Wind Energy Conversion Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19EE531 | Advanced Control Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19EE532 | Advanced Microprocessors and Microcontrollers | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **SEMESTER VI**<br>**PROFESSIONAL ELECTIVE II** | | | | | | | | | |
| 1 | U19EE503 | Power System Operation and Control | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19EE504 | High Voltage Engineering | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19EE513 | Advanced Power Semiconductor Devices | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EE514 | Modern Power Converters | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19EE523 | Design of Solar Photovoltaic Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19EE524 | Distributed Generation and Microgrid | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19EE533 | Microcontroller Based System Design | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19EE534 | PLC and SCADA | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **SEMESTER VII**<br>**PROFESSIONAL ELECTIVE III** | | | | | | | | | |
| 1 | U19EE505 | HVDC and EHVAC Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19EE506 | Electrical Energy Utilization and Conservation | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19EE515 | Flexible AC Transmission Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EE516 | Power Quality | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19EE525 | Smart Grid | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19EE526 | Electric Vehicles and Power Management | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19EE535 | Virtual Instrumentation | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19EE536 | Process Control and Instrumentation | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **SEMESTER VII**<br>**PROFESSIONAL ELECTIVE IV** | | | | | | | | | |
| 1 | U19EE507 | Power System Planning and Reliability | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19EE508 | Restructured Power Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19EE517 | Application of Power Electronics to Power Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EE518 | Microprocessor Applications in Power Electronics | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19EE527 | Solar and Energy Storage Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19EE528 | Grid Integration of Renewable Energy Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19EE537 | Nano Electronics | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19EE538 | Embedded Networked systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

**SEMESTER VIII**
**PROFESSIONAL ELECTIVE V**

| Sl. No. | Course Code | Course Title | Periods / week | | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| 1 | U19EE509 | Digital Protection of Power Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19EE510 | AI Applications to Power System | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19EE519 | Micro Electro Mechanical Systems | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EE520 | Switched Mode Power Conversion | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19EE529 | Power Electronics for Renewable Energy System | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19EE530 | Energy Conservation Practices | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19EE539 | Electric Vehicle Mechanics and Control | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19EE540 | Control of Electrical Machines | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **OPEN ELECTIVES (OE)** | | | | | | | | | |
| | | **Open Electives offered by Department of Computer and Communication Engineering** | | | | | | | | | |
| 1 | U19CC601 | Multi-Core Architecture and Programming | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19CC602 | Service Oriented Architecture | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19CC603 | Network Protocols | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19CC604 | Software Defined Networks | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19CC605 | GPU Architecture and Programming | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19CC606 | High Speed Networks | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19CC607 | Introduction to Industrial Networking | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19CC608 | Basics of Mobile Communication | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 9 | U19CC609 | Introduction to Wireless Communication Networks | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 10 | U19CC610 | Basics of Video Analytics | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **Open Electives offered by Department of Computer Science and Engineering** | | | | | | | | | |
| 1 | U19CS601 | Database Technologies | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19CS602 | Java Programming | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19CS603 | Fundamentals of Operating System | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19CS604 | Introduction to Artificial Intelligence | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19CS605 | Advanced Data Structures | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19CS606 | Fundamentals of Python Programming | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19CS607 | Fundamentals of Data Structures | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19CS608 | Quantum Computing Technologies | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 9 | U19CS609 | Java Ful Stack | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 10 | U19CS610 | UI Design using Java | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 11 | U19CS611 | Algorithmic Design Techniques | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **Open Electives offered by Department of Electronics and Communication Engineering** | | | | | | | | | |
| 1 | U19EC601 | Discrete Time Signal Processing | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19EC602 | Principles of Analog and Digital Communication | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19EC603 | Digital Systems and VLSI Design | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19EC604 | Introduction to IoT | OE | 4 | 2 | 0 | 2 | 3 | 40 | 60 | 100 |
| 5 | U19EC605 | Basics of Biomedical Instrumentation | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19EC606 | Introduction to Image processing | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19EC607 | Microcontroller and Embedded Systems | OE | 4 | 2 | 0 | 2 | 3 | 40 | 60 | 100 |
| 8 | U19EC608 | Introduction to Wireless Sensor Networks | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 9 | U19EC609 | Introduction to Robotics and Automation | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 10 | U19EC610 | Embedded C | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

**Open Electives offered by Department of Mechanical Engineering**

| Sl. No. | Course Code | Course Title | Periods / week | | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| 1 | U19ME601 | Product Design and Innovation | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19ME602 | 3D Printing and Tooling | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19ME603 | Quality Management | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19ME604 | Enterprise Resource Planning | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19ME605 | Micro Electro Mechanical Systems | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19ME606 | Quality Control Tools and Techniques | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19ME607 | World Class Manufacturing | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19ME608 | Industrial Safety Engineering | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 9 | U19ME609 | Introduction to Industry 4.0 | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 10 | U19ME610 | Lean Six Sigma and Supply Chain Management | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 11 | U19ME611 | Business Organisation and Development | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 12 | U19ME612 | Product Distribution and Promotion Management | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 13 | U19ME613 | Business Ethics, Corporate Social Responsibility and Governance | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **Open Electives offered by Department of Information Technology** | | | | | | | | | |
| 1 | U19IT601 | Basics of Software Engineering | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19IT602 | Web Programming | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19IT603 | Basics of Software Testing | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19IT604 | Introduction to Blockchain Technology | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19IT605 | Soft Computing Techniques | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | U19IT606 | Fundamentals of IT Infrastructure Management | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | U19IT607 | Mobile Application Development | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | U19IT608 | Introduction to Computer Networks | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **Open Electives offered by Department of Artificial Intelligence and Data Science** | | | | | | | | | |
| 1 | U19AD601 | Machine Learning Techniques | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19AD602 | Introduction to Augmented Reality (AR) / Virtual Reality (VR) | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19AD603 | Data Science Essentials | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19AD604 | Artificial Intelligence Essentials | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **Open Electives offered by Department of Computer Science and Business Systems** | | | | | | | | | |
| 1 | U19CB601 | Data Integration & Big data | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19CB602 | Fundamentals of Software Project Management | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19CB603 | Introduction to Agile Software Development | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19CB604 | Enterprise Systems | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19CB605 | Behavioral Economics | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | U19CB606 | Financial Management | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **Open Electives offered by Humanities and Social Sciences** | | | | | | | | | |
| 1 | U19HS601 | English for Competitive Examinations | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19HS602 | Personality Development and Interpersonal Skills | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19HS603 | Communication Techniques for Employability | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19HS604 | Mass Communication | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | U19HS605 | Operational Research | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

**Open Electives offered by Department of Department of Physics**

| Sl. No. | Course Code | Course Title | Periods / week | | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | CAT | CP | L | T | P | C | CIA | SEE | Total |
| 1 | U19PH601 | Laser Technology | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19PH602 | Nanomaterials and Applications | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19PH603 | Physics for Solar PV Systems | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19PH604 | Medical Physics | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **Open Electives offered by Department of Chemistry** | | | | | | | | | |
| 1 | U19CY601 | Chemical Sensors and Biosensors | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | U19CY602 | Energy Storing Devices | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | U19CY603 | Forensic Science | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | U19CY604 | Industrial and Material Chemistry | OE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| | | **PROJECT WORK (PW)** | | | | | | | | | |
| 1 | U19EE281 | Mini Project | PW | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 2 | U19EE381 | Innovative / Multi-Disciplinary Project | PW | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| 3 | U19EE481 | Project Work – Phase I | PW | 6 | 0 | 0 | 6 | 3 | 60 | 40 | 100 |
| 4 | U19EE482 | Project Work – Phase II | PW | 16 | 0 | 0 | 16 | 8 | 60 | 40 | 100 |
| | | **EMPLOYABILITY ENHANCEMENT COURSES (EM)** | | | | | | | | | |
| 1 | U19EM101 | Soft Skills | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 2 | U19ICXXX | Industry Oriented Course I | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 3 | U19EM201 | Verbal and Soft Skills | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 4 | U19EM202 | Summer Internship | EM | - | - | - | - | NC | - | - | - |
| 5 | U19EM301 | Aptitude I | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 6 | U19EM302 | Aptitude II | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 7 | U19EM303 | Design Thinking Laboratory | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 8 | U19ICXXX | Industry Oriented Course II | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| | | **INDUSTRY ORIENTED COURSES** | | | | | | | | | |
| 1 | U19IC308 | OCJP Certification | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 2 | U19IC501 | Electrical Estimation, Cost and Auditing | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 3 | U19IC502 | Solar PV Systems: Design, Simulation, and Monitoring and Control | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 4 | U19IC503 | Automotive Electrical Systems | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 5 | U19IC504 | Electronics Design and Automation | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 6 | U19IC505 | Industrial Automation using PLC | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| 7 | U19IC506 | Industrial Robotics | EM | 2 | 0 | 0 | 2 | 1 | 100 | - | 100 |
| | | **MANDATORY COURSES (MC)** | | | | | | | | | |
| 1 | U19MC201 | Environmental Science | MC | 1 | 1 | 0 | 0 | NC | - | - | - |
| 2 | U19MC202 | Indian Constitution and Tradition | MC | 1 | 1 | 0 | 0 | NC | - | - | - |

**SEMESTER – I**

| U19HS101 | TECHNICAL ENGLISH | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Express their ideas effectively using appropriate vocabulary | K2 |
| CO2 | **(Apply)** Develop reading skills with the help of relevant reading strategies | K3 |
| CO3 | **(Apply)** Apply various interactive techniques for effective communication | K3 |
| CO4 | **(Apply)** Write letters, Contents and articles with proper structure | K3 |
| CO5 | **(Apply)** Make use of writing skills to communicate effectively | K3 |

**MODULE I INTRODUCTION TO EFFECTIVE SPEAKING** **9**

**Listening** – Listening process and practice - Exposure to recorded and short talks, Classroom lectures - **Speaking** - Introducing oneself, one's family / friend; Talk about preferences – Agree and Disagree – Giving opinions – Body language – Eye contact - **Reading** - Introduction of different kinds of reading materials (Technical and Non-technical) - **Writing** - Principles of clear writing – completing sentences – Word formation – Word expansion (root words / etymology) - Hints development, Reading comprehension exercises - **Grammar** – Parts of speech, articles, Questions – WH type, Yes/ No and Tag Questions.

**MODULE II DIFFERENT STRATEGIES OF READING** **9**

**Listening** - Listening to specific information – Active listening, Listening and responding to video lectures / talks - **Speaking** - Strategies for good conversation - Improving fluency and self expression – Articulation – Voice quality – Accent and intonation - **Reading** - Different reading strategies, Skimming, Scanning, Predicting, Pre-reading, Post-reading and inductive reading - **Writing** - Biographical writing (place, people), Descriptions, Instructions, Recommendations, Definitions – Single sentence definition - **Grammar** - Types of sentences, Use of imperatives, Prepositions, Modal verbs.

**MODULE III GROUP INTERACTION** **9**

**Listening** - Listening to telephonic conversation and conveying the messages - **Speaking** - Group interaction - Speaking in formal situations (teachers, officials, foreigners) - **Reading** - Longer technical texts, Identifying the various transitions in the text - **Writing** - Paragraph writing - Cohesion and Coherence in writing, Jumbled Sentences, Letter writing – Formal - Different forms and uses of words; **Grammar** - Synonym and antonym, Tenses – ( present form), Adjectives - Cause and Effect expressions.

**MODULE IV INTRODUCTION TO EFFECTIVE WRITING** **9**

**Listening** – Listening to Identify topic, Context, function, speakers, opinion, etc - **Speaking**- Responding to questions – Different forms of interviews – Speaking at different types of interviews - **Reading** – Identifying relationship between characters, facts and ideas, comparing facts and figures - **Writing** - Email-etiquette, summarizing and paragraphing – Single word substitutes - Free writing on any given topic (My favourite place / Hobbies / School life, etc.) **Grammar** – Tenses – (Past form), Adverbs and Phrasal verbs.

**MODULE V EFFECTIVE WRITING** **9**

**Listening** – Listening to dialogues, conversations and completing exercises based on them – Listening to specific task – focused audio track **Speaking** - Participating in conversation-short/group conversations - Role-play **Reading** - Reading and understanding specific meaning in a text - note making, Vocabulary Extension, cloze reading - **Writing** – Types of essays, story writing - dialogue writing. Use of abbreviations and acronyms - **Grammar** - Tenses – (Future form), Collocations, fixed and semi fixed expressions.

**Total: 45 Hours**

**TEXT BOOKS**


1. Jack C. Richards, "Interchange Student's Book 1", Cambridge University Press, Fourth Edition, 2015.
2. Mahalakshmi S. N, "Communicative English for Engineers", V. K. Publications, Ninth Edition, 2019.

**REFERENCES**


1. Rizvi M. Ashraf, “Effective Technical Communication”, Tata McGraw Hill, 2007.
2. Andrea J. Rutherfoord, “Pearson Education” Inc. and The Darling Kindersley Publishing Inc., 2006.
3. Raman Meenakshi and Sharma Sangeetha “Technical Communication Principles and Practice”, Oxford University Press, 2014.
4. Richards C. Jack, “Interchange”, Cambridge University Press, Fourth Edition, 2012.
5. Butterfield, Jeff, “Soft skills for Everyone”, Sixth Indian Reprint, 2015.


| U19MA101 | MATRIX ALGEBRA AND CALCULUS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Determine inverse, higher integral powers by Cayley Hamilton theorem and convert quadratic form to canonical form by orthogonal transformation. | K3 |
| CO2 | **(Apply)** Test the convergence or divergence of series of positive terms and alternating series by various techniques. | K4 |
| CO3 | **(Apply)** Classify the extreme values of functions of two variables and functional dependence. | K4 |
| CO4 | **(Apply)** Apply integration concepts to compute area of the given surfaces, integrals in cartesian and polar coordinates. | K3 |
| CO5 | **(Apply)** Apply triple integration concepts to compute volume of the given surfaces and solid structure and area, volume of the surface using Gamma and Beta functions. | K3 |

**MODULE I MATRICES** **12**

Eigen values and Eigen vectors of a real matrix – Properties of Eigen values and Eigen vectors – Cayley Hamilton theorem (excluding proof) – Orthogonal matrices – Orthogonal transformation of a symmetric matrix to diagonal form – Reduction of quadratic form to canonical form by orthogonal transformation.

**MODULE II SEQUENCES AND SERIES** **12**

Sequences: Definition and examples. Series: Types and Convergence – Series of positive terms – Tests of convergence: Comparison test, Integral test and D’Alembert’s ratio test. Alternating series – Leibnitz’s test – Series of positive and negative terms – Absolute and conditional convergence.

**MODULE III MULTIVARIABLE CALCULUS** **12**

Partial derivatives – Total derivative – Differentiation of implicit functions – Jacobian – Properties – Taylor’s series – Maxima and minima of functions of two variables – Lagrange’s method of undetermined multipliers.

**MODULE IV DOUBLE INTEGRATION** **12**

Double integrals – Change of order of integration – Double integrals in polar coordinates - Area enclosed by plane curves.

**MODULE V INTEGRATION AND ITS APPLICATION** **12**

Evaluation of triple integrals **–** Volume as triple integral – Simple problems – Volume of solid – Gamma and Beta functions.

**Total: 60 Hours**

**TEXT BOOKS**


1. Grewal. B. S, “Higher Engineering Mathematics”, Khanna Publications, 44th Edition, 2015.
2. Erwin Kreyszig, “Advanced Modern Engineering Mathematics”, John Wiley and Sons, Tenth Edition, 2017.


**REFERENCES**


1. Dass H. K, “Advanced Engineering Mathematics”, S. Chand & Company, Reprint, 2009.
2. John Bird, “Higher Engineering Mathematics”, An imprint of Elsevier, Burlington, Reprint 2010.
3. Bali. N. P and Manish Goyal, “A Text book of Engineering Mathematics”, Laxmi publications Ltd, Eighth Edition, 2011.
4. Veerarajan. T, “Engineering Mathematics”, Tata Mc Graw Hill, Third Edition, 2011.

| U19PH101 | ENGINEERING PHYSICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**After completion of this course, the students will be able to**

**Outcomes**

| | | |
|---|---|---|
| CO1 | **(Apply)** Learn the basic of properties of matter and its applications | K3 |
| CO2 | **(Apply)** Acquire knowledge on the concepts of optical devices and their applications in fibre optics | K3 |
| CO3 | **(Apply)** Have adequate knowledge on the concepts of thermal properties of materials and their applications in expansion joints and heat exchangers. | K3 |
| CO4 | **(Apply)** Get knowledge on advanced physics concepts of quantum theory and its applications in tunneling microscopes. | K3 |
| CO5 | **(Understand)** Understand the basics of quantum structures and their applications in spintronics and carbon electronics. | K2 |

**MODULE I PROPERTIES OF MATTER** **9**

Elasticity – Hooke's law – Stress-strain diagram and its uses – factors affecting elastic modulus– Torsional stress and deformations – Twisting couple – Torsion pendulum: theory and experiment – Bending of beams – bending moment – cantilever: theory and experiment – Applications – I-shaped girders – Viscosity – coefficient of viscosity – Stoke's theorem – Bernoulli's Theorem – Application.

**MODULE II LASER AND FIBRE OPTICS** **9**

Lasers: population of energy levels, Einstein's A and B coefficients derivation – resonant cavity, optical amplification (qualitative) – Semiconductor lasers: homojunction and heterojunction – Fiber optics: principle, numerical aperture and acceptance angle – Types of optical fibres (material, refractive index, mode) – losses associated with optical fibers - fibre optic sensors: pressure and displacement.

**MODULE III THERMAL PHYSICS** **9**

Transfer of heat energy – thermal expansion of solids and liquids – expansion joints – bimetallic strips - thermal conduction, convection and radiation – heat conduction in solids – thermal conductivity - Lee's disc method: theory and experiment - conduction through compound media (series and parallel) – thermal insulation – applications: heat exchangers, refrigerators and solar water heaters.

**MODULE IV QUANTUM MECHANICS** **9**

Black body radiation –Compton effect: theory and experimental verification – wave particle duality – electron diffraction – concept of wave function and its physical significance – Schrödinger's wave equation – time independent and time dependent equations –particle in a one-dimensional rigid box – tunneling (qualitative) - scanning tunneling microscope.

**MODULE V INTRODUCTION TO NANOSCIENCE** **9**

Nano Scale – Quantum Confinement – Quantum dot – Different forms of nano materials Fabrication methods – Top down and bottom up approach - Ball milling - CVD - Properties of nano materials – Dendrimers - Coulomb blockade effects - Single electron phenomena and Single electron transistor –Carbon nano tubes properties and applications.

**Total: 45 Hours**

**TEXT BOOKS**


1. Avathanulu M.N and Kshirsagar P.G, "A Text Book of Engineering Physics", S. Chand and company, 11th Edition, 2014.
2. Bhattacharya D.K and Poonam T, "Engineering Physics", Oxford University Press, 2017.


**REFERENCES**


1. Halliday D, Resnick R and Walker J, "Principles of Physics", Wiley, Ninth Edition, 2010.
2. Arthur Beiser, "Concepts of Modern Physics", Tata McGraw Hill, Ninth Edition, 2015.
3. Pillai S.O, "Solid State Physics", New Age International Publishers, Third Edition, 2015.

| U19CS101 | PROBLEM SOLVING USING C | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Apply appropriate looping and conditional constructs for given problems | K3 |
| CO2 | **(Apply)** Use pointers, arrays and strings to solve complex problems | K3 |
| CO3 | **(Apply)** Use Structures, unions and files for problem solving | K3 |
| CO4 | **(Apply)** Apply problem solving techniques to real world problems | K3 |
| CO5 | **(Apply)** Make use of functions to build modular programming | K3 |

**MODULE – I PROBLEM SOLVING FUNDAMENTALS** **10**

Introduction to problem solving - Flow Chart, Algorithm, Pseudocode - Procedural Programming (Modular and Structural)- Program Compilation, Execution, Debugging, Testing – Preprocessors – Basic features of C, Structure of C program - Data types – Storage Classes – Tokens in C – Input and Output Statements in C, Operators – Bitwise, Unary, Binary and Ternary Operators, Precendence and Associativity – Expression Evaluation

**MODULE – II CONDITIONAL STATEMENTS AND LOOPING CONSTRUCTS** **8**

Problem solving using Conditional or Selection or Branching Statements: Structure of if, if-else, else-if ladder, nested-if, switch constructs - Looping constructs: Structure of for, while, do-while constructs, usage of break, return, goto and continue keywords

**MODULE – III ARRAYS AND STRINGS** **8**

1D Array –Declaration, Initialization, 2DArray - Declaration, Initialization, Multi-dimensional Arrays Strings: Declaration, Initialization, String operations: length, compare, concatenate, copy

**MODULE – IV FUNCTIONS AND POINTERS** **9**

Functions: Built-in Functions, User defined functions – Function Prototypes –Recursion – Command Line Argument - Arrays and Functions – Strings and Functions. Pointers: Declaration – Pointer operators – Pointer arithmetic -Passing Pointers to a Function – Pointers and one dimensional arrays - Dynamic Memory Allocation

**MODULE – V STRUCTURES, UNION AND FILE HANDLING** **10**

Structure: Create a Structure-Member initialization - Accessing Structure Members - Nested structures – Pointer and Structures – Array of structures -Self Referential Structures – type def-Unions, Files –Opening and Closing a Data File, Reading and writing a data file.

**Total: 45 Hours**

**TEXTBOOKS**


1. Kernighan B. W. and Ritchie D. M., “C Programming Language (ANSI C)”, Prentice Hall India, 2010.
2. Herbert Schildt, “C – The Complete Reference”, Tata McGraw Hill, 2017.


**REFERENCES**


1. Deitel and Deitel, “C How to Program”, Pearson Education, 2011.
2. Byron S. Gottfried and Jitendar Kumar Chhabra, “Programming with C”, Tata McGraw Hill, 2011.


| U19ME101 | ENGINEERING GRAPHICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 1 | 0 | 4 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Draw orthographic projection to represent three dimensional objects in two dimensional views | K3 |
| CO2 | **(Apply)** Communicate industry standards through engineering drawings | K3 |
| CO3 | **(Apply)** Draw the projection of simple solids using graphic principles | K3 |
| CO4 | **(Apply)** Draw the sectional views of simple solids and develop the surfaces of sheet metal components. | K3 |
| CO5 | **(Apply)** Draw isometric projection and perspective projection of simple objects | K3 |

**MODULE – I FREE HAND SKETCHING AND CURVES 15**

**Introduction**

Importance of graphics in engineering applications – Use of drafting instruments – BIS conventions and specifications – Size, layout and folding of drawing sheets – Lettering and dimensioning.

**Visualization concepts and Free Hand sketching:** Visualization principles –Representation of Three Dimensional objects – Layout of views. Application of free hand sketching

**Curves**

Curves used in engineering practices: Conics – Construction of ellipse, parabola and hyperbola by eccentricity method – Construction of cycloid – construction of involutes of square and circle – Drawing of tangents and normal to the above curves. Application of curves.

**MODULE – II PROJECTION OF POINTS, LINES AND SURFACES 15**

Projection of points. Projection of straight lines located in first quadrant using rotating line method - Traces, Projection of plane surfaces like polygonal lamina and circular lamina. Application of projection of points, lines and surfaces

**MODULE – III PROJECTION OF SOLIDS 15**

Projections of simple solids like prism, pyramid, cylinder and cone - Drawing views when the axis of the solid is inclined to one reference plane by rotating object method. Application of projection of solids.

**MODULE – IV SECTIONS AND DEVELOPMENT 15**

Introduction to 'section of solids'. Section of simple solids in simple vertical position, when the cutting plane is inclined to the one of the principal planes and perpendicular to the other – obtaining true shape of section. Development of lateral surfaces of truncated prisms, pyramids, cylinders and cones. Application of sections of solids and development of lateral surfaces.

**MODULE – V ISOMETRIC AND PERSPECTIVE PROJECTION 15**

Principles of isometric projection – isometric scale –Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders, cones- combination of two solid objects in simple vertical positions- Applications of isometric projection. Perspective projection of simple solids-Prisms, pyramids and cylinders by visual ray method. Applications of perspective projection.

**Computer Aided Drafting (Demonstration Only)**

Introduction to computer aided drafting and dimensioning using appropriate software. 2D drawing commands: Zoom, Picture editing commands, Dimensioning, Isometric drawing, Isoplanes and 3D drafting. Plotting of drawing. Practice includes drawing the projection of lines and solids. Prepare isometric view of simple solids like prisms, pyramids, cylinders and cones.

**Total: 75 HOURS**

**TEXT BOOKS**


1 Natrajan K.V., “A text book of Engineering Graphics”, Dhanalakshmi Publishers, Chennai,2019

2 Venugopal K. And Prabhu Raja V., “Engineering Graphics”, New Age International (P) Limited,2019.


**REFERENCES**


1 Bhatt N.D, “Machine Drawing”, Charotar Publishing House, 1st Edition, 2010.

2 Basant Agarwal and Agarwal C.M., “Engineering Drawing”, Tata McGraw Hill, First Edition, 2008.

3 Gopalakrishna K.R., “Machine Drawing in first angle projection, Subhas Stores, First Edition, 2007.

4 K Leo Dev Wins., “Engineering Drawing”, Pearson (Wins) Publications, Latest Edition, 2019.

5 Luzzader, Warren.J. and Duff,John M., “Fundamentals of Engineering Drawing with an Introduction to Interactive Computer Graphics for Design and Production, Prentice Hall of India, 2005.

6 N S Parthasarathy and Vela Murali, “Engineering Graphics”, Oxford University Press, 2015.


**Publication of Bureau of Indian Standards:**

1. IS 10711 – 2001: Technical products Documentation – Size and lay out of drawing sheets.

2. IS 9609 (Parts 0 & 1) – 2001: Technical products Documentation – Lettering.
3. IS 10714 (Part 20) – 2001 & SP 46 – 2003: Lines for technical drawings.
4. IS 11669 – 1986 & SP 46 – 2003: Dimensioning of Technical Drawings.
5. IS 15021 (Parts 1 to 4) – 2001: Technical drawings – Projection Methods.

**Special points applicable to University Examinations on Engineering Graphics:**

1. There will be five questions, each of either or type covering all units of the syllabus.
2. All questions will carry equal marks of 20 each making a total of 100.
3. The answer paper shall consist of drawing sheets of A3 size only. The students will be permitted to use appropriate scale to fit solution within A3 size.
4. The examination will be conducted in appropriate sessions on the same day

| U19PH111 | PHYSICS LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | Understand the various experiments in the areas of optics, mechanics and thermal physics will nurture the students in all branches of Engineering. | K2 |
| CO2 | Interpret and formulate experiments in engineering physics. | K3 |

**List of Experiments**

1. Determination of Young's modulus – Uniform bending method
2. Determination of Rigidity modulus – Torsion Pendulum
3. Determination of Young's modulus – Cantilever method.
4. Determination of thickness of a thin wire – Air Wedge
5. Determination of coefficient of viscosity of a given liquid – Poiseuille's method
6. Determination of wavelength of laser using grating –Semiconductor laser
7. Determination of band gap of a semiconductor
8. Determination of wavelength of Mercury spectrum - Spectrometer
9. Determination of velocity of Ultrasonic waves in Liquids and Compressibility of the liquid - Ultrasonic Interferometer
10. Determination of thermal conductivity of a bad conductor – Lee's Disc Method
11. Determination of hysteresis losses in a ferromagnetic material.
12. Determination of specific resistance – Carey Foster's Bridge.
13. Determination of dispersive power of prism – Spectrometer.
14. Determination of refractive index of the given liquid- Semiconductor laser

**Total: 30 Hours**

**TEXT BOOKS**

1. In house laboratory manual "Physics Manual" prepared by the faculty members (Physics) – Sri Eshwar College of Engineering – Coimbatore.

**REFERENCES**

1. Shukla, R.K. and Anchal Srivastava, "Practical Physics", New Age International, 2011.
2. Arora, C.L., "Practical Physics", S. Chand & Co., 2012.

| U19GE111 | ENGINEERING PRACTICES LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Fabricate and experiment with Mechanical and Carpentry components and pipe connections. | K3 |

| | | |
|---|---|---|
| CO2 | **(Apply)** Use fabrication tools to join and assembling the structures. | K3 |
| CO3 | **(Apply)** Identify and Illustrate the various parts of pumps, plumbing works, welding and machine tools. | K3 |
| CO4 | **(Apply)** Apply electrical and electronic fundamentals to understand basic circuit elements and emerging technologies | K3 |
| CO5 | **(Apply)** Use electrical fundamentals to solve domestic / industrial wiring faults. | K3 |

**GROUP A (CIVIL & MECHANICAL)**

**MODULE – I CIVIL ENGINEERING PRACTICES** **10**

**Plumbing**

1. Basic pipe connections involving the fittings like valves, taps, coupling, unions, reducers, elbows and other components used in household fittings. Preparation of plumbing line sketches.
2. Laying pipe connection to the suction & delivery side of a pump – inlet & outlet
3. Practice in mixed pipe connections: Metal, plastic and flexible pipes used in household appliances.

**Wood Work**

1. Sawing, planning and making common joints: T-Joint, Mortise and Tennon joint, Dovetail joint.

**Study**

1. Study of joints in door panels, wooden furniture.
2. Study of common industrial trusses using models.

**MODULE – II MECHANICAL ENGINEERING PRACTICES** **13**

**Welding**

1. Arc welding of butt joints, lap joints, tee joints.
2. Gas welding Practice.

**Basic Machining**

1. Simple turning, drilling and tapping operations.

**Sheet Metal Work**

1. Forming & Bending.
2. Model making – Trays, funnels, etc.
3. Different type of joints.

**Demonstration only**

Study and assembling the following:

1. Centrifugal pump.
2. Submersible pump sets.

**Demonstration only**

1. Basics of Smithy operations.
2. Foundry operation like mould preparation for grooved pulley.
3. Refrigeration and Air-Conditioning System.

**GROUP B (ELECTRICAL & ELECTRONICS)**

**MODULE – III ELECTRICAL ENGINEERING PRACTICES** **11**

1. Basic household wiring using single phase energy meter, 1/2 way switches, MCB, indicator, lamp-etc.,
2. Fluorescent Lamp–wiring and Godown wiring
3. Measurement of electrical quantities like voltage, current, power, power factor and energy using various measuring equipment.
4. Experiment using protective equipment like Fuse, MCB and RCCBs
5. Earthing and Measurement of earth resistance.

**MODULE – IV ELECTRONICS ENGINEERING PRACTICES** **11**

1. Study of Electronic components and equipment – Resistor, color coding measurement of AC signal parameter (peak-peak, rms period, frequency) using CRO.
2. Study of logic gates AND, OR, EX-OR and NOT.
3. Soldering practice – Components Devices and Circuits – Using general purpose PCB.
4. Measurement of ripple factor of HWR and FWR.

**GROUP C (MULTI-DISCIPLINARY)**

**MODULE – V EMERGING TECHNOLOGIES** **15**

**Laser Cutting Machine Practice**

1. Study of Laser Cutting Machine
2. Hands on exercise in Laser Cutting Machine

**Demonstration of 3D Printer**

1. Briefing of 3D Printing process flow in model creation
2. Model creation of simple 3D objects

**Introduction to IoT**

1. Briefing of IoT and its applications
2. Hands on exercise - IoT based Switch

**Demonstration of AVR**

1. Study of Augmented Reality/Virtual Reality
2. Video Demonstration: Human-Computer Interaction (AVR lab)

**Total: 60 Hours**

| U19CS111 | PROBLEM SOLVING USING C LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Solve problems using data types and operators | K3 |
| CO2 | **(Apply)** Apply appropriate looping and conditional constructs for given C programs | K3 |
| CO3 | **(Apply)** Use functions to build modular programs | K3 |
| CO4 | **(Apply)** Use appropriate IDE and tools to write, compile, debug & execute a C Program. | K3 |
| CO5 | **(Apply)** Implement structures, unions and File Operations | K3 |

**MODULE – I PROBLEM SOLVING AND BASICS OF C PROGRAMMING** **10**

- Problem solving design using Scratch tool
- Algorithm/flowchart/pseudocode
- I/O
- Datatypes
- Operators
- Preprocessors
- Introduction to C-IDE, Compilers, debugging

**MODULE – II CONDITIONAL STATEMENTS AND LOOPING CONSTRUCTS** **10**

- Conditional Statements- if-if else-else if ladder- nested if- switch
- Looping Constructs – for – while- do-while
- break, return, goto, continue keywords in C programs

**MODULE – III ARRAYS AND STRINGS** **10**

- One dimensional Arrays
- Two dimensional Arrays
- String functions (without Library Functions)
- String functions (with Library Functions)

**MODULE – IV FUNCTIONS** **10**

- Functions- Modular Programming
- Recursions
- Command line arguments
- Pass by value and pass by reference
- Pointers
- Pointers and arrays
- Dynamic Memory Allocation

**MODULE – V STRUCTURES, UNIONS AND FILE HANDLING** **10**

- Structures
- Union
- Programs to illustrate File operations
- Mini Project –Console based application in C

**Total: 60 Hours**

| **U19EM101** | **SOFT SKILLS I** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **0** | **0** | **2** | **1** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | (**Apply)** Apply the basic personality traits in social activity for future working environment | K3 |
| CO2 | (**Apply)** Apply receptiveness and get customized to today's corporate world | K3 |
| CO3 | **(Analyze)** Analyze and mingle with different types of people to overcome and eradicate fear | K4 |
| CO4 | (**Create)** Create a team environment in the classroom to measure their individual team player skills | K6 |
| CO5 | (**Create)** Create a vivid vision about their behaviour and discipline in future and through which they can measure themselves in socializing | K6 |

**MODULE – I BEHAVIOURAL SESSION, GOAL SETTING, POWER DRESSING** **6**

Behavioral session – Regarding interview and Life Skills a practical session is hosted for the students for how they should carry themselves in today's society and how to meet up the company's expectations. Goal Setting – Activities and goal establishment psychology classes are conducted for the students to improve their short term and long term goals (A Goal Sheet is prepared)

Power Dressing – Perking up their dressing style.

**MODULE – II LANGUAGE PROFICIENCY, COMMUNICATION BUILDING** **6**

Language proficiency – Neutral accent refinement speaking classes for students

Communication building – Multi tasking activities for communication building.

**MODULE – III LEXICON BUILDING, BODY LANGUAGE, STORY BUILDING** **6**

Lexicon Building – (Speaking session)

Body Language – (Demo and practical session)

Story Building – (Activity)

**MODULE – IV TEAM BUILDING, OUTDOOR SPEECH** **6**

Team Building – Activity

Outdoor Speech – Basic Topic (Change of environment)

**MODULE – V OUTDOOR JOURNALISM** **6**

Outdoor journalism – (Activity)

**Total: 30 Hours**

**REFERENCES**


1. Norman Lewis, “Word power made easy”
2. Sylvia Reyes, “Team Building: The Ultimate Guide to Build & Manage Winning Teams”, MC Graw hill, I
3. Dan Clay, “How to write the perfect resume”
4. Tyler Hayden**,”** Communication Activities: A Team Building Activity Book**”,**
5. Ian Tuhovsky, “Communication Skills Training: A Practical Guide to Improving Your Social Intelligence, Presentation, Persuasion and Public Speaking (Positive Psychology Coaching Series Book 9)”

## SEMESTER – II

| U19HS102 | BUSINESS ENGLISH | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Apply different conversation techniques in day-to-day communication. | K3 |
| CO2 | **(Apply)** Practice effective listening techniques during conversations. | K3 |
| CO3 | **(Apply)** Develop good reading practice. | K3 |
| CO4 | **(Apply)** Report ideas and concepts in an effective manner. | K3 |
| CO5 | **(Apply)** Articulate effectively during discussions and presentations. | K3 |

**MODULE – I TYPES OF CONVERSATION** **9**

**Listening** – Listening texts, importance of listening in corporate world – **Speaking** -Types of conversation- formal and informal – **Reading** -Reading with purpose-taking notes out of technical writing - Eye reading visual perception, analytical and critical reading practice **Writing** - Sentence structures, writing instructions, checklists - word formation – **Grammar** - Regular and irregular verbs, Subject verb Agreement, Active and Passive voice.

**MODULE – II LISTENING COMPREHENSION** **9**

**Listening** -Various scientific and technical talks-completing information-gap filling exercises - **Speaking** - Describing a process - **Reading** - Reading different kinds of texts like entertaining messages, general messages, reference materials, business documents and scientific and technical texts – **Writing** - Summarising a paragraph, interpreting charts and graphs – Autobiographical writing **-** words often confused. **Grammar** - Purpose expressions, if conditionals.

**MODULE – III READING PRACTICE** **9**

**Listening** - Classroom lectures-note taking practice - **Speaking** -Techniques to develop effective presentation - Improving responding capacity – extempore, speech practice - facial expression – gestures. **Reading** - Active and passive reading, speed reading, word meaning recognition - **Writing** - Minutes of meeting – format and practice in the preparation of minutes - Writing summary after reading articles from journals – **Grammar** - Embedded sentences, verbal analogies, homophones and homonyms, Sequence of words.

**MODULE – IV REPORT WRITING** **9**

**Listening** - Listening process and practice - expose to recorded and structure talks - **Speaking** - Presentation at the business meeting - connecting ideas-collaborative tasks - **Reading** - use of extensive readers, transcoding verbal and non-verbal - **Writing** - types of report - Report writing- Idioms and their meanings – using idioms in sentences; **Grammar** – Simple, compound and complex sentences.

**MODULE – V GROUP DISCUSSION** **9**

**Listening**- Listening to TED/ink talks - **Speaking** - Group discussion practice, interpersonal conversation - developing persuasive speaking skill - **Reading** - Intensive reading, note-making, reading and interpreting graphic information - **Writing** - Applying for a job – cover letter, resume preparation - vision, mission and goals of the candidate; - **Grammar** - Numerical expressions, reported speech, Error Spotting, Connectives (discourse markers).

**Total: 45 Hours**

**TEXT BOOKS**


1. Jack C. Richards, “Interchange – Student’s Book 2”, Cambridge University Press, Fourth Edition, 2015.
2. Mahalakshmi S. N, “Technical English for Engineers”, V. K. Publications, Eighth Edition, 2018.


**REFERENCES**


1. Rizvi M. Ashraf, “Effective Technical Communication”, Tata McGraw-Hill, Third Edition, 2006.
2. Andrea J. Rutherfoord, “Pearson Education” Inc. and The Darling Kindersley Publishing Inc.,2006.
3. Meenakshi Raman and Sangeetha Sharma, “Technical Communication: Principles and Practice”, Oxford University Press India, Third Edition, 2015.
4. Jack C. Richards, “Interchange - Intro Student’s Book”, Cambridge University Press, Fourth Edition, 2018.
5. Butterfield Jeff, “Soft skills for Everyone”, Sixth Indian Reprint, 2015.

| U19HS112 | BASIC JAPANESE | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Recognize and write Japanese alphabet | K2 |
| CO2 | **(Understand)** Speak using basic sounds of the Japanese language | K2 |
| CO3 | **(Apply)** Apply appropriate vocabulary needed for simple conversation in Japanese language | K3 |
| CO4 | **(Apply)** Apply appropriate grammar to write and speak in Japanese language | K3 |
| CO5 | **(Apply)** Comprehend the conversation and give correct meaning | K3 |

**MODULE – I INTRODUCTION TO JAPANESE** **9**

Introduction to Japanese - Japanese script - Pronunciation of Japanese (Hiragana), (Katakana) - Long vowels - Pronunciation of in, tsu, ga - Letters combined with ya, yu, yo - Daily Greetings and Expressions - Numerals. N1 wa N2 desu - N1 wa N2 ja arimasen - S ka - N1mo - N1 no N2 - san

**MODULE – II POSITIONS GRAMMAR PATTERNS** **9**

Positions Grammar Patterns - Kore - Sore – Are – Kono N – Sono N – Ano – N – Sou desu – Souja Arimasen – S1 ka – S2 ka – N1 no N2 – Sou desu ka – Koko – Soko – Asoko – Kochira – Sochira – Achira – Ni wa N2 (place) desu – Doko – Dochira – N1 no N2 – Ko – So – A – Do (Demonstrative words) – O kuni – Kanji10 – Technical Japanese Vocabulary (30 Numbers)

**MODULE – III INTRODUCTION TO TIME** **9**

Introduction to time – Ji – Fun – Pun – Introduction of verbs – V Masu – V Masu – V Masen – V Mashita – V Masendeshita – N (Time) Ni V – N1 Kara - N2 Made – N1 to N2 - S Ne – N (Place) e Ikimasu – Kimasu – Kaerimasu – Doko (e) Mo Ikimasen – Ikimasendeshita – N (Vechile) de Ikimase – Kimasu – Kaerimasu

**MODULE – IV VERBAL CONJUGATION** **9**

Verbal Conjugation - No (Person / Animal) to V – Itsu – S Yo – N o (transitive) – N o Shimasu – Nani o Shimasuka – Nan and Nani – N (place) de V – V Masenka – V Mashou – o – Kanji 50 – Technical Japanese Vocabulary - N (tool/means) de V – Word/Sentence wa Go de Nani desu ka – N (person) Ni Agemasu, etc – N (person) Ni Moraimasu - Mou V Mashite.

**MODULE – V INTRODUCTION TO ADJECTIVES** **9**

Introduction to Adjectives – N wa Na – adj (Na) desu – N wa II adj (II) desu – Na adj Na n – II adj (II) N – Totemo – Amari – N wa Dou desuka – N1 wa Donna N2 desuka – S1 Ga S2 – Dore – N ga Arimasu – Wakarimasu – N Ga Sukidesu – Kiraidesu – Jozu desu – Heta desu – Donna N – Yoku – Daitai – Takusan – Sukoshi – Amari – Zenzen – S1 kara S2 – Doushite – Kanji 50 – Technical Japanese Vocabulary

**Total: 45 Hours**

**TEXT BOOKS**

1. "Japanese for Everyone: Minna no Nihongo", Goyal publishers& Distributers Pvt. Ltd., Second edition, 2017
2. Nihongo challenge for KANJI PART

**REFERENCES**

1. Nihongo Shoho-1
2. Nihongo Shoho-2

| U19HS113 | BASIC GERMAN | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Recognize and write German alphabet | K2 |
| CO2 | **(Understand)** Speak using basic sounds of the German language | K2 |
| CO3 | **(Apply)** Apply appropriate vocabulary needed for simple conversation in German language | K3 |

CO4 **(Apply)** Apply appropriate grammar to write and speak in German language K3

CO5 **(Apply)** Comprehend the conversation and give correct meaning K3

**MODULE – I BASIC INTRODUCTION TO GERMAN SCRIPTS 9**

Theme and Text (Introduction to German - German script, Deutsche Namen, Daily Greetings and Expressions) – Grammar ('wh' questions, das Alphabet)– Speak Action (Buchstabieren, sich und andere vorstellen nach Namen und Herkunft fragen, internationale Wörter auf Deutsch verstehen, jemanden begrüßen)– pronunciation (Buchstabieren J,V,W,Y, - Long vowels A,E,I,O,U - Pronunciation of Ä,Ü,Ö) – To learn (internationale Wörter in Texten finden, Wörter sortieren)

Theme and Text (Gespräche im caf'e, Getränkekarte, Telefon-buch, Namen, Rechnungen) – Grammar (Frägesatze mit wie, woher, wo, was Verben in präsens Singular und Plural, das Verb Sein, Personalpronomen und Verben)– Speak Action (eine Gespräch beginnen sich und andere vorstellen zählen, etwas bestellen und bezhalen Telefonnummern und verstehen)– pronunciation (Wortakzent in Verben und in Zahlen) – To learn (Grammatiktabelle ergänzen, mit einem Redemittelkasten arbeiten)

**MODULE – II NUMBERS AND NOMINATIVE CASE 9**

Theme and Text (Numbers – 1 to 12 (Eins bis Zwolf) – 20, 30, 40, 90 (zwanzig-Neunzig) – All Numbers (1-10000) – German Currency (Euro) – Basic Mathematics (plus, Minus, Malen, Geteilt durch) – Grammar (Introduction of verbs –Have Verb – To Come, To Speak, To Read, To Drive, To Fly, To write, To Eat, To sleep, To take etc.,)

Theme and Text (Communication in course) – Grammar (Singular and Plural, Artikel: der,das,die/ ein,eine, verneinung: kein, keine, Komposita: das Kursbuch) – Speak Action (Gegenständen fragen/ Gegenstände benennen im kurs:) – pronunciation (word accent Marking, Umlaute ö ä ü hören und sprechen) – To learn (Lernkarten schreiben, Memotipps, eine Regel selbst finden)

Theme and Text (City, Town, Language: Nachbar, Sprachen, Sehenswürdigkeiten in Europa) – Grammar (Past tense for Sein, W-Frage, Aussagesatz und Satzfrage) – Speak Action (about city and siteseeing) – pronunciation (Satzakzent in Frage- und Aussagesätzen) – To learn (eine Regel ergänzen, eine Grammatiktabelle erarbeiten, Notizen machen)

**MODULE – III AKKUSATIVE CASE AND PREPOSITIONS 9**

Theme and Text (Menschen und Hauser, Furniture catalogue, E-Mail, House information) – Grammar (possesivartikel im Nominativ, Artikel im Akkusativ, Adjektive im satz, Graduierung mit zu)– Speak Action (Whonung bescreiben about perons and things)– pronunciation (consonant - ch) – To learn (wortschatz systematisch)

Theme and Text (Termine - Appointment and punctuality in Germany) – Grammar (questions with wann?, Preposition (am, um, von... bis), verneinung mit nicht, trennbare verben, präteritum von haben) – Speak Action (Daily plan making, time commitment, excuse for late coming) – pronunciation (consonants- p,b,t,d / k,g) – To learn (Rollenkarten arbeiten)

Theme and Text (orientation in working area, go for work, floor plan city plan, office and computer) – Grammar (preposition: in,neben, unter, auf, vor, hinter, an, zwischen, bei und mit + Datic)– Speak Action (work place, work, giving appointments)– pronunciation (consonants: f,w und v) – To learn (Making notice in calender)

**MODULE – IV DATIV CASE AND PREPOSITIONS 9**

Theme and Text (Holiday and Party, holiday plan, party plan in Germany) – Grammar (regular and iregular verbs) – Speak Action (holiday speak, accident, Ich-Text schreiben) – pronunciation (lange und kurze vokale markieren) – To learn (Text Order)

Theme and Text (organising an Excursion to Berlin through city orientation, Bus plan, City plan, post card, Excursion programme) – Grammar (preposition: in, durch, über + Akkusativ: zu, an... vorbei + Dativ, Modalverb wollen) – Speak Action (Tourism, culture, postcard preparation, travel description) – pronunciation (r and l)– To learn (plaket making)

Theme and Text (Beruf und all Tag, Visiten karten, wörterbuch) – Grammar – Speak Action (profession, statistic speaking) – pronunciation (n,ng and nk)– To learn (wörterbuch , text information in tabel)

**MODULE - V ADJECTIVES AND PRONUNCIATION 9**

Theme and Text (Haushaltstipp, kochrezept, maße und gewichte, Mahlzeiten und Gerichte) – Grammar (jeden Tag, manchmal, nie, Question - welche, Comparison – viel, gut, gern) – Speak Action (about eat, drink question and answers) – pronunciation (e,en,el,er) – To learn (Text auswerten und zusammenfassen)

Theme and Text (Clothing, colour, weather) – Grammar (Adjecktive im Akkusativ, unbestimmer Artikel) – Speak Action (weather, dress and colour understanding) – pronunciation (e-o- ö and ie-u- ü) – To learn (wetter and Farben interkulturelle) Theme and Text (in super market, purchase, House Maintenance, Emotion, Sports, Body parts) – Grammar (Modal Verb) – Speak Action (Body parts) – To learn (Rollenkarten arbeiten)

**Total: 45 Hours**

**TEXT BOOKS**

1. Funk, Kuhn, Demme, "Studio D A1 Deutsch als Fremdsprache", Goyal Publishers and Distributors, 2016.
2. Hueber, "Fit for Goethe- Zertifikat A1 (Start Deutsch 1)", Goyal Publishers and Distributors, 2016.

**REFERENCES**

1. Stefanie Dengler, "Netzwerk Deutsch Als Fremdsprache A1", Goyal Publishers & Distributors Pvt Ltd.
2. Fran Martin, "Grammar Tables for Student of German", Independently Published, 2017.

| U19MA102 | ADVANCED CALCULUS AND COMPLEX VARIABLES | L | T | P | C |
|---|---|---|---|---|---|
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After completion of this course, students will be able to

| | | |
|---|---|---|
| **Outcomes** | **CO1** **(Analyze)** Compare the ideas of vector integral theorems for solving given problems and exhibit the relation between them. | K4 |
| | **CO2** **(Apply)** Make use of Milne Thomson method to construct analytic functions related to complex variable. | K3 |
| | **CO3** **(Apply)** Apply the concepts of integration for complex functions in certain regions to determine real integrals. | K3 |
| | **CO4** **(Apply)** Apply Laplace transform and inverse transform of simple functions, properties, various related theorems and application to differential equations with constant coefficients. | K3 |
| | **CO5** **(Apply)** Apply various techniques in solving differential equations. | K3 |

**MODULE – I VECTOR CALCULUS** **12**

Gradient and directional derivative - Divergence and curl - Irrotational and solenoidal vector fields - Green's theorem in a plane, Gauss divergence theorem and Stoke's theorem (excluding proofs) – Verification of theorem and applications (for cubes and rectangular parallellopipeds).

**MODULE – II COMPLEX DIFFERENTIATION** **12**

Analytic functions - Cauchy-Riemann equations (excluding proof) – Properties of analytic function – Harmonic conjugate - Construction of analytic function by Milne Thomson method – Bilinear transformation.

**MODULE – III COMPLEX INTEGRATION** **12**

Cauchy's integral theorem- Cauchy's integral formula- Cauchy's integral formula for derivatives- Cauchy residue theorem - Taylor's and Laurent's series – Contour integral in unit circle and semi circle (Excluding poles on real axis).

**MODULE – IV LAPLACE TRANSFORM** **12**

Existence conditions - Properties (excluding proofs) - Transform of elementary and special functions - Transforms of derivatives and integrals - Periodic function – Inverse Laplace transform - Applications to solution of linear second order ordinary differential equations with constant coefficients.

**MODULE – V ORDINARY DIFFERENTIAL EQUATIONS** **12**

Higher order linear differential equations with constant coefficients – Cauchy's and Legendre's linear differential equations - Method of variation of parameters - Application of ordinary differential equations in simple harmonic motion and basic elements of electrical circuits.

**Total: 60 Hours**

**TEXTBOOKS**

1. Grewal B.S, "Higher Engineering Mathematics", Khanna Publications, 44$^{th}$ Edition, 2015.

2. Monty J. Strauss, Gerald J. Bradley and Karl J. Smith, “Calculus”, Third Edition, 2002.

**REFERENCES**

1. Erwin Kreyszig, “Advanced Modern Engineering Mathematics”, John Wiley, Tenth Edition, 2017.
2. Bali N. P and Manish Goyal, “A Text book of Engineering Mathematics”, Laxmi Publications, 8th Edition, 2011.
3. Jain R.K. and Iyengar S.R.K, “Advanced Engineering Mathematics”, Narosa Publications, Third Edition, 2007.

| U19CY101 | ENGINEERING CHEMISTRY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Apply the principles of electrochemistry and corrosion in engineering. | K3 |
| CO2 | **(Understand)** Understand the quality of water, and its treatment methods. | K2 |
| CO3 | **(Apply)** Apply the concepts relevant to thermodynamics. | K3 |
| CO4 | **(Understand)** Understand the Engineering materials. | K2 |
| CO5 | **(Understand**) Understand the science of polymer and polymer reactions. | K2 |

**MODULE – I ELECTROCHEMISTRY AND CORROSION 9**

**Basics of electrochemistry** – Electrochemical cell – Reversible and irreversible cell – EMF measurements – Standard Weston Cadmium cell – Nernst equation and problems – Electrodes – single electrode potential – Types of electrodes – Calomel electrode – Electrochemical series – Significance – Conductometric titration-Potentiometric titration

**Corrosion:** Definition – Classification of corrosion and its mechanism – Factors influencing corrosion – Corrosion control – Sacrificial anode and cathodic protection method – Corrosion inhibitors – Electroplating of Nickel and chromium – Paints – Constituents and their function.

**MODULE – II WATER TECHNOLOGY 9**

Introduction – Hardness of water – Determination of hardness of water by EDTA method – Alkalinity of water – Types of alkalinity – Estimation of alkalinity – Domestic water treatment – Pre-treatment – Removal of suspended impurities – Disinfection methods – Boiler feed water – Requirement of boiler feed water – Boiler troubles – scales and sludges – Treatment of boiler feed water – External treatment – Zeolite process – ion exchange method – Internal treatment method – Desalination – Reverse Osmosis.

**MODULE – III CHEMICAL THERMODYNAMICS 9**

Introduction to thermodynamics – Terminologies – Laws of Thermodynamics (only definitions) – second law – Entropy as a thermodynamic quantity – Entropy change of an ideal gas – reversible and irreversible process, physical transformations – Clausius inequality theorem – Free energy and work function: Helmholtz and Gibbs free energy function – problems – Gibbs Helmholtz equation – problems – Clausius Clapeyron equation – Maxwell relation – Van’t Hoff isotherm and its applications

**MODULE – IV CHEMISTRY OF MATERIALS 9**

**Refractories** – Classification – criteria of good refractory-properties and its application – Manufacture of Alumina, Magnesite and Silicon carbide.

**Glass:** Manufacture of glass by tank furnace method – Types and properties of glass.

**Cement:** Portland cement – Comparison and Manufacture by rotary kiln technology – Chemistry of setting and hardening of cement – Role of gypsum.

**Nanomaterials:** Carbon nano tubes – shape memory alloys – C60 fullerene – Liquid crystals – properties and its application.

**MODULE – V POLYMER TECHNOLOGY 9**

Introduction – Terminologies – molecular weight of polymers (only definition) – Classification of polymers – natural and synthetic, thermoplastics and thermosetting plastics – Types and mechanism of polymerization: addition (free radical) – condensation and copolymerization – Properties of polymers – some commercial thermosetting resin – Phenol formaldehyde resin, Amino resins, Silicone resins – some thermoplastics – Polyethylene, PVC, polyvinyl acetate.

**Total: 45 Hours**

**TEXT BOOKS**


1. Vairam S and Subha Ramesh, “Engineering Chemistry”, Wiley India, 2015
2. Jain P. C. and Jain M. “Engineering Chemistry”, Dhanpat Rai Publishing Company, 16th Edition, 2017.


**REFERENCES**


1. Dara S.S. and Umare S.S, “A Text book of Engineering Chemistry”, S. Chand Publishing, 12th Edition, 2014.
2. Pahari A and Chauhan B, “Engineering Chemistry”, Laxmi Publications, Second Edition, 2010.
3. Devender Singh, Balraj Deshwal, Sathish Kumar, “Comprehensive Engineering Chemistry”, IK International, 2007.
4. Chopra H. K, Parmer A, “Chemistry for Engineers”, Narosa Publishing House, 2016.


| U19PH102 | SEMICONDUCTOR PHYSICS | L | T | P | C |
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**Outcomes**

After completion of this course, students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Understand the basics of crystals, their structures and different crystal growth techniques. | K2 |
| CO2 | **(Apply)** Map the operation of semiconductor devices with generalized switch and voltage rectifier. | K3 |
| CO3 | **(Apply)** Apply the knowledge on VI characteristics of semiconductor device and specific application with Zener diode. | K3 |
| CO4 | **(Analyze)** Analyze the biasing in BJT semiconductor to study the operation as voltage divider and a switch. | K4 |
| CO5 | **(Analyze)** Analyze the biasing in FET semiconductor devices to study the flow of current and stability of operation. | K4 |

**MODULE – I CRYSTAL PHYSICS** **9**

Single crystalline, polycrystalline and amorphous materials – unit cell, crystal systems, Bravais lattices, Miller indices: ditections and planes in a crystal - interplanar distance for a cubic crystal - coordination number and packing factor for SC, BCC, FCC, HCP and diamond structures - crystal imperfections: point defects, line defects – Burger vectors – Growth of single crystals: Bridgman and Czochralski methods.

**MODULE – II PN JUNCTION DIODE** **9**

Energy band theory of crystals: Insulators, conductors, and metals – PN Junction as a diode: Unbiased Diode, Forward Bias, Reverse Bias – Current components in a PN diode – Volt-Ampere Characteristics – PN diode switching times – Breakdown diodes - PN Junction diode as a rectifier.

**MODULE – III SPECIAL SEMICONDUCTOR DEVICES** **9**

Circuit symbol, construction, operation and V-I characteristics: Schottky barrier diode - Zener diode – LED - SCR – DIAC – TRIAC - Photo diode and photo transistor - Opto Coupler - Zener diode as a voltage regulator.

**MODULE – IV BIPOLAR JUNCTION TRANSISTOR** **9**

Unbiased Transistor, NPN Transistor operation, Input and Output characteristics of CE, CB, and CC configurations, h parameter model for CE, CB, and CC configurations - Need for biasing - AC and DC Load lines- Biasing methods for BJT: Fixed bias – Collector to base bias - Voltage divider bias - BJT as a switch.

**MODULE – V FIELD EFFECT TRANSISTORS** **9**

Junction Field Effect Transistor: construction, operation, Drain and Transfer characteristics – MOSFET: Enhancement MOSFET, Depletion MOSFET, Drain and Transfer characteristics - Biasing methods for FET - Biasing methods for FET - Fixed bias - Self bias - Voltage divider bias.

**TOTAL: 45 HOURS**

**TEXT BOOKS**


1. Kasap S.O, “Principles of Electronic Materials and Devices”, Tata McGraw Hill, Third Edition, 2007.

2. Umesh K Mishra and Jasprit Singh, “Semiconductor Device Physics and Design”, Springer, Second Edition, 2008.
3. Pillai S.O, “Solid State Physics”, New age International Publishers, Seventh Edition, 2015.

**REFERENCES**

1. Avathanulu M.N and Kshirsagar P.G, “Engineering Physics”, S. Chand and company, 11th Edition, 2014.
2. Jacob Millman, Christos C, Halkias and Satyabrata Jit, "Electronic Devices and Circuits", Tata McGraw Hill, Second Edition, 2010.
3. Salivahanan S, “Electronic Devices”, Tata McGraw Hill, Second Edition, 2018.
4. Donald A Neaman, “Semiconductor Physics and Devices”, Tata Mc Graw Hill, Third Edition, 2007.
5. Robert Boylestad and Louis Nashelsky, “Electron Devices and Circuit Theory”, Pearson Prentice Hall, Tenth Edition, 2008.

| U19EE103 | CIRCUIT THEORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Apply the basic concepts to solve simple electric circuit problems. | K2 |
| CO2 | **(Apply)** Select various circuit theorems to solve all types of electrical circuits. | K2 |
| CO3 | **(Understand)** Explain the phenomenon of resonance and its applications. | K3 |
| CO4 | **(Apply)** Derive the transient response of circuits with AC and DC supply. | K3 |
| CO5 | **(Analyze)** Analyze different types of three phase circuits and draw the phasor diagrams. | K4 |

**MODULE – I BASIC CONCEPTS** **12**

Basic circuit terminologies – circuit elements – series and parallel – Ohm’s law – Kirchhoff’s Laws – mesh and nodal analysis of DC and AC circuits. Fundamentals of alternating current – phase relationship in a pure resistor, inductor and capacitor – complex impedance – power triangle – applications.

**MODULE – II NETWORK THEOREMS** **12**

Voltage and current division – source transformation – star/delta conversion – Thevenin’s theorem – Norton’s theorem – Superposition theorem – Maximum power transfer theorem – applications.

**MODULE – III RESONANCE AND COUPLED CIRCUITS** **12**

Series and parallel resonance – resonant frequency – frequency response – quality factor – bandwidth. Self and mutual inductance – coefficient of coupling – dot convention – series and parallel connection of coupled inductors – applications.

**MODULE – IV TRANSIENT RESPONSE IN DC AND AC CIRCUITS** **12**

Circuit elements in the S-domain – behaviour of passive elements with AC/DC input – transient response of RL, RC and RLC Circuits for DC input and AC sinusoidal input – applications.

**MODULE – V THREE PHASE CIRCUITS** **12**

Introduction to three phase system – voltage, current and power in star and delta connected systems – analysis of three phase balanced / unbalanced circuits with phasor diagrams – power and power factor measurement – applications.

**Total: 60 Hours**

**TEXT BOOKS**

1. A Sudhakar and Shyammohan S Pali, “Circuits and Networks: Analysis and Synthesis”, Tata McGraw Hill, Fifth Edition, 2015.
2. William H Hayt, Jack E Kemmerly and Steven M Durbin, “Engineering Circuit Analysis”, Tata McGraw Hill, Ninth Edition, 2018.

**REFERENCES**

1. Charles K Alexander and Mathew N O Sadiku, “Fundamentals of Electric Circuits”, Tata McGraw Hill, Third Edition, 2009.
2. Mahadevan. K and Chitra. C, “Electric Circuits Analysis,” Prentice Hall India, 2015.

3. Chakrabarti A, “Circuits Theory (Analysis and synthesis)”, Dhanpat Rai and Sons, 1999.
4. Nahvi M and Edminister J, “Schaum’s Outline of Electric Circuits”, Tata McGraw Hill, Fifth Edition, 2011.

| U19CS103 | DATA STRUCTURES AND ALGORITHMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, students will be able to

| | | |
|---|---|---|
| **CO1** | **(Analyze)** Analyze the representation and manipulation of data structures in memory. | K4 |
| **CO2** | **(Apply)** Use appropriate linear data structure to solve various applications. | K3 |
| **CO3** | **(Apply)** Apply the tree concepts for efficient storage and retrieval of data. | K3 |
| **CO4** | **(Apply)** Apply the graph algorithms to solve real-world challenges. | K3 |
| **CO5** | **(Evaluate)** Choose the optimal searching, sorting and hashing techniques to solve real-time applications. | K5 |

**MODULE – I INTRODUCTION** **9**

Abstract Data Types (ADT) – List ADT: Array implementation, Linked list implementation (Singly, Doubly & Circular)– Applications: Polynomial Evaluation.

**MODULE – II STACKS AND QUEUES** **9**

**Stack ADT:** Array and Linked Stacks, Applications: Arithmetic expression convertion - Postfix evaluation – **Queue ADT:** Array and Linked Queue, Circular Queue – Applications.

**MODULE – III TREES** **9**

Tree Terminologies – tree traversal - Binary Tree –Threaded Binary Trees - Binary Search Trees – AVL Trees – B-Tree - Heap – Applications.

**MODULE – IV GRAPHS** **9**

Representation of Graph - Types of graph –Graph traversal – Minimum Spanning Tree - Shortest path algorithm – Topological Sort –Real world applications.

**MODULE – V SEARCHING, SORTING AND HASHING** **9**

**Searching:** Linear and Binary Search – **Sorting:** Bubble sort – Insertion sort – Quick sort - Merge sort – **Hashing:** Hash Functions – Collision Avoidance Techniques: Separate chaining – Open Addressing – Linear probing, Quadratic probing, Double hashing – Rehashing – Applications.

**Total: 45 Hours**

**TEXT BOOKS**

1. Mark A.Weiss., “Data Structures and Algorithm Analysis in C”, Second Edition, Pearson Education, 2010.
2. Reema Thareja, “Data Structures using C”, 2nd Edition, Oxford University Press, 2011.

**REFERENCES**

1. Karumanchi Narasimha, “Data Structures and Algorithms Made Easy”, Career Monk Publication, Fifth Edition, 2016.
2. Seymour Lipschutz, “Data Structures with C”, McGraw Hill, Revised First Edition, 2014.
3. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, “Fundamentals of Computer Algorithms” University Press, Second Edition, 2011.
4. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, “Introduction to Algorithms”, The MIT Press, Third Edition, 2009.
5. Y. Langsam, M. J. Augenstein and A. M. Tenenbaum, “Data Structures using C”, Pearson Education, 2004.

| U19CY111 | CHEMISTRY LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Analyse)** Analyse the role of water quality related parameters. | K4 |

CO2 **(Create)** Design the engineering materials against corrosion. K6

**LIST OF EXPERIMENTS**

1. Determination of total, permanent and temporary hardness of water by EDTA method.
2. Estimation of copper in brass by EDTA method.
3. Determination of alkalinity and TDS of water sample.
4. Estimation of chloride content in water by Argentometric method.
5. Determination of strength of acid by Conductometric titration (strong acid Vs strong base & strong base Vs mixture of acids)
6. Determination of strength of given hydrochloric acid using ph meter.
7. Estimation of ferrous ion content of the given solution using potentiometer.
8. Determination of do content of water sample by Winkler's method.
9. Determination of chemical oxygen demand of water.
10. Determination of rate of corrosion of mild steel by weight loss method
11. Determination of efficiency of corrosion inhibitors in mild steel.
12. Estimation of sodium and potassium present in sample using flame photometer.
13. Estimation of iron in water sample using photometer (Thiocyanate method).
14. Determination of molecular weight of polyvinyl alcohol using Ostwald viscometer.

(Any 8 experiments of the above)

**Total: 30 Hours**

**TEXT BOOK**

1. R. Rathinam, "Chemistry Laboratory Manual", Gems Publishers, 2019.

**REFERENCES**

1. Vogel's, "Textbook of Quantitative Chemical Analysis", Pearson publications, 2014.
2. Daniel C. Harris, "Quantitative Chemical Analysis", W. H. Freeman and Co., Seventh Edition, 2007.

| **U19CS103** | **DATA STRUCTURES AND ALGORITHMS LABORATORY** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **0** | **0** | **4** | **2** |

**Outcomes**

After completion of this course, students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Apply linear data structures to solve problems. | K3 |
| CO2 | **(Apply) Implement** the concept of trees and graphs using non-linear data structures. | K3 |
| CO3 | **(Apply) Select** suitable sorting and searching algorithms | K3 |
| CO4 | **(Analyse)** Examine various searching and sorting algorithms for the given problem. | K4 |
| CO5 | **(Apply)** Apply linear and non-linear data structure and develop a real time software application. | K3 |

**MODULE – I INTRODUCTION TO DATASTRUCTURES** **12**

- Arrays and pointers – (single and double pointer)
- Linked List implementation – Arrays and pointers
- Singly, doubly linked List, Circular linked list and its operations

**MODULE – II STACKS AND QUEUES** **12**

- Stack implementation and its applications
- Queue implementation
- Linked queue and Circular queue

**MODULE – III TREES** **12**

- Tree Creation and traversals – Inorder, preorder, postorder, levelorder

- BTree and Binary Search Tree
- AVL
- Heap

**MODULE – IV GRAPHS** **12**

- Graph construction and traversals
- Minimum spanning tree
- Shortest path algorithms

**MODULE – V SEARCHING, SORTING AND HASHING** **12**

- Searching algorithms
- Sorting algorithms
- Hashing Data structure

**Total: 60 Hours**

| **U19EE111** | **ELECTRIC CIRCUITS AND ELECTRONIC DEVICES LABORATORY** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **0** | **0** | **2** | **1** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Make use of basic semiconductor device and construct amplifier and rectifier circuits | K3 |
| CO2 | **(Apply)** Solve the basic circuit Problems using Circuit laws | K3 |
| CO3 | **(Apply)** Develop the frequency response of series and parallel resonance circuit | K3 |
| CO4 | **(Analyze)** Analyse the characteristics of basic semiconductor device | K4 |
| CO5 | **(Analyze)** Simulate and verify various circuit theorems | K4 |

**LIST OF EXPERIMENTS**

1. Characteristics of PN diode and Zener diode.
2. Characteristics of NPN Transistor under common emitter, common collector and common base configurations.
3. Single Phase half wave and full wave rectifiers with inductive and capacitive filters.
4. Simulation and experimental Verification of Ohm’s law and Kirchhoff’s law.
5. Simulation and experimental verification of Thevenin’s theorem.
6. Simulation and experimental verification of Norton’s theorem.
7. Simulation and experimental Verification of Superposition theorem.
8. Simulation and experimental verification of Maximum power transfer theorem.
9. Design and Simulation of series resonance circuit.
10. Design and Simulation of Parallel resonance circuit.

**Total: 30 Hours**

**SEMESTER – III**

| U19MA201 | TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Apply the mathematical principles to solve partial differential equations. | K3 |
| CO2 | **(Apply)** Solve engineering problems using Fourier series. | K3 |
| CO3 | **(Apply)** Utilize the concepts of Fourier series for solving wave and heat flow equations in various situations. | K3 |
| CO4 | **(Apply)** Make use of Fourier transform to convert the time function into sum of sine waves of different frequencies. | K3 |
| CO5 | **(Apply)** Apply Z- transform to convert a discrete time signal into a complex domain. | K3 |

**MODULE – I PARTIAL DIFFERENTIAL EQUATIONS** **12**

Solutions of standard types of first order partial differential equations – Lagrange's linear equations – Linear homogeneous partial differential equations of second and higher order with constant coefficients.

**MODULE – II FOURIER SERIES** **12**

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series and cosine series – Parseval's identity.

**MODULE – III APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS** **12**

Classification of second order linear partial differential equations – Solutions of one-dimensional wave equation – Solutions of one-dimensional heat equation (excluding insulated ends)- Steady state solution of two-dimensional equation of heat conduction.

**MODULE – IV FOURIER TRANSFORMS** **12**

Fourier Transforms -Fourier sine and cosine transforms- Properties-Transforms of simple functions-Convolution theorem and Parseval's identity (Statement) – Evaluation of integrals using Parseval's identity.

**MODULE – V Z – TRANSFORMS** **12**

Z-transform of standard functions – Properties – Initial and final value theorem – Inverse Z–transform of standard functions – Inverse Z- transform using convolution, partial fraction and residue methods – Application to difference equations using Z-transform techniques.

**Total: 60 Hours**

**TEXT BOOKS**


1. Grewal B. S., "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, 2015.
2. Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, Third Edition, 2013.


**REFERENCES**


1. Erwin Kreyszig, "Advanced Modern Engineering Mathematics", John Wiley, Tenth Edition, 2017.
2. Bali N. P and Manish Goyal," Higher Engineering Mathematics", Laxmi Publications, Eighth Edition, 2013.
3. Ramana B. V., "Advanced Engineering Mathematics", Tata Mc Graw Hill, 2016.

| U19EE201 | FIELD THEORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Remember)** Recall the basic laws and theorems applicable to Electrostatics and Magneto static fields | K1 |
| CO2 | **(Understand)** Explain the applications of laws and theorems applicable to Electrostatic and Magneto static fields | K2 |
| CO3 | **(Apply)** Apply various laws, theorems and concepts to find the parameters in Electrostatic and Magneto static fields | K3 |
| CO4 | **(Apply)** Solve to find the parameters in Electrodynamic fields and in Electromagnetic waves | K3 |
| CO5 | **(Apply)** Apply the concepts of electromagnetic fields in various practical applications | K3 |

**MODULE – I ELECTROSTATICS** **12**

Sources and effects of electromagnetic fields – Coordinate Systems – Vector fields –Gradient, Divergence, Curl – theorems and applications – Coulomb's Law – Electric field intensity- Gauss's law- Electrical potential – Electric field and equi potential plots – Electric field in free space, conductors, dielectric – Dielectric polarization, Electric field in multiple dielectrics – boundary conditions.

**MODULE – II MAGNETOSTATICS** **12**

Lorentz force, magnetic field intensity (H) – Biot–Savart's Law - Ampere's Circuit Law – H due to straight conductors, circular loop, infinite sheet of current, Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetization, Magnetic field in multiple media – Boundary conditions, scalar and vector potential, Poisson's Equation.

**MODULE – III ELECTRODYNAMIC FIELDS** **12**

Magnetic Circuits – Faraday's law – Transformer and motional EMF – Displacement current – Maxwell's equations (differential and integral form) – Relation between field theory and circuit theory – Applications**.**

**MODULE – IV ELECTROMAGNETIC WAVES** **12**

Electromagnetic wave generation and equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors - skin depth - Poynting vector and Poynting theorem.

**MODULE – V PRACTICAL APPLICATIONS OF ELECTROMAGNETIC FIELDS** **12**

Electrostatics – Magnetic Fields – Motors, Levitation – Moving conductor generators, Magnetic Brake, Uniform field devices – Application for Current Measurement – Time Varying Electric and Magnetic Fields – Circulators and Isolators.

**Total: 60 Hours**

**TEXT BOOKS**


1. Gangadhar K. A, "Electromagnetic Field Theory", Khanna Publishers, Eighth Reprint, 2015.
2. Kraus and Fleish, "Electromagnetics with Applications", Tata McGraw Hill, Fifth Edition, 2010.
3. Ghosh S. P, Lipika Datta, "Electromagnetic Field Theory", Tata McGraw Hill, First Edition, 2012.


**REFERENCES**


1. Mathew N. O. Sadiku, "Principles of Electromagnetics", Oxford University Press, Sixth Edition, 2015.
2. William H. Hayt and John A. Buck, "Engineering Electromagnetics", Tata McGraw Hill, 2014.
3. Sarwate V. V, "Electromagnetic fields and waves", New Age Publishers, First Edition, 1993.
4. Tewari J. P, "Engineering Electromagnetics - Theory, Problems and Applications", Khanna Publishers, Second Edition.
5. Joseph. A. Edminister, "Schaum's Outline of Electromagnetics", McGraw Hill, Third Edition, 2010.

| U19EE202 | DC MACHINES AND TRANSFORMERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Outline the concept of Magnetic Circuit and Electromagnetic Energy Conversion applicable to DC machines and Transformers | K2 |
| CO2 | **(Apply)** Investigate the constructional details and Performance of DC Generators | K3 |
| CO3 | **(Apply)** Explore the principle of operation, speed control and braking techniques of DC motors | K4 |
| CO4 | **(Analyse)** Examine various testing methods adopted to verify the performance of DC machines and transformers | K4 |
| CO5 | **(Apply)** Study the constructional details, Performance and various three phase connections of Transformers | K3 |

**MODULE – I PRINCIPLES OF ENERGY CONVERSION** **12**

Basic magnetic circuit analysis – Faraday's law of electromagnetic induction – Energy conversion via electric field – principles of electro mechanical energy conversion – Basic concepts of rotating machines – Dynamic Equation of Electromechanical Systems.

**MODULE – II DC GENERATORS** **12**

DC Machines – construction – DC Generators – principle of operation – EMF equation – magnetization characteristics – process of voltage buildup – critical resistance – critical speed – no load and load characteristics –armature reaction – commutation – reactance voltage – parallel operation – applications.

**MODULE – III DC MOTORS** **12**

DC Motors – principle of operation – Back EMF and torque equations – Types of DC Motors – Circuit model –electrical and mechanical characteristics - starting of DC motors – various types of starters. Speed control of DC motors – field control – armature control methods. Braking of DC motors –plugging – dynamic braking – regenerative braking. Special type of dc motors – Brushless D.C. motor concepts – D.C. servo motors – Permanent magnet D.C. motors – selection of D.C. motors for various industrial applications

**MODULE – IV TRANSFORMERS** **12**

Principle of Operation – Construction – EMF Equation – Transformer on No Load and Load – Phasor Diagram – Equivalent Circuit – Voltage Regulation – Losses – Efficiency – All Day Efficiency –– Principle of Operation of auto transformer – Saving of Copper– applications. Three phase transformer connections: star-star, star-delta, delta-delta connection and voltage ratios

**MODULE – V TESTING OF DC MACHINES AND TRANSFORMERS** **12**

Losses and efficiency in DC machines – Condition for maximum efficiency – Testing of DC machines – Brake test, Swinburne's test, Retardation test and Hopkinson's test. Testing of single phase transformer- - performance evaluation. Sumpner's Test – Separation of Losses. Three phase to two phase conversion- Scott connection

**Total: 60 Hours**

**TEXT BOOKS**


1. Kothari D. P and Nagrath I. J, "Electric Machines", Tata McGraw Hill, Fourth Edition, 2014.
2. Gupta J. B, "Theory and Performance of Electrical Machines", S. K. Kataria and Sons, 14th Edition, 2010.


**REFERENCES**


1. Stephen J. Chapman, "Electric Machinery Fundamentals", Tata McGraw Hill, Fourth Edition, 2010.
2. Bimbhra P. S, "Electrical Machinery", Khanna Publishers, 2011.
3. Fitzgerald A.E, Kingsely C, Umans S. D, "Electric Machinery", Tata McGraw Hill, Sixth Edition, 2003.
4. Rajput R. K, "Electrical Machines", Laxmi Publications (P) Ltd, 2003.

| U19EE203 | LINEAR AND DIGITAL ELECTRONICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain IC fabrication and the various characteristics of Op amp | K2 |
| CO2 | **(Understand)** Demonstrate the basic applications of Op amp | K2 |
| CO3 | **(Understand)** Define the fundamental blocks and the working of various special and application ICs | K3 |
| CO4 | **(Understand)** Understand number representation, conversion between different representation in digital electronic circuits and various logic families. | K3 |
| CO5 | **(Analyse)** Analyse logic processes and implement logical operations using combinational logic circuits and synchronous sequential systems. | K4 |

**MODULE – I IC FABRICATION AND CHARACTERISTICS OF OPERATIONAL AMPLIFIER 12**

Fundamentals of IC Fabrication, Operational Amplifier: Symbol, Circuit schematic of μA 741, Ideal, Ac and DC Characteristics, Frequency response characteristics and its compensation, Inverting and Non-inverting amplifiers, Differential amplifier, Instrumentation amplifier. Integrator and Differentiator

**MODULE – II SPECIAL AND APPLICATION ICs 12**

Functional block, characteristics of 555 Timer, IC-566 voltage-controlled oscillator IC; 565-phase locked loop, IC LM78XX, LM79XX; Fixed voltage regulators its application as Linear power supply - LM317, 723 Variable voltage regulators, switching regulator

**MODULE – III BOOLEAN ALGEBRA, LOGIC GATES AND DIGITAL FAMILIES 12**

Binary number systems - Binary arithmetic – Binary codes – Boolean algebra and theorems - Boolean functions – Simplifications of Boolean functions using Karnaugh map and tabulation methods – Realization of Boolean functions using Logic gates - Resistor Transistor Logic (RTL), Diode Transistor Logic (DTL), Transistor-Transistor Logic (TTL), Emitter Coupled Logic (ECL) and MOS-logic, Comparison of Various Logic Families.

**MODULE – IV COMBINATIONAL LOGIC AND SYNCHRONOUS SEQUENTIAL LOGIC 12**

Combinational circuits – Analysis and design procedures - Circuits for arithmetic operations - Code conversion - Multiplexers and Demultiplexers - Decoders and encoders - Flip flops - Shift registers – Counters.

**MODULE – V HARDWARE DESCRIPTION LANGUAGE (HDL) 12**

Programmable Logic Array (PLA) – Programmable Array Logic (PAL) – Field Programmable Gate Arrays (FPGA) – Implementation of combinational logic circuits using PLA, PAL.

**Total: 60 Hours**

**TEXT BOOKS**


1. David J. Comer, “Digital Logic and State Machine Design”, Oxford University Press, Third Edition.
2. D. Roy Choudhary, Sheil B. Jani, “Linear Integrated Circuits”, New Age, Second Edition, 2003.
3. Ramakant A. Gayakward, “Op-amps and Linear Integrated Circuits”, Pearson Education, Fourth Edition, 2003.
4. Malvino & Leach, “Digital Principles and Applications”, Seventh Edition, McGraw-Hill Education.


**REFERENCES**


1. Salivahanan, “Electron Devices and Electronic Circuits”, Tata McGraw-Hill, 2004.
2. Morris Mano M and Michael D. Ciletti, “Digital Design”, Pearson Education Fourth Edition, 2008.
3. Fiore, “Opamps & Linear Integrated Circuits Concepts & applications”, Cengage, 2010.
4. Volnei A. Pedroni, “Digital Electronics and Design with VHDL”, Elsevier, 2008.
5. Maini A. K., “Digital Electronics: Principles and Integrated Circuits”, Wiley India, First Edition, 2008.

| U19EE204 | MEASUREMENTS AND INSTRUMENTATION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Realize the standards and characteristics of measuring instruments | K2 |
| CO2 | **(Understand)** Outline the construction and principle of operation of measuring instruments | K2 |
| CO3 | **(Apply)** Apply the basic concepts for the measurement of various circuit parameters. | K3 |
| CO4 | **(Understand)** Explain the operation of various storage and display devices | K2 |
| CO5 | **(Understand)** Classify transducers and study about data acquisition systems | K2 |

**MODULE – I INTRODUCTION** **9**

Functional elements of an instrument – Static and dynamic characteristics – Errors in measurement – Statistical evaluation of measurement data – Standards and calibration.

**MODULE – II MEASUREMENTS OF ELECTRICAL QUANTITIES** **9**

Measurement of Voltage, Current energy and power factor – PMMC Instruments – Moving Iron Instruments – Dynamometer type watt meter and induction type energy meter – Principle and types of analog and digital voltmeters, ammeters, Power factor meter, Synchroscope Measurement of frequency and phase. Measurement of power using Instrument Transformers.

**MODULE – III COMPARATIVE METHODS OF MEASUREMENTS** **9**

D.C potentiometers, D.C Bridges: (Wheat stone, Kelvin and Kelvin Double bridge) & A.C bridges: (Maxwell, Anderson and Schering bridges), transformer ratio bridges, self-balancing bridges.

**MODULE – IV STORAGE AND DISPLAY DEVICES** **9**

Magnetic disk and tape – Recorders, digital plotters and printers, CRT display, digital CRO, LED, LCD & Dot matrix display – Data Loggers.

**MODULE – V TRANSDUCERS AND DATA ACQUISITION SYSTEMS** **9**

Classification of transducers – Selection of transducers – Resistive, capacitive & inductive Transducers – Piezoelectric, Hall effect, optical and digital transducers – Introduction to data acquisition systems – Elements of data acquisition system.

**Total: 45 Hours**

**TEXTBOOKS**


1. Sawhney A. K., “A Course in Electrical & Electronic Measurements & Instrumentation”, Dhanpat Rai and Co, 2010.
2. Kalsi H. S., “Electronic Instrumentation”, Tata McGraw Hill, Third Edition, 2010.


**REFERENCES**


1. Ernest O. Doeblin, “Measurement Systems: Applications and Design”, Tata McGraw Hill, 2001.
2. Cooper A. D. and Helfrik A. D., “Modern Electronic Instrumentation and Measurement Techniques”, Prentice Hall of India, 2001.
3. Alan. S. Morris, “Principles of Measurements and Instrumentation”, Prentice Hall of India, Second Edition, 2003.
4. D.V.S. Murthy, “Transducers and Instrumentation”, Prentice Hall of India, 2015.
5. Rangan C S, Sharma G R, Mani V S, “Instrumentation Devices and Systems”, Tata McGraw Hill, 2004.


| U19MC201 | ENVIRONMENTAL SCIENCE | L | T | P | C |
|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 0 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Analyze)** Analyze human interaction for the sustainability of a social eco-system. | K3 |
| CO2 | **(Analyze)** Examine the impact of pollution and hazardous chemical on environment and human health. | K3 |
| CO3 | **(Analyze)** Inspect the effect of different wastes and chemical on the environment and its mitigation methods, | K3 |

CO4 **(Apply)** Identify the application of natural resources for creating a good eco-system. K4

CO5 **(Analyze)** Apply the basic concepts to understand various environmental issues. K4

**MODULE – I ENVIRONMENT AND ECOSYSTEM** **6**

Key environmental issues, their basic causes and sustainable solutions-concept of an ecosystem–structure and function of an ecosystem–producers, consumers and decomposers–energy flow in the ecosystem–food chains and food webs.

**MODULE – II ENVIRONMENTAL POLLUTION** **6**

Primary and secondary air pollutants-Air, Water, Marine and soil pollution: causes, effects and control measures.

**MODULE – III RISK AND SECURITY OF ENVIRONMENT** **6**

Heavy metals, E-waste and Hazardous waste management-green and blue revolution, GM crops: merits and demerits-ecological impacts of modern agriculture- Biofertilizer technology-organic farming.

**MODULE – IV ENERGY RESOURCES** **6**

Non-renewable energy resources- oil, Natural gas, Coal, Nuclear energy. Renewable energy resources - Solar energy, Hydroelectric power, Wind, biomass and geothermal energy.

**MODULE – V SOCIAL ISSUES AND THE ENVIRONMENT** **6**

Environmental ethics: Issues and possible solutions-water conservation, rain water harvesting, watershed management - Sustainable development– global climatic change, global warming, ozone layer depletion.

**Total: 45 Hours**

**TEXTBOOKS**

1. Babu E and Tharaneeswaran V, “Environmental Sciences”, V K Publishers, 2019.

**REFERENCES**

1. Miller T. G. and Spoolman S. E., “Environmental Science”, Cengage learning, Fifteenth Edition, 2016.
2. Sinha J., Environmental Science, Galgotia Publications, Second Edition, 2011.
3. Air Pollution - https://nptel.ac.in/courses/105104099.
4. Energy Resources – https://slideshare.net/PritiThakkar/energy-resources-65436458.

| U19EE211 | DC MACHINES AND TRANSFORMERS LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

CO1 **(Understand)** Outline the concept of Electro Magnetic Energy Conversion applicable for DC machines and transformers K2

CO2 **(Understand)** Explain the constructional details and operation of DC machines and transformers K3

CO3 **(Apply)** Choose appropriate dc machine and transformer for specific applications K3

CO4 **(Apply)** Apply the concepts to determine the characteristics of DC machines and transformers K3

CO5 **(Analyse)** Analyse the performance of the DC Machines and transformers using test data K3

**List of Experiments**

1. Open circuit and load characteristics of DC generators (self, separately and compound)
2. Load test on DC motors (shunt, series and compound)
3. Swinburne’s test and speed control of DC shunt motor
4. Hopkinson’s test on DC motor – Generator set
5. Load test on single-phase transformer
6. Open circuit and short circuit tests on single phase transformer
7. Sumpner’s test on single phase transformers
8. Design and fabrication of transformer for power supply
9. Development of project using low power DC motors

**Total: 30 Hours**

| U19EE212 | LINEAR AND DIGITAL ELECTRONICS CIRCUITS LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Examine the performance and operation of Logical gates, Adder and Subtractor circuits. | K3 |
| CO2 | **(Apply)** Determine the principle of operation of code converters, Parity generator, Parity Checking and Combinational Circuits. | K3 |
| CO3 | **(Apply)** Construct 3 bit modulo counter using Flip Flop ICs and Counter ICs. | K3 |
| CO4 | **(Apply)** Develop various application circuits using Operational Amplifier. | K3 |
| CO5 | **(Understand)** Explain the principle of operation of Multi-vibrator and Phase Lock Loop. | K2 |

**List of Experiments**

1. Implementation of Boolean Functions, Adder and Subtractor circuits.
2. Code converters: Excess-3 to BCD and Binary to Gray code converter and vice-versa.
3. Parity generator and parity checking.
4. Encoders and Decoders.
5. Design and implementation of 3-bit modulo counters as Synchronous and Asynchronous types using FF IC's and specific counter IC.
6. Application of Op-Amp: inverting and non-inverting amplifier, Adder, comparator, Integrator and Differentiator.
7. Verification of Voltage to frequency characteristics of NE/ SE 566 IC.
8. Design of Regulated Power Supply using IC LM 317.
9. Project 1
10. Development of project using digital electronics.

**Total: 30 Hours**

## Semester – IV

| U19MA205 | STATISTICS AND NUMERICAL METHODS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Apply the concept of testing of hypothesis for small and large samples in real life problems. | K3 |
| CO2 | **(Analyze)** Analyze an experiment for an appropriate situation using analysis of variance techniques. | K4 |
| CO3 | **(Analyze)** Analyze the numerical techniques to obtain approximate solutions for algebraic, transcendental and system of linear equations. | K4 |
| CO4 | **(Apply)** Appreciate the numerical techniques of interpolation in various intervals and apply the numerical techniques of differentiation and integration for engineering problems. | K3 |
| CO5 | **(Apply)** Execute the numerical techniques for solving initial value problems. | K3 |

**MODULE – I TESTING OF HYPOTHESIS** **12**

Sampling distributions – large sample test: Tests for mean – small sample tests: Tests for mean (t test)-F test-Chi-square test for Goodness of fit and Independence of attributes.

**MODULE – II DESIGN OF EXPERIMENTS** **12**

Analysis of variance: Completely randomized design - Randomized block design - Latin square design.

**MODULE – III SOLUTION OF EQUATIONS AND EIGEN VALUE PROBLEMS** **12**

Solution of algebraic and transcendental equations: Newton Raphson method- Solution of system of linear equations: Gauss Jordan method – Gauss Seidel method - Eigen values of a matrix by power method.

**MODULE – IV INTERPOLATION, NUMERICAL DIFFERENTIATION AND INTEGRATION** **12**

Interpolation: Lagrange's interpolation formula - Newton's divided difference formula - Newton's forward and backward interpolation formulae- Numerical differentiation using Newton's forward and backward interpolation formulae- Trapezoidal rule- Simpson's one third rule for single integrals.

**MODULE – V SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS** **12**

Solution of first order ordinary differential equations: Taylor series method – Euler method – Modified Euler's method - Fourth order Runge-Kutta method - Multistep method: Milne's predictor and corrector method.

**Total: 60 Hours**

**TEXT BOOKS**


1. Burden R. L and Douglas Faires J, "Numerical Analysis Theory and Applications", Cengage Learning, Ninth Edition, 2016.
2. Richard A. Johnson, Miller & Freund's, "Probability and Statistics for Engineers", Prentice Hall, Ninth Edition, 2016.


**REFERENCE BOOKS**


1. Chapra, S. C and Canale, R. P. "Numerical Methods for Engineers", Tata McGraw Hill, Seventh Edition, 2016.
2. Gerald C. F and Wheatley P.O, "Applied Numerical Analysis", Pearson Education, Seventh Edition, 2015.
3. Walpole R.E, Myers R.H, Myers R.S.L and Ye K, "Probability and Statistics for Engineers and Scientists", Pearson's Education, Ninth Edition, 2017.

| U19EE205 | AC MACHINES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Analyse)** Predetermine voltage regulation and load sharing of Synchronous generator | K4 |
| CO2 | **(Understand)** Illustrate construction and working of Synchronous motor | K2 |
| CO3 | **(Analyse)** Analyse and determine the performance of induction motor | K4 |
| CO4 | **(Understand)** Study the various starting and speed control techniques of Induction motor | K2 |
| CO5 | **(Understand)** Study performance of single-phase induction motors and Special machines | K3 |

**MODULE – I SYNCHRONOUS GENERATOR** **12**

Construction – Cylindrical and salient pole machines – EMF Equation – Voltage Regulation – Predetermination of regulation by EMF, MMF and Potier Method – Blondel's two reaction theory – Slip test – Regulation of salient pole alternator. Parallel Operation – Synchronizing Power – Synchronizing torque – Change of excitation, frequency and mechanical input.

**MODULE – II SYNCHRONOUS MOTOR** **12**

Principle of operation – Starting methods – Torque equation –characteristics – Operation on infinite bus bars – V and inverted V curves – Power-load angle relations – Current loci for constant power input, constant excitation and constant power developed – losses and efficiency – Hunting and methods of suppression – Synchronous condenser – applications.

**MODULE – III THREE PHASE INDUCTION MOTOR** **12**

Construction – Types of rotors – Principle of Operation – Equivalent Circuit – Phasor Diagram – Performance – Torque and Power Output – Slip-Torque Characteristics – No load and Blocked Rotor Tests – Circle Diagram – Equivalent circuit – Performance evaluation

**MODULE – IV STARTING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTOR** **12**

Need for starting – Types of starters – Stator resistance and reactance, rotor resistance, autotransformer and star delta starters – Speed control by Changing voltage, frequency, number of poles and slip – Cascaded connections – Slip power recovery scheme – Kramer's system – Scherbius system – Application of slip power recovery scheme

**MODULE – V SINGLE PHASE INDUCTION MOTORS AND SPECIAL MACHINES** **12**

Constructional details – Two revolving field theory – Equivalent circuit – No load and blocked rotor tests – Performance analysis – Starting methods – Types and applications – Special machines – Shaded pole induction motor, reluctance motor, repulsion motor, hysteresis motor, stepper motor, Linear induction motor and AC series motor – linear induction motor – Applications.

**Total: 60 Hours**

**TEXT BOOKS**


1. D.P. Kothari and I.J. Nagrath, "Electric Machines", Tata McGraw Hill, 2010.
2. J. B. Gupta, "Theory and Performance of Electrical Machines", 14th Edition, S. K. Kataria and Sons, 2010.


**REFERENCE BOOKS**


1. Bimbhra P. S., "Electrical Machinery", Khanna Publishers, Seventh Edition, 2011.
2. Stephen J. Chapman, "Electric Machinery Fundamentals", Tata McGraw Hill, Fourth Edition, 2010.
3. Fitzgerald. A.E., Charles Kingsely Jr, Stephen D. Umans, "Electric Machinery", Tata McGraw Hil, Sixth Edition, 2003.
4. Theraja B L, "Textbook of Electrical Technology", Volume 2, S Chand & Co Ltd. Publisher, 2018.
5. Murugesh Kumar, "Electric Machines", Vikas Publishing House Pvt. Ltd, 2002.

| U19EE206 | CONTROL SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Make use of various analysis techniques for physical systems | K3 |
| CO2 | **(Apply)** Apply time domain analysis to determine the parameters and characteristics of controllers | K3 |
| CO3 | **(Apply)** Solve physical systems using frequency domain to verify its stability | K3 |
| CO4 | **(Analyse)** Analyze the parameters of compensators using stability and state variable approach | K4 |
| CO5 | **(Analyse)** Analyze various representations of system models using engineering fundamentals | K4 |

**MODULE – I SYSTEMS REPRESENTATION 12**

Basic Concept of Control Systems and its components. Transfer function of physical systems: Mechanical systems - Translational and Rotational systems, Electrical network. Transfer function of AC and DC servomotors, Block diagram reduction techniques, Signal flow graphs- Mason's gain formula.

**MODULE – II TIME DOMAIN ANALYSIS 12**

Various standard test signals and its importance, Time domain specifications, Generalized error series – Steady state error. P, PI, PID modes of feedback control – Tuning and its applications. Definitions - Root locus diagram - Rules to construct root loci.

**MODULE – III FREQUENCY DOMAIN ANALYSIS 12**

Introduction -Frequency domain specifications- Bode plot – Polar plot. Correlation between frequency domain and time domain specifications.

**MODULE – IV STABILITY AND COMPENSATOR DESIGN 12**

Concepts of stability, Effect of Lag, lead and lag-lead compensation on frequency response- Design of Lag, lead and lag lead compensator using bode plots. Routh-Hurwitz stability criterion, Nyquist criterion.

**MODULE – V STATE VARIABLE ANALYSIS 12**

Concept of state variables, Solution of state and output equation in controllable canonical form – Concepts of controllability and observability.

**Total: 60 Hours**

**TEXT BOOKS**


1. Benjamin C. Kuo, "Automatic Control Systems", Wiley, 2014.
2. Nagarath, I.J. and Gopal, M., "Control Systems Engineering", New Age International Publishers, 2017.


**REFERENCES**


1. Katsuhiko Ogata, "Modern Control Engineering", Pearson, 2015.
2. Richard C. Dorf and Robert H. Bishop. "Modern Control Systems", Pearson Prentice Hall, 12th Edition, 2010.
3. Norman S Nise, "Control System Engineering", John Wiley & Sons, 2013.
4. John J.D., Azzo Constantine, H. and Houpis Stuart, N Sheldon, "Linear Control System Analysis and Design with MATLAB", CRC Taylor and Francis, 2009.
5. Nagoor Kani, "Control Systems Engineering", RBA Publications, 2018.

| U19EE207 | GENERATION, TRANSMISSION AND DISTRIBUTION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Summarize the types of power generating station. | K2 |
| CO2 | **(Understand)** Explain the concept of transmission line parameters. | K2 |
| CO3 | **(Analyse)** Analyse the performance of different transmission line models. | K4 |
| CO4 | **(Apply)** Make use of insulators and supports for constructing transmissions line. | K3 |
| CO5 | **(Understand)** Explain the types of underground cables and distribution system. | K2 |

**MODULE – I POWER GENERATION** **9**

Structure of Electric Power System – Generation, Transmission and Distribution Scenario – Types of generating Stations – Thermal Power Plant, Hydro Power Plant, Gas Power Plant, Nuclear Power Plant – Solar power plant – Wind power plant.

**MODULE – II TRANSMISSION SYSTEM AND LINE PARAMETERS** **9**

Transmission line parameters–R, L & C of Single and 3 Phase lines – Skin effect and Proximity effect –Symmetrical and unsymmetrical spacing – Transposition – Bundled conductors –selection of conductors.

**MODULE – III MODELLING AND PERFORMANCE OF TRANSMISSION LINE** **9**

Classification of transmission line – Short, medium and long transmission lines –ABCD constants – equivalent circuit – Phasor diagrams – Line regulation – Efficiency – Ferranti effect –Surge impedance and surge impedance loading.

**MODULE – IV LINE INSULATORS AND SUPPORTS** **9**

Insulator types –Voltage distribution in insulator string–grading of insulators – Methods of increasing string efficiency – Testing of insulators. Line supports – types – stress and sag calculation – corona – factors affecting corona – selection of insulator and support.

**MODULE – V UNDER GROUND CABLES AND DISTRIBUTION SYSTEMS** **9**

Construction and classification of UG cables – selection of cables – Grading– Comparison between overhead lines and underground cables. Substations and types – Single line diagram of substation – Introduction to Gas Insulated Substation – Feeders, distributors and service mains – Radial, ring main and interconnected systems – Tariff.

**Total: 45 Hours**

**TEXT BOOKS**


1. R. K Rajput, “Power System Engineering”, Laxmi Publications(P) Ltd, Seventh Edition.
2. S. N. Singh, “Electric Power Generation, Transmission and Distribution “, Prentice Hall of India Pvt. Ltd, Second Edition, 2011.


**REFERENCES**


1. Soni M. L, Gupta P. V, Bhatnagar U. S, Chakrabarthi A, "A Text Book on Power System Engineering", Dhanpat Rai and Co., 2013.
2. Mehta V K Rohit Mehta, "Principles of Power Systems", S. Chand & Co., 2017.
3. Duncan Glover J, Mulukutla S. Sarma, Thomas Jeffrey Overbye, Thomas J. Overbye, “Power System Analysis and Design”, Cengage Learning, Sixth Edition, 2016.
4. Uppal S L, "Electrical Power Systems ", Khanna Publishers, 2009.

| U19MC202 | INDIAN CONTITUTION AND TRADITION | L | T | P | C |
|---|---|---|---|---|---|
| | | 1 | 0 | 0 | 0 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Understand the characteristics of the Constitution of India | K2 |
| CO2 | **(Understand)** Understand the fundamental rights and duties | K2 |
| CO3 | **(Understand)** Understand the federal structure and distribution of legislative and financial powers | K2 |
| CO4 | **(Understand)** Understand the constitutional amendments and emergency provisions | K2 |
| CO5 | **(Understand)** Understand the fundamental right to equality, freedom, life and personal freedom | K2 |

**MODULE – I HISTORY OF INDIAN CONSTITUTION** **9**

Meaning of the constitution law and constitutionalism - Historical perspective of the Constitution of India - Salient features and characteristics of the Constitution of India

**MODULE – II FUNDAMENTAL RIGHTS AND DUTIES** **9**

Scheme of the fundamental rights - Fundamental Duties and its legal status - Directive Principles of State Policy – Its importance and implementation

**MODULE – III FEDERAL STRUCTURE AND DISTRIBUTION OF POWERS** **9**

Federal structure and distribution of legislative and financial powers between the Union and the States - Parliamentary Form of Government in India – The constitution powers and status of the President of India – Amendment of the Constitutional Powers and Procedure

**MODULE – IV CONSTITUTIONAL AMENDMENTS AND EMERGENCY PROVISIONS** **9**

The historical perspectives of the constitutional amendments in India - Emergency Provisions: National Emergency, President Rule, Financial Emergency - Local Self Government – Constitutional Scheme in India

**MODULE – V RIGHT TO EQUALITY, FREEDOM, AND PERSONAL LIBERTY** **9**

Scheme of the Fundamental Right to Equality - Scheme of the Fundamental Right to certain Freedom under Article 19 - Scope of the Right to Life and Personal Liberty under Article 21

**Total: 45 Hours**

**REFERENCES**


1. Sunil Khilnani, “The Idea of India”, Penguin India Ltd., New Delhi.
2. Madhav Khosla, “The Indian Constitution”, Oxford University Press. New Delhi, 2012.
3. Brij Kishore Sharma, “Introduction to the Indian Constitution”, PHI, New Delhi
4. Sumantra Bose, “Transforming India: Challenges to the World’s Largest Democracy”, Picador India, 2013.
5. Atul Kohli, “Democracy and Discontent: India’s Growing Crisis of Governability”, Cambridge University Press, Cambridge, U. K., 1991.
6. M. P. Singh and Rekha Saxena, “Indian Politics: Contemporary Issues and Concerns”, PHI, New Delhi, 2008, latest edition.
7. Rajni Kothari, “Rethinking Democracy”, Orient Longman, New Delhi, 2005.


| U19EE213 | AC MACHINES LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Demonstrate the performance characteristics of synchronous machines and Induction machines | K2 |
| CO2 | **(Understand)** Illustrate various methods for starting and speed control of synchronous and induction motors | K2 |

| | | |
|---|---|---|
| CO3 | **(Apply)** Apply the concepts to determine the various parameters of Synchronous machines and Induction machines | K3 |
| CO4 | **(Apply)** Develop equivalent circuit models for induction motors | K3 |
| CO5 | **(Analyse)** Analyse and predetermine the performance of synchronous and induction machines | K4 |

**List of Experiments**

1. Regulation of three phase alternator by EMF, MMF and ZPF methods.
2. Regulation of three phase salient pole alternator by slip test.
3. V and inverted V curves of three phase synchronous motor.
4. Load test on three phase induction motor.
5. Load test on three phase double winding induction motor.
6. No load and blocked rotor tests on three-phase induction motor.
7. Load test on single phase induction motor.
8. No load and blocked rotor test on single-phase induction motor.
9. Speed control of AC machines.
10. Development of project using special machines.

**Total: 30 Hours**

| **U19EE214** | **CONTROL AND INSTRUMENTATION LABORATORY** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **0** | **0** | **2** | **1** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Understand control theory and apply them to electrical engineering problems. | K2 |
| CO2 | **(Understand)** Understand the basic concepts of bridge networks | K2 |
| CO3 | **(Understand)** Illustrate the basics of signal conditioning circuits. | K2 |
| CO4 | **(Apply)** Utilize the simulation packages | K3 |
| CO5 | **(Analyze)** Analyse the various types of controllers and compensators | K4 |

**List of Experiments**

**Control Systems**

1. Study of P, PI, PID Controllers
2. Simulation of Lag, Lead and Lag-Lead Compensators using MATLAB/SCILAB
3. Synchro-Transmitter- Receiver and Characteristics
4. Transfer function of armature-controlled D.C. motor and servo motor

**Instrumentation**

5. Bridge Networks – AC and DC Bridges
6. Measurement of pressure using load cell and Pressure Transducer
7. Calibration of Temperature sensors (RTD / thermo couple / thermistor)
8. Measurement of linear displacement using LVDT and Measurement of strain using Strain gauge.
9. Analog-to-Digital Conversion and Digital-to-Analog conversion
10. Development of projects using sensors and transducers

**Total: 30 Hours**

| U19EE281 | MINI PROJECT | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Identify the problem statement | K2 |
| CO2 | **(Understand)** Explain the process the solve the problem statement | K2 |
| CO3 | **(Understand)** Identify the methodologies to be adopted to solve the problem statement | K2 |
| CO4 | **(Apply)** Employ the concepts to develop the solution for the problem statement. | K3 |
| CO5 | **(Apply)** Develop the prototype model for the problem statement | K3 |

The student in a group of 3 to 4 works on a topic approved by the head of the department and prepares a comprehensive mini project report after completing the work to the satisfaction. The progress of the project is evaluated based on a minimum of two reviews. The review committee may be constituted by the Head of the Department. A mini project report is required at the end of the semester. The mini project work is evaluated based on oral presentation and the mini project report jointly by external and internal examiners constituted by the Head of the Department.

**SEMESTER – V**

| U19EE301 | POWER SYSTEM ANALYSIS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Model electrical network parameters illustrate the power system network under healthy and faulty conditions. | K3 |
| CO2 | **(Apply)** Determine the power flow in a transmission network. | K3 |
| CO3 | **(Apply)** Devise a Power System model based on symmetrical components and estimate the maximum interrupting current during short circuit. | K3 |
| CO4 | **(Understand)** Illustrate the transient behaviour of power system network under open circuit and short circuit conditions. | K2 |
| CO5 | **(Analyse)** Analyse the stability of the power system and maintaining a reliable electric power system. | K4 |

**MODULE – I MODELLING OF POWER SYSTEM** **12**

Need for System Analysis in Planning and Operation of Power System - Necessity of Modelling - Types of Modelling – Different Models for Generator, Load, and Transmission Line based on the analysis - Single Line Diagram – Per Phase Representation – Per Unit Representation. Primitive Network And its Matrices - Bus Incidence Matrix - Formation of Bus Admittance by Two-Rule Method and Singular Transformation.

**MODULE – II POWER FLOW ANALYSIS** **12**

Problem definition – Bus classification – Derivation of power flow equation – Methods of Power flow analysis - Algorithm and flowchart for Gauss Seidel, Newton Raphson method - Computation of slack bus power, transmission loss and line flows – Comparison of power flow methods-Numerical solution of power flow problem by GS method not more than three buses.

**MODULE – III SYMMETRICAL FAULT ANALYSIS** **12**

Introduction – Types of Faults – Consideration of pre-fault load current – 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.

**MODULE – IV UNSYMMETRICAL FAULT ANALYSIS** **12**

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 – Open Conductor Fault – Unsymmetrical fault analysis using bus impedance matrix.

Indian Standards for Short Circuit analysis IS-13234.

**MODULE – V POWER SYSTEM STABILITY ANALYSIS** **12**

Steady state and transient stability – Swing equation – Modified Euler's method – Runge Kutta method (Qualitative analysis) – Synchronous machine representation by Classical machine model – power angle equation – Equal area criterion – Critical clearing angle and time.

**Total: 60 Hours**

**TEXT BOOKS**

1. Nagrath I.J. and Kothari D.P., "Modern Power System Analysis", Tata McGraw Hill, New Delhi, 4th Edition, 2011.

**REFERENCES**

1. Wadhwa C.L., "Electrical Power Systems", New Age International Publishers Pvt. Ltd., Sixth Edition, 2012.
2. Duncan J. Glover, Mulukutla S. Sarma and Thomas J. Overbye, "Power System Analysis and Design", Thomas Learning, Fifth Edition, 2011.
3. John J. Grainger, William D. Stevenson, Gary W. Chang, "Power System Analysis", Tata McGraw Hill, New Delhi, 2016.
4. John J. Grainger and W.D. Stevenson, "Elements of Power System Analysis", Tata McGraw Hill, 2007.
5. Hadi Saadat, "Power System Analysis", Tata McGraw Hill, Third Edition, 2004.

| U19EE302 | POWER ELECTRONICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Understand the different types of power semi-conductor devices and plot their switching characteristics. | K2 |
| CO2 | **(Apply)** Analyse the operation, characteristics and performance parameters of phase controlled converters. | K4 |
| CO3 | **(Understand)** Illustrate the operation, switching techniques and basic topologies of DC to DC converters. | K2 |
| CO4 | **(Apply)** Apply the different PWM modulation techniques to inverters and to realize the harmonic reduction methods. | K3 |
| CO5 | **(Understand)** Illustrate the operation of AC to AC Converters. | K2 |

**MODULE – I POWER SEMICONDUCTOR DEVICES** **12**

Study of switching devices: Power diode, SCR, TRIAC, GTO, BJT, MOSFET, IGBT – Static and Dynamic characteristics – Triggering and commutation circuit for SCR – Driver and snubber circuits.

**MODULE – II PHASE CONTROLLED CONVERTERS** **12**

2-pulse, 3-pulse and 6-pulseconverters – analysis of performance parameters – Effect of source inductance – – Dual converters – Applications.

**MODULE – III DC TO DC CONVERTERS** **12**

Step-down and step-up chopper – Steady state operation – Time ratio control and current limit control – Buck, boost, buck-boost converter – Forward and flyback topology – DC-DC Converters for PV systems – Applications.

**MODULE – IV INVERTERS** **12**

Single phase and three phase (both $120^0$ mode and $180^0$ mode) inverters – PWM techniques: Sinusoidal PWM, modified sinusoidal PWM – multiple PWM – Introduction to space vector modulations – Voltage and harmonic control – Current source inverter – Introduction to multilevel inverters – Applications.

**MODULE – V AC TO AC CONVERTERS** **12**

Single phase AC voltage controllers – Multistage sequence control – single and three phase cycloconverters – Introduction to Integral cycle control – Power factor control – Matrix converters – Applications.

**Total: 60 Hours**

**TEXT BOOKS**


1. Ned Mohan, Tore. M. Undeland, William. P. Robbins, “Power Electronics: Converters, Applications and Design”, John Wiley India, Third Edition Reprint, 2009.
2. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Twenty Third Reprint, 2012.


**REFERENCES**


1. Rashid M. H, “Power Electronics: Circuits, Devices & Applications”, Pearson, Third Edition, 2004.
2. Rama Reddy S, “Fundamentals of Power Electronics”, Narosa Publishing House, Second Edition, 2014.
3. Singh M. D. and Khanchandani K. B., “Power Electronics”, Tata McGraw Hill, 2013.
4. Philip T. Krein, “Elements of Power Electronics”, Oxford University Press, Second Edition, 2015.
5. Joseph Vithayathil, “Power Electronics: Principles and Applications”, Tata McGraw Hill, Second Reprint, 2010.

| U19EE303 | MICROPROCESSORS AND MICROCONTROLLERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Illustrate the functionalities of 8085 & 8086 architectures and Assembly language programming. | K2 |
| CO2 | **(Understand)** Explain the architecture and functional block of 8051 microcontroller. | K2 |
| CO3 | **(Apply)** Program the functional units of 8051 microcontroller for the given specifications using C/Assembly language. | K3 |
| CO4 | **(Understand)** Outline the function of various peripheral devices such as 8255, 8279, 8251, 8253, 8259 and 8237. | K2 |
| CO5 | **(Apply)** Experiment the various applications using 8051 microcontroller and basic architectures of PIC, ARM & ATMEGA microprocessors & microcontrollers | K3 |

**MODULE – I 8085 AND 8086 MICROPROCESSORS** **9**

Introduction to 8085 Architecture, Timing Diagram, Addressing Modes, Instruction Formats, Instruction Set. Introduction to 8086 Architecture, Features, Signals, I/O & Memory Interfacing, Addressing Modes, Instruction Formats, Instruction Set, Assembler Directives, Interrupts, Minimum Mode & Maximum Mode Operation, Assembly Language Programming.

**MODULE – II 8051 ARCHITECTURE** **9**

Hardware features, Architecture, Internal RAM structure, Special Function Registers, Memory Organization, I/O Ports and Circuits, Timers, Interrupts, Serial Communication, Interfacing of External Memory, Interfacing LCD & Keyboard, Real Time Clock.

**MODULE – III 8051 PROGRAMMING** **9**

Addressing Modes, Instruction Set, Assembly Language Programming and C Programming, Timer Counter Programming, Serial Communication Programming, Interrupt Programming.

**MODULE – IV I/O INTERFACING** **9**

Parallel Peripheral Interface (8255), A/D & D/A Interface, Timer / Counter (8254), Keyboard and Display Controller (8279), USART (8251), Interrupt Controller (8259), DMA Controller (8237).

**MODULE – V MICROCONTROLLER APPLICATIONS AND ADVANCED PROCESSOR** **9**

Temperature Control System, Motor Speed Control System, Traffic light System, Elevator System, Data Acquisitions System, Introduction to Architecture of PIC Microcontroller, ARM Processor, ATMEGA Processor.

**Total: 45 Hours**

**TEXT BOOKS**


1. S. K. Mandal, “Microprocessors and Microcontrollers: Architecture, Programming & Interfacing using 8085, 8086, and 8051”, Tata McGraw Hill, First Edition, 2011.
2. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D McKinlay, “The 8051 Microcontroller and Embedded Systems using Assembly and C”, Pearson Education Asia, Second Edition, 2007.


**REFERENCES**


1. Ramesh S Gaonkar, “Microprocessor Architecture, Programming and application with 8085”, Penram International Publishing, New Delhi, Sixth Edition, 2011.
2. A.K Ray and K.M. Burchandi, “Advanced Microprocessor and peripherals Architectures, Programming and interfacing”, Tata McGraw Hill, Third Edition, 2012.
3. Kenneth J Ayala, “The 8051 Microcontroller Architecture Programming and Application”, Penram International Publishing, New Delhi, Second Edition, 1996.

| U19EE311 | POWER ELECTRONICS LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Illustrate power electronic converter design and testing | K2 |
| CO2 | **(Analyze)** Design linear and digital electronic circuits | K4 |
| CO3 | **(Apply)** Examine the characteristics of MOSFET, IGBT and analyze its switching behaviours | K3 |
| CO4 | **(Analyze)** Analyze the working of Switched mode power converter and Step down and step up MOSFET based choppers | K4 |
| CO5 | **(Understand)** Simulate PE circuits and create the driver circuits for different converters in MATLAB | K2 |

**List of Experiments**

1. Characteristics of SCR and TRIAC
2. Characteristics of MOSFET and IGBT
3. AC to DC half controlled converter
4. AC to DC fully controlled Converter
5. Step down and step up MOSFET based choppers
6. IGBT based single phase PWM inverter
7. IGBT based three phase PWM inverter
8. AC Voltage controller
9. Switched mode power converter
10. Simulation of PE circuits (1Φ & 3Φ semi converters, 1Φ & 3Φ full converters, DC-DC converters, AC voltage controllers)

**Total: 30 Hours**

| U19EE312 | MICROPROCESSOR AND MICROCONTROLLER LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Distinguish the fundamentals of assembly language programming for microprocessors and microcontrollers. | K2 |
| CO2 | **(Apply)** Apply the programming concepts to understand functions like arithmetic and logical functions in 8085 & 8051. | K3 |
| CO3 | **(Apply)** Examine the different communication standards in 8085 & 8051. | K3 |
| CO4 | **(Apply)** Contrast how different I/O devices can be interfaced to processors and will explore several techniques of interfacing. | K3 |
| CO5 | **(Apply)** Utilize assembly language programs of 8085 and 8051 for various applications. | K3 |

**List of Experiments**

1. Simple arithmetic operations: addition / subtraction / multiplication / division.
2. Programming with control instructions:
   (i) Ascending / Descending order, Maximum / Minimum of numbers
   (ii) Programs using Rotate instructions
   (iii) Hex / ASCII / BCD code conversions.
3. Interface Experiments: with 8085
   (i) A/D Interfacing & D/A Interfacing.
4. Traffic light controller.

5. I/O Port / Serial communication.
6. Programming Practices with Simulators/Emulators/open source.
7. Read a key, interface display.
8. Demonstration of basic instructions with 8051 Micro controller execution, including:
   (i) Conditional jumps, looping
   (ii) Calling subroutines.
9. Programming I/O Port 8051
   (i) study on interface with A/D & D/A
   (ii) study on interface with DC & AC motor.
10. Mini project development with processors.

**Total: 30 Hours**

| **U19EM301** | **APTITUDE I** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **0** | **0** | **2** | **1** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Students will be able to solve problems based on application of aptitude concepts in real life | K2 |
| CO2 | **(Understand)** Will understand the importance and impact created by aptitude concepts in real life | K2 |
| CO3 | **(Apply)** Will be able to create shortcut formulas by self. | K3 |
| CO4 | **(Apply)** Will be able to analyze, evaluate and compare different scenarios given in a problem and find the strategically best solutions. | K3 |
| CO5 | **(Apply)** Will be capable of creating their own questions based on parameters and constraints given. | K3 |
| CO6 | **(Apply)** Will understand lot of learning methods and will be able to apply them in real life problems. | K3 |

**MODULE – I FOUNDATION** **6**

Why Aptitude? - Need for Problem solving skill– Application of problem solving in real life – Different types of problems and its worth – Product Vs Service companies - case study – Creativity and Innovation – problem statement – Design thinking basics. Understanding Vs Method memorization, validation of understanding, different algorithms in problem solving - Brute force approach, Pattern finding method and Deep Learning Approach.

**MODULE – II NUMBER SYSTEMS** **6**

Primes and factors, Eulers theorem, Totient function & application, factors and factorials, divisibility rule, unit digit calculation and power cycle method, remainder concepts, primality tests, Binomial theorem.

**MODULE – III AVERAGES** **6**

Introduction – Traditional approach – Thinking methods - Arithmetic progression – Application /formula creation - Insert and Delete problems - group averages - ANT method – Weighted averages – principle of balancing moments – see-saw method and its application, practical demonstration.

**MODULE – IV PERCENTAGES - PROFIT AND LOSS - INTERESTS CALCULATION** **6**

Introduction - Utility of percentage - fraction to percentage conversion table increase and decrease concepts – successive increase decrease concepts, shortcuts and its application. Creative problems – dry/fresh fruit – 2x2 problem – venn diagrams application.

Basic understanding of Gain/Loss and percentage gain/percentage loss-Multiplying equivalents to find sale price - an article sold at two different selling price / two different articles sold at same selling price -percentage gain or percentage loss on selling price -percentage gain or percentage loss on whole property, False weight problem

Basic understanding and calculation of simple and compound interest, varies problems based on simple interest & compound interest, shortcuts. Rule of 72.

Financial education fundamentals – Understanding of assets & liabilities - Money Box / Corpus fund / pension scheme creation – sample visualization. Application of CI in real life -Warren buffet – case study.

**MODULE – V RATIO, PROPORTION / MIXTURE** **6**

Definition –DP/IP concepts and it's application – Problem based on ages – coin bag problems – partnerships- allegation rule –cris x cross method – Solid mixing – 3-variable mixing – liquid mixing problem – Percentage and ratio based problem – profit loss application – water addition and replacement problems – repetitive iteration problems.

**Total: 30 Hours**

**REFERENCES**


1. https://www.hackerearth.com/
2. https://www.geeksforgeeks.org/
3. Dr. R. S. Aggarwal, Quantitative Aptitude, Seventh Revised Edition, S. Chand Publishing Company Ltde(s)
4. Arun Sharma, "How to prepare for Quantitative Aptitude for the CAT", Fifth Edition, Tata McGraw-Hill Publishing Company Ltd, 2013
5. Rich Dad Poor Dad, "7 Habits of Highly Effective People", Richest Man in Babylon, Think and Grow Rich.

**SEMESTER – VI**

| U19EE304 | SOLID STATE DRIVES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the steady state operation of a motor load system. | K2 |
| CO2 | **(Understand)** Describe the operation of the converter/chopper fed dc drive. | K2 |
| CO3 | **(Understand)** Describe the operation of the Induction motor drive. | K2 |
| CO4 | **(Understand)** Explain the operation of the Synchronous motor drive. | K2 |
| CO5 | **(Apply)** Illustrate the current and speed controllers for a closed loop solid state DC motor drive. | K3 |

**MODULE – I DRIVE CHARACTERISTICS** **9**

Introduction to Electric drive – Equations governing motor load dynamics – Steady state stability of an Electrical drive – Multi quadrant Dynamics: acceleration, deceleration, starting & stopping – Typical load torque characteristics – Selection of motor.

**MODULE – II CONVERTER / CHOPPER FED DC MOTOR DRIVE** **9**

Steady state analysis of the single and three phase converter fed separately excited DC motor drive – continuous conduction – Time ratio and current limit control – 4 quadrant operation of converter / chopper fed drive – Applications.

**MODULE – III INDUCTION MOTOR DRIVES** **9**

Stator voltage control – V/F control – Rotor Resistance control – Qualitative treatment of slip power recovery drives – Closed loop control – Vector control – Applications.

**MODULE – IV SYNCHRONOUS MOTOR DRIVES** **9**

V/f control and self-control of synchronous motor: Margin angle control and power factor control – Permanent Magnet Synchronous Machine – Three phase voltage/current source fed synchronous motor – Applications.

**MODULE – V DESIGN OF CONTROLLERS FOR DRIVES** **9**

Transfer function for DC motor / load and converter – Closed loop control with Current and speed feedback – armature voltage control and field weakening mode – Design of controllers: current controller and speed controller – Converter selection and characteristics.

**Total: 45 Hours**

**TEXT BOOKS**


1. Gopal K. Dubey, “Fundamentals of Electrical Drives”, Narosa Publishing House, Second Edition, 1992.
2. Krishnan R, “Electric Motor Drives: Modeling, Analysis and Control, Pearson, 2001.


**REFERENCES**


1. Bimal K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, 2002
2. Vedam Subramanyam, “Electric Drives Concepts and Applications”, McGraw Hill, Second Edition, 2016.
3. Shaahin Felizadeh, “Electric Machines and Drives: Principles, Control, Modeling and Simulation”, CRC Press, 2013.
4. John Hindmarsh and Alasdain Renfrew, “Electrical Machines and Drives System”, Elsevier 2012.
5. Theodore Wildi, “Electrical Machines, Drives and power systems”, Pearson, Sixth Edition, 2015.
6. N.K.De., P.K. Sen, “Electric drives”, PHI Pvt. Ltd., Ninth Edition, 2009.

| U19EE305 | POWER SYSTEM PROTECTION AND SWITCHGEAR | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Realize the various protection schemes for power system protection | K2 |
| CO2 | **(Analyse)** Analyze the characteristics and functions of relays and protection schemes. | K3 |
| CO3 | **(Understand)** Identify the different protection techniques for electrical apparatus | K2 |
| CO4 | **(Apply)** Design protection system using static relays and numerical protection | K3 |
| CO5 | **(Understand)** Realize the different types of circuit breakers and select them for suitable application | K2 |

**MODULE – I INTRODUCTION TO POWER SYSTEM PROTECTION** **9**

Principles and need for protective schemes – Nature and Cause of Faults – Types of Faults – Effects of Faults – Fault Statistics – Zones of Protection – Primary and Backup Protection – Essential Qualities of Protection – Performance of Protective Relaying – Fault current calculation using symmetrical components.

**MODULE – II ELECTROMAGNETIC RELAYS** **9**

Operating principles of relays – Universal relay – Torque equation – R-X diagram – Electromagnetic Relays: Over current, Directional, Distance, Differential, Negative sequence and Under frequency relays.

**MODULE – III APPARATUS PROTECTION** **9**

Current transformers – Potential transformers – Applications of CTs and PTs in protection schemes – Protection of transformer, generator, motor, bus bars and transmission line.

**MODULE – IV STATIC RELAYS AND NUMERICAL PROTECTION** **9**

Static relays – Phase and Amplitude Comparators – Synthesis of various relays using Static comparators – Block diagram of Numerical relays – Over current protection – Transformer differential protection – Distant protection of transmission lines.

**MODULE – V CIRCUIT BREAKERS** **9**

Physics of arcing phenomenon and arc interruption – DC and AC circuit breaking – re-striking voltage and recovery voltage – rate of rise of recovery voltage – resistance switching – current chopping – interruption of capacitive current – Types of circuit breakers – air blast, air break, oil, SF6, MCBs, MCCBs and vacuum circuit breakers – Comparison of different circuit breakers – Rating and selection of Circuit breakers.

**Total: 45 Hours**

**TEXT BOOKS**

1. Badri Ram, B.H. Vishwakarma, “Power System Protection and Switchgear”, Tata McGraw Hill Education Private Limited, Second Edition 2011.

**REFERENCES**

1. Sunil S.Rao, “Switchgear and Protection”, Khanna Publishers, New Delhi, 2008.
2. Veerappan N, Krishnamurthy S.R, “Power System Switchgear and Protection”, S. Chand & Company Pvt. Ltd. First Edition, 2009.
3. Wadhwa C.L, “Electrical Power Systems”, New Age International Publishers, Sixth Edition, 2009.

| U19EE306 | SPECIAL ELECTRICAL MACHINES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the Construction, Principle of Operation of Stepper Motors and its applications | K2 |
| CO2 | **(Understand)** Illustrate the Construction, Principle of Operation of Switched Reluctance Motor | K2 |
| CO3 | **(Understand)** Describe the concept behind the construction, principle of operation of PMBLDC Motor | K2 |
| CO4 | **(Understand)** Outline the construction, principle of operation and control techniques of Permanent Magnet Synchronous Motor | K2 |
| CO5 | **(Understand)** Summarize the construction, principle of operation and applications of Special Machines | K2 |

**MODULE – I STEPPER MOTOR** **9**

Construction – Principle of operation of Variable Reluctance Stepper Motor – PMSM – HSM – Torque Equation – Characteristics – Open loop – Closed loop – Microprocessor based Control – Comparison of Permanent Magnet, VR and Hybrid Stepper Motor – Applications.

**MODULE – II SWITCHED RELUCTANCE MOTOR** **9**

Construction – Principle of operation – Basics of SRM Analysis – Torque Equation and Characteristics – Power Converter Circuits – Control of SRM – RPS – Microprocessor Based and Sensorless Control of SRM – Applications

**MODULE – III PERMANENT MAGNET BRUSHLESS DC MOTOR** **9**

Construction – Principle of Operation – Classification – Electronic Commutation – BLDC Square Wave Motor - Microprocessor Based and Sensorless Control of PMBLDC Motor – Comparison of Conventional DC and BLDC Motor – Applications

**MODULE – IV PERMANENT MAGNET SYNCHRONOUS MOTOR** **9**

Construction – Principle of Operation – EMF Equation – Torque Equation – Phasor Diagram – Comparison of Conventional Motor and PMSM – Control of PMSM – Applications

**MODULE – V OTHER SPECIAL MACHINES** **9**

Construction – Principle of Operation – Applications: Synchronous Reluctance Motor, AC Series Motor, Repulsion Motor, Hysteresis Motor, Universal Motor, Servo Motors and Linear Induction Motors.

**Total: 45 Hours**

**TEXT BOOKS**


1. Janardanan E.G, “Special Electrical Machines”, PHI Learning Private Limited, Delhi, 2014.


**REFERENCES**


1. Acarnley P, “Stepping Motors: A Guide to Motor Theory and Practice”, The Institution of Electrical Engineers, Fourth Edition, 2002.
2. Takashi Kenjo, “Stepping Motors and their Microprocessor Controls”, Clarendon Press London, 1994.
3. Krishnan R, “Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design and Application”, CRC Press, New York, 2001.
4. Kenjo T and Nagamori S, “Permanent Magnet and Brushless DC Motors”, Clarendon Press, London, 1988.
5. Miller T.J.E, “Brushless Permanent Magnet and Reluctance Motor Drives”, Oxford University Press, 1989.
6. Venkataratnam K, “Special Electrical Machines”, Universities Press (India) Private Limited, 2009.

| U19EE313 | POWER SYSTEMS LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Illustrate the power system planning and operational studies | K2 |
| CO2 | **(Understand)** Explain the Formation of Bus Admittance and Impedance Matrices and Solution of Networks. | K2 |
| CO3 | **(Analyze)** Analyze the Power flow solution of small systems using simple method, Gauss-Seidel P.F. method. | K4 |
| CO4 | **(Apply)** Examine the Symmetric and Unsymmetrical fault in Power System | K3 |
| CO5 | **(Understand)** Explain the concepts of Economic Dispatch and Electromagnetic Transients | K2 |

**List of Experiments**

1. Computation of Transmission Line Parameters
2. Formation of Bus Admittance and Impedance Matrices and Solution of Networks
3. Power Flow Analysis using Gauss-Seidel Method
4. Power Flow Analysis using Newton Raphson Method
5. Symmetric and unsymmetrical fault analysis
6. Transient stability analysis of SMIB System
7. Economic Dispatch in Power Systems
8. Load – Frequency Dynamics of Single- Area and Two-Area Power Systems
9. State estimation: Weighted least square estimation
10. Electromagnetic Transients in Power Systems: Transmission Line Energization

**Total: 30 Hours**

| U19EE381 | INNOVATIVE/ MULTI-DISCIPLINARY PROJECT | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Analyse)** Analyze and identify the problem and technology to be adopted | K4 |
| CO2 | **(Apply)** Function as a team in planning and execution of the project work | K3 |
| CO3 | **(Apply)** Apply appropriate knowledge of engineering to achieve identified objectives of the project. | K3 |
| CO4 | **(Create)** Create a demonstrable output. | K4 |

The students in a group of 3 to 4 works on a topic approved by the head of the department under the guidance of a faculty member and prepares a comprehensive innovative/ multi-disciplinary project report after completing the work to the satisfaction of the supervisor.

**Continuous Internal Assessment Method:**

| **Review - I (20 Marks)** | | **Review - II (20 Marks)** | | **Review - III (20 Marks)** | |
|---|---|---|---|---|---|
| Review Committee | Guide | Review Committee | Guide | Guide | Project Coordinator |
| 10 | 10 | 10 | 10 | 10 | 10 |

**Project Work – Assessment Method:**

| Review Phase | Allocation of Marks | Parameters | | | | |
|---|---|---|---|---|---|---|
| | | Design Methodology | Technical Competency | Communication | Presentation | Viva |
| 1st | 100 | 30 | 20 | 15 | 15 | 20 |
| 2nd | 100 | 30 | 20 | 15 | 15 | 20 |
| 3rd | 100 | 30 | 20 | 15 | 15 | 20 |

- The progress of the project is evaluated based on a minimum of three reviews.
- The review committee may be constituted by the Head of the Department.
- A project report is required at the university examination.
- The project work is evaluated based on oral presentation and the project report jointly by project coordinator constituted by the Head of the Department.

**Total: 15 Hours**

| U19EM302 | APTITUDE II | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Students will be able to solve problems based on application of aptitude concepts in real life | K2 |
| CO2 | **(Understand)** Will understand the importance and impact created by aptitude concepts in real life | K2 |
| CO3 | **(Apply)** Will be able to create shortcut formulas by self. | K3 |
| CO4 | **(Apply)** Will be able to analyze, evaluate and compare different scenarios given in a problem and find the strategically best solutions. | K3 |
| CO5 | **(Apply)** Will be capable of creating their own questions based on parameters and constraints given. | K3 |
| CO6 | **(Apply)** Will understand lot of learning methods and will be able to apply them in real life problems. | K3 |

**MODULE – I ALGORITHM AND CONCEPTS USED IN PROBLEM SOLVING 6**

Recursion and Back tracking, N step Problems, Horse movement/N Queen Problem. eieve of Eratosthenes, Totient function, Inclusion/Exclusion principals, line sweep technique, Line Intersection using Bentley algorithm. complex puzzle solving algorithm

**MODULE – II TIME AND WORK 6**

Introduction - Basic concepts -Concepts on working with different efficiency -Pipes and Cisterns –Work equivalence (Man Days) -Alternative approach, Shortcut methods.

**MODULE – III TIME, SPEED AND DISTANCE 6**

Definition -Basics of Time, Speed and Distance - Relative speed - Problems based on Trains – Effective Speed - Problems based on Boats and Streams -Problems based on Races – Escalator problems. Xeno's Paradox.

**MODULE – IV PERMUTATION AND COMBINATION 6**

Fundamental principle of counting -Theorems on Permutation -Theorems on Combinatorics different types of problems in combination & permutations.

**MODULE – V PROBABILITY AND GEOMETRY 6**

Importance of probability - Real-Life estimation of probability – Conditional probability -Basic facts about probability -some important consideration while defining event – different types of problems. 2-D and 3-D objects - Mensuration – Area & Volume – complex diagrams – Divide and conquer – self creation of formula and demonstration using Octagonal pyramid case – co-ordinate geometry – heights & distance.

**Total: 30 Hours**

**REFERENCES**

1. https://www.hackerearth.com/
2. https://www.geeksforgeeks.org/
3. https://www.indiabix.com
4. Aggarwal R.S, "Quantitative Aptitude", S. Chand Publishing Company Ltd., Seventh Revised Edition.
5. Arun Sharma, "How to prepare for Quantitative Aptitude for the CAT", Tata McGraw-Hill Publishing Company Ltd, Fifth Edition, 2013.

| **U19EM303** | **DESIGN THINKING LABORATORY** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **0** | **0** | **2** | **1** |

**Outcomes**

Upon completion of this course, students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Interpret mind maps for design thinking process | K2 |
| CO2 | **(Apply)** Develop prototype with ideation and innovation techniques | K3 |
| CO3 | **(Analyze)** Validate the design and develop professional interpersonal and presentation skills | K4 |

**List of Experiments:**

| **Week No** | **Activity** | **Number of Hours** |
|---|---|---|
| Week 1 | Introduction to Design Thinking | 1 |
| Week 2 | Design Thinking Frameworks<br>• **Exercise**: Review the Case Study | 1 |
| Week 3 | Identify Problem Statement<br>• **Exercise:** Brainstorming for the problem<br>• **Exercise**: Users interview conduction | 1 |
| Week 4 | Construct empathy maps for the problem identified | 1 |
| Week 5 | Define the Problem<br>• **Exercise:** Layout the problem statement<br>• **Exercise**: Define the Point of View | 1 |
| Week 6 | Ideate<br>• Brainstorming<br>• **Exercise**: Develop Potential Solutions<br>• **Exercise**: Feedback on the Solutions | 1 |
| Week 7<br>Week 8<br>Week 9 | Prototype<br>• **Exercise**: Design and development of Prototype for the problem Identified<br>• **Exercise**: Review the Prototype and Gain Feedback | 3 |
| Week 10<br>Week 11 | Testing<br>• **Exercise**: Test the Prototype | 2 |
| Week 12<br>Week 13 | Design Validation<br>• Validate the Prototype | 2 |
| Week 14<br>Week 15 | PITCH Deck | 2 |

**TOTAL: 15 Hours**

**REFERENCES**

1. Idris Mootee, "Design Thinking for Strategic Innovation", John Wiley & Sons, 2013.
2. John.R.Karsnitz, Stephen O'Brien and John P. Hutchinson, "Engineering Design", Cengage learning (International Edition), Second Edition, 2013.
3. "Human-Centered Design Toolkit: An Open-Source Toolkit to Inspire New Solutions in the Developing World", IDEO.

**SEMESTER – VII**

| U19HS401 | PRINCIPLES OF MANAGEMENT AND PROFESSIONAL ETHICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the management concepts, evolution of management and contemporary management thoughts and issues | K2 |
| CO2 | **(Analyze)** Analyze steps in planning, decision making and structure of organization | K4 |
| CO3 | **(Apply)** Apply motivational theories and leadership qualities | K3 |
| CO4 | **(Apply)** Apply human values in engineering ethics | K3 |
| CO5 | **(Understand)** Explain safety, Rights and responsibilities of employee and employer | K2 |

**MODULE – I MANAGEMENT CONCEPTS** **9**

Management – Definition – Importance – Functions – Skills required for managers - Roles and functions of managers – Science and Art of Management –Management and Administration-Evolution of Classical, Behavioural and Contemporary management thoughts.

**MODULE – II PLANNING AND ORGANIZING** **9**

Hrs Nature & Purpose – Steps involved in Planning – Forms of Planning – Types of plans – Plans at Individual, Department and Organization level - Managing by Objectives. Forecasting – Purpose – Steps and techniques. Decision-making – Steps in decision making-Nature and Purpose of Organizing - Types of Business Organization - Formal and informal organization – Organization Chart – Structure and Process – Strategies of Departmentation– Line and Staff authority – Benefits and Limitations. Centralization Vs De- Centralization and Delegation of Authority. Staffing – Manpower Planning – Recruitment – Selection – Placement – Induction.

**MODULE – III DIRECTING AND CONTROLLING** **9**

Nature & Purpose – Manager Vs. Leader - Motivation - Theories and Techniques of Motivation. Leadership – Styles and theories of Leadership. Communication – Process – Types – Barriers – Improving effectiveness in Communication. Controlling – Nature – Significance – Tools and Techniques-Corporate Governance Social responsibilities – Ethics in business – Recent issues. American approach to Management, Japanese approach to Management, Chinese approach to Management and Indian approach to Management.

**MODULE – IV HUMAN VALUES AND ENGINEERING ETHICS** **9**

Definition, Moral issues, Human values -Types of inquiry- Morality and issues of morality- Kohlberg and Gilligan's theories- consensus and controversy- Professional and professionalism-moral reasoning and ethical theories- virtues, professional responsibility, integrity, self-respect, duty ethics, ethical rights, self-interest, moral obligations-Engineering as social experimentation- codes of ethics – case studies.

**MODULE – V RIGHTS, RESPONSIBILITY OF ENGINEERS AND GLOBAL ISSUES** **9**

Safety and risk – assessment of safety and risk-Collegiality and loyalty – respect for authority – collective bargaining – confidentiality – conflicts of interest – occupational crime – professional rights – employee rights – Intellectual Property Rights (IPR) – discrimination - Multinational Corporations – Environmental ethics – computer ethics – weapons development – Engineers as trend setters for global values – case studies.

**Total: 45 Hours**

**TEXT BOOKS**


1. Tripathy P.C, Reddy P.N, "Principles of Management", Tata McGraw-Hill, Ninth Edition, 2018.
2. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, 2018.


**REFERENCES**


1. Dinkar Pagare, "Principles of Management", Sultan Chand & Sons, 2014.
2. Stephen A. Robbins, David A. Decenzo, Mary Coulter, "Fundamentals of Management", Pearson Education, Ninth Edition, 2017.

3. Harold Koontz, Heinz Weihrich, “Essentials of Management: An International perspective”, Tata McGraw Hill, Eighth Edition, 2015.
4. Mike Martin, Roland Schinzinger, “Ethics in Engineering”, Tata McGraw-Hill, 2005.

| U19EE401 | EMBEDDED SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the functional blocks and selection procedure of Processors in the Embedded domain. | K2 |
| CO2 | **(Understand)** Illustrate the design and development of typical embedded systems. | K2 |
| CO3 | **(Apply)** Explain the design Procedure for Embedded Firmware. | K3 |
| CO4 | **(Apply)** Establish the role of Real time Operating Systems in Embedded Systems. | K3 |
| CO5 | **(Understand)** Outline the tack communication concepts. | K2 |

**MODULE – I INTRODUCTION TO EMBEDDED SYSTEMS** **9**

Definition of Embedded System, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Purpose of Embedded Systems, Characteristics and Quality Attributes of Embedded Systems.

**MODULE – II TYPICAL EMBEDDED SYSTEM** **9**

Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs, Commercial Off-The-Shelf Components (COTS), Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Communication Interface: Onboard and External Communication Interfaces.

**MODULE – III EMBEDDED FIRMWARE** **9**

Reset Circuit, Brown-out Protection Circuit, Oscillator Unit, Real Time Clock, Watchdog Timer, Embedded Firmware Design Approaches and Development Languages.

**MODULE – IV RTOS BASED EMBEDDED SYSTEM DESIGN** **9**

Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling – Case study.

**MODULE – V TASK COMMUNICATION** **9**

Shared Memory, Message Passing, Remote Procedure Call and Sockets, Task Synchronization: Task Communication/Synchronization Issues, Task Synchronization Techniques, Device Drivers, Selection of RTOS

**Total: 45 Hours**

**TEXT BOOKS**

1. Shibu K.V, “Introduction to Embedded Systems”, McGraw Hill Education, Second Edition, 2017.

**REFERENCES**

1. Raj Kamal, “Embedded Systems- Architecture, Programming and Design”, McGraw Hill Education, Third Edition, 2017.
2. Tony Givargis Frank Vahid, “Embedded System Design: A Unified Hardware / Software Introduction”, Wiley, Student Edition, 2006.

| U19EE481 | PROJECT WORK - PHASE I | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 6 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Solve a specific problem right from its identification and literature review till the successful solution of the same. | K3 |
| CO2 | **(Analysis)** Take up any challenging practical problems and analyse the possible outcome. | K4 |
| CO3 | **(Create)** Find solution by formulating proper methodology and by creating a product. | K6 |

**GUIDELINES FOR REVIEW AND EVALUATION**

The students may be grouped into 2 to 4 and work under a project supervisor. The device/ system/component(s) to be designed may be decided in consultation with the supervisor and if possible, with an industry. A project report to be submitted by the group and the fabricated model, which will be reviewed and evaluated for internal assessment by a committee constituted by the Head of the Department. At the end of the semester examination the project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

**Total: 90 Hours**

**SEMESTER – VIII**

| U19EE482 | PROJECT WORK – PHASE II | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 16 | 8 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Solve a specific problem right from its identification and literature review till the successful solution of the same. | K3 |
| CO2 | **(Analysis)** Take up any challenging practical problems and analyse the possible outcome. | K4 |
| CO3 | **(Create)** Find solution by formulating proper methodology and by creating a product. | K6 |

**GUIDELINES FOR REVIEW AND EVALUATION**

The students in a group of 3 to 4 works on a topic approved by the head of the department under the guidance of a faculty member and prepare a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

**Total: 240 Hours**

**INDUSTRY ORIENTED COURSES**

| U19IC501 | ELECTRICAL ESTIMATION, COST AND AUDITING | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Make use of the concepts for planning, estimating and costing for wiring a residential building. | K3 |
| CO2 | **(Apply)** Apply the concepts for planning, estimating and costing for wiring an industrial building. | K3 |
| CO3 | **(Apply)** Utilize the tools for conducting electrical energy audit for a load center. | K3 |

**MODULE – I ELECTRICAL WIRING, ESTIMATING AND COSTING FOR RESIDENTIAL BUILDINGS** **12**

**Theory:**

System of Wiring-Types-Earthing-Planning-Estimating-Costing

**Practical:**

1.1 Residential Building-Planning

1.2 Residential Building-Estimating & Costing

**Minor Project:**

Electrical wiring planning, estimating and costing of given residential building

**MODULE – II ELECTRICAL WIRING, ESTIMATING AND COSTING FOR INDUSTRIAL BUILDINGS** **12**

**Theory:**

System of Wiring-Types-Earthing-Planning-Estimating-Costing

**Practical:**

2.1 Industrial Building-Planning

2.2 Industrial Building-Estimating & Costing

**Minor Project:**

Electrical wiring planning, estimating and costing of given industrial building

**MODULE – III ELECTRICAL ENERGY AUDITING** **6**

**Theory:**

Introduction to Energy Audit-Instruments for Energy Audit

**Practical:**

3.1 Energy Auditing

**Minor Project:**

Energy Auditing for a given load centre.

**Total: 30 Hours**

**TEXT BOOKS**


1. K. B. Raina, “Electrical Design Estimating and Costing”, New Age International Publishers, 2018.
2. Albert Thumann, Terry Niehus, William.J.Younger “Handbook of Energy Audits”, The Fairmont Press, CRC Press, 2013.


**REFERENCES**


1. Gupta J. B., “A course in Electrical Installation Estimating & Costing”, Katson Publishers,2018.
2. Shivaga Naik H, Talwar M. N, “Electrical Estimation & Costing”, Eastern Book Promoters Belgaum, 2018.
3. Turner W. C., “Energy Management Handbook”, CRC Press, Fifth Edition, 2004.

| U19IC502 | SOLAR PV SYSTEMS: DESIGN, SIMULATION, MONITORING AND CONTROL | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the fundamentals of solar PV Systems | K2 |
| CO2 | **(Apply)** Apply the concepts to model a stand-alone PV System | K3 |
| CO3 | **(Apply)** Utilize the concepts to design a grid connected PV System | K3 |

**MODULE – I INTRODUCTION TO SOLAR PV SYSTEMS** **10**

**Theory:**

Introduction of Solar PV Modules – Types of Solar PV systems – Photovoltaic System Components

**Practical:**

Interconnections of PV Modules, Shading analysis on PV modules, VI Characteristics of PV module

**Mini Project:**

Design of solar powered lamp/charger.

**MODULE – II STAND – ALONE PV SYSTEM** **10**

**Theory:**

Preparation of Load Chart – Solar Array Sizing – Battery Bank Sizing – Charge Controller Selection – Inverter Selection

**Practical:**

Installation of solar street light and off grid systems.

**Mini Project:**

Design of 1 kw solar off grid system

**MODULE – III GRID CONNECTED PV SYSTEM** **10**

**Theory:**

Assessment of Site condition – Estimation of Annual energy usage – average solar radiation of the site – Required demand – Inverter Selection – Solar Array Sizing – Balance of System (BOS) Selection – Net metering

**Practical:**

Installation of on grid system.

**Mini Project:**

Design of 1 kw on grid system

**Total: 30 Hours**

**TEXT BOOKS**


1. Solanki C.S., “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning Pvt. Ltd.,2015.
2. Rai. G.D,” Solar Energy Utilization”, Khanna publishes, 1993.
3. Wenham S. R, Green M. A, Watt M. E, Corkish R, “Applied Photovoltaics”, Third Edition, 2013.


**REFERENCES**


1. Mc Neils, Frenkel, Desai, “Solar & Wind Energy Technologies”, Wiley Eastern, 1990.
2. Sukhatme S. P, “Solar Energy”, Tata McGraw Hill,1987.
3. Eduardo Lorenzo G. Araujo, “Solar electricity engineering of Photovoltaic systems”, Progensa,1994


| U19IC503 | AUTOMOTIVE ELECTRICAL SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Outline the basics of automotive electrical systems and demonstrate the testing and maintenance of batteries. | K2 |
| CO2 | **(Understand)** Explain the operations of starting, ignition and lighting systems. | K2 |
| CO3 | **(Understand)** Describe the operation of various electrical equipment and accessories used in automotive systems. | K2 |

**MODULE – I BATTERY AND CHARGING SYSTEMS** **10**

**Theory:**

Recent trends in modern automobiles – Block diagram of electrical system – Components of an Automobile Electronic system and their functions.

Vehicle batteries – charging and testing – Requirements of charging system – Charging system principles – Smart charging – Maintenance.

**Practical:**

Battery charging and testing – Maintenance

**MODULE – II STARTING, IGNITION AND LIGHTING SYSTEMS** **10**

**Theory:**

Requirements of starting systems – Starter motor and circuits – Types of starter motor – Ignition system fundamentals – Electronic ignition – Spark plug.

Lighting fundamentals – Lighting circuits – Earth return system – Insulated earth return – Colour coding of electrical wires.

**Practical:**

Automotive wiring and circuits

**MODULE – III ELECTRICAL EQUIPMENT AND ACCESSORIES** **10**

**Theory:**

Dashboard instruments – Speedometer – Electric horns – Windscreen wiper and washer – Wiper motors – Central locking system.

**Practical:**

Wiring of wiper motors, starter motors

**Project:**

Design of a central locking system

**Total: 30 Hours**

**TEXT BOOKS**


1. Tom Denton, “Automobile Electrical and Electronics systems”, Routledge Taylor and Francis Group, Fifth Edition, 2008.
2. Babu A. K, “Automotive Electrical and Electronics”, Khanna Book Publishing Co. (P) Ltd., 2016.


**REFERENCES**


1. Kohli P. L, “Automotive Electrical Equipment”, Tata McGraw Hill, 27th Reprint, 2006.
2. Vaughn D. Martin, “Automotive Electrical Systems”, Prompt Publications, 1999.
3. Arthur W. Judge, “Modern Electrical Equipment of Automobiles”, Chapman and Hall, 1992.


| **U19IC504** | **ELECTRONICS DESIGN AND AUTOMATION** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **0** | **0** | **2** | **1** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Understand the concepts of PCB Designing and the importance of an Arduino Shield | K2 |
| CO2 | **(Understand)** Summarize the applications of Raspberry Pi Extension Boards and develop the commands scripts and user language programs | K2 |
| CO3 | **(Analyse)** Construct the library functions for Design and Automation | K4 |

**MODULE – I PCB DESIGNING AND ARDUINO SHIELD** **10**

PCB- Methods of PCB Designing- software used for PCB Designing. Introduction, Shield Design, Arduino R3 Shield Template

**MODULE – II RASPBERRY PI EXTENSION BOARDS AND ITS COMMANDS SCRIPTS AND USER LANGUAGE PROGRAMS** **10**

Design Considerations, The schematic of the board. Commands Scripts and User Language Programs of a raspberry pi extension boards

**MODULE – III CREATING LIBRARIES AND PARTS** **10**

Creating a library, copying a device from another library, The Part Editor (creating parts for Devices, Symbols & Packages)

**Total: 30 Hours**

**TEXT BOOKS**

1. Simon Monk, Duncan Amos, “Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards, Second Edition, 2017.
2. Khandpur R. S, “Printed Circuit Boards: Design, Fabrication, Assembly and Testing”, Tata McGraw Hill, 2005.

**REFERENCES**


1. Simon Monk, “Programming Arduino: Getting Started with Sketches”, Tata McGraw Hill, Second Edition, 2016.
2. Ethan J. Upton, “2 IN 1: Rasberry Pi Master Series: Beginners Guide + Projects Workbook”, Amazon Digital Services, 2019.
3. Jeremy Blum, “Exploring Arduino: Tools and Techniques for Engineering Wizardry”, Wiley, Second Edition, 2019.
4. Simon Monk, “Raspberry Pi Cookbook: Software and Hardware Problems & Solutions”, O’Reilly, Third Edition, 2019.


| **U19IC505** | **INDUSTRIAL AUTOMATION USING PLC** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **0** | **0** | **2** | **1** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Utilize concepts to develop ladder logic for Industrial applications. | K3 |
| CO2 | **(Apply)** Develop HMI screens and interface with PLC. | K3 |
| CO3 | **(Apply)** Apply the concepts to control the speed of Induction motor using PLC. | K3 |

**MODULE – I INTRODUCTION TO PLC PROGRAMMING** **10**

**Theory:**

Basics of PLC- Architecture – Types – Hardware details.

**Practical:**

1.3 Introduction to Ladder logic

1.4 NO/NC Operation

1.5 Timers and Counters

1.6 Arithmetic, Logical and Data transfer instructions

**Minor Project:**

Design a ladder logic for the given application.

**MODULE – II INTERFACING OF PLC WITH HMI** **10**

**Theory:**

Introduction to HMI - Hardware- Types.

**Practical:**

2.1 Interfacing HMI with PLC

2.2 Text display and Bitwise operations

2.3 Numerical input and output

2.4 Alarm and script writing

**Minor Project:**

Design the HMI screens for a given application.

**MODULE – III INTERFACING OF PLC WITH DRIVES** **10**

**Theory:**

Introduction to Variable Frequency Drives – Hardware- Type.

**Practical:**

3.1 Power wiring and Control Wiring

3.2 Parameter settings

3.3 Analog and Digital I/O for drives

3.4 Speed control of Induction Motor

**Minor Project:**

Design the speed control scheme for a specific motor.

**Total: 30 Hours**

**TEXT BOOK**

1. Bolton W, “Programmable logic controllers”, Elsevier, Fifth Edition, 2009.

**REFERENCES**

1. Frank D. Petruzella, “Programmable Logic Controllers”, Tata McGraw-Hill, 2016.
2. John R. Hackworth, Fredrick D. Hackworth, “Programmable Logic Controllers: Programming Methods and Applications”, Pearson Education, Fourth Edition, 2008.
3. Mitsubishi Electric India PLC, SERVO, VFD & ROBOTICS Programming Manuals.

| U19IC506 | INDUSTRIAL ROBOTICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 1 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the functional elements of robotics and principles of direct and inverse kinematics. | K2 |
| CO2 | **(Understand)** Summarize the operation of control modules and manipulators. | K2 |
| CO3 | **(Apply)** Make use of the concepts for the controls of manipulators. | K2 |

**MODULE – I BASIC CONCEPTS AND DIRECT & INVERSE KINEMATICS** **10**

Brief history – Types of Robot – Technology – Robot classifications and specifications – Design and Control issues – Various manipulators – Sensors – work cell – Programming languages.

Mathematical representation of Robots – Position and orientation – Homogeneous transformation - Degrees of freedom – Direct Kinematics – Inverse kinematics

**MODULE – II MANIPULATOR DIFFERENTIAL MOTION AND STATICS** **10**

Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity. Definition - Joint space technique - Use of p-degree polynomial - Cubic polynomial - Cartesian space technique

**MODULE – III DYNAMICS AND CONTROL** **10**

Lagrangian mechanics – 2DOF Manipulator-Lagrange Euler formulation – Dynamic model – Linear control schemes – PID control scheme.

**Total: 30 Hours**

**TEXT BOOK**

1. Mittal R. K., Nagrath I. J., “Robotics and Control”, Tata McGraw Hill, Sixth Reprint, 2007.

**REFERENCES**

1. John J. Craig, “Introduction to Robotics Mechanics and Control”, Pearson Education, Third Edition, 2009.
2. Groover M. P, Weiss M, Nagel R.N, Odrey N.G, “Industrial Robotics: Technology, Programming and Applications”, Tata McGraw-Hill, Third Reprint, 2008.
3. Ashitava Ghoshal, “Robotics: Fundamental Concepts and Analysis”, Oxford University Press, Sixth Edition, 2010.

**PROFESSIONAL ELECTIVE – I**

| U19EE501 | ENERGY AUDITING AND MANAGEMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the basic of industrial energy audits, objectives, methodology and outcomes. | K2 |
| CO2 | **(Apply)** Identify energy consumption pattern of various electrical utilities. | K3 |
| CO3 | **(Apply)** Explain possible auditing methods in electric fans, motors and blower along with energy conservation measures. | K3 |
| CO4 | **(Apply)** Identify energy consumption pattern of various thermal utility system. | K3 |
| CO5 | **(Analyse)** Analyse practice calculation methods to prepare viable energy conservation proposals using project and financial management. | K4 |

**MODULE – I INTRODUCTION TO ENERGY AUDITING** **9**

Classification of Energy - Energy Scenario - Energy Needs of Growing Economy - Energy Pricing in India – Energy and Environment - Energy Conservation Act - Role of energy managers and auditors-Energy Auditing Types, objectives and Methodology -Audit instruments.

**MODULE – II ENERGY AUDIT IN ELECTRICAL UTILITIES** **9**

Electric Power Supply Systems - Electricity Billing – Electrical Load Management and Maximum Demand Control- Power factor improvement and its benefit - Factors involved in determination of motor efficiency- Energy efficient motors-Lightning-Energy efficient light sources-Energy Conservation in Lighting schemes.

**MODULE – III FANS, BLOWERS AND PUMPS** **9**

Fan Types - Blower Types- Fan Performance evaluation- Fan Laws- Flow control strategies- Pumps- Types – Factors affecting pump performance- System characteristics- Efficient Pumping system operation- Flow Control Strategies- Energy conservation opportunities in pumping systems

**MODULE – IV ENERGY AUDIT IN THERMAL UTILITIES** **9**

Steam – Introduction, Properties of steam, Steam distribution systems - Boilers- Types and Classification- Performance Evaluation of Boilers – Boiler Efficiency- Direct and Indirect methods – Energy Conservation opportunities in boilers-Principle of cogeneration – Technical options for cogeneration- Waste heat recovery - Classification and benefits.

**MODULE – V PROJECT AND FINANCIAL MANAGEMENT** **9**

Financial analysis techniques-Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis; Financing options, Energy performance contracting and role of ESCOs.

**Total: 45 Hours**

**TEXT BOOKS**


1. Bureau & Energy Efficiency, "Energy Efficiency in Electrical Utilities", Guide Book for National Certification Examination for Energy Managers and Energy Auditors, 2013. (www.bee - india.nic.in)


**REFERENCES**


2. Hamies, "Energy Auditing and Conservation; Methods, Measurements, Management & Case Study", Hemisphere, Washington, 1980.
3. Larry C Witte et. al, "Industrial Energy Management & Utilization". Springer Publication, First Edition, 1990.
4. Eastop T.D and Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical publications,1990.
5. Reay D.A, "Industrial Energy Conservation", Pergamon Press, First Edition, 1977.

| U19EE502 | POWER SYSTEM TRANSIENTS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course- the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Realize the generation of switching transients and analyze its effects. | K2 |
| CO2 | **(Analyse)** Analyze the switching transient origins and design proper protective techniques | K4 |
| CO3 | **(Understand)** Explain the mechanism of lightning strokes and design protection system for transmission line and tower. | K3 |
| CO4 | **(Apply)** Identify the propagation, reflection and refraction of travelling waves and design to suitable filters to suppress the surge waves. | K3 |
| CO5 | **(Analyse)** Analyze the impact of transient in integrated power system. | K4 |

**MODULE – I INTRODUCTION** **9**

Review and importance of the study of transients – causes for transients. RL circuit transient with sine wave excitation – double frequency transients – basic transforms of the RLC circuit transients. Different types of power system transients – effect of transients on power systems – role of the study of transients in system planning.

**MODULE – II SWITCHING TRANSIENTS** **9**

Over voltages due to switching transients – resistance switching and the equivalent circuit for interrupting the resistor current – load switching and equivalent circuit – waveforms for transient voltage across the load and the switch – normal and abnormal switching transients. Current suppression – current chopping – effective equivalent circuit. Capacitance switching – effect of source regulation – capacitance switching with a restrike, with multiple restrikes. Illustration for multiple restriking transients – ferro resonance.

**MODULE – III LIGHTNING TRANSIENTS** **9**

Review of the theories in the formation of clouds and charge formation – rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke – factors contributing to good line design – protection using ground wires – tower footing resistance – Interaction between lightning and power system.

**MODULE – IV COMPUTATION OF TRANSIENTS** **9**

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling waves.

**MODULE – V TRANSIENTS IN INTEGRATED POWER SYSTEMS** **9**

The short line and kilometric fault - distribution of voltages in a power system - Line dropping and load rejection - voltage transients on closing and reclosing lines - over voltage induced by faults -switching surges on integrated system Qualitative application of EMTP for transient computation.

**Total: 45 Hours**

**TEXT BOOKS**


1. Allan Greenwood, "Electrical Transients in Power Systems", Wiley Inter Science, Second Edition, 1991.
2. Indulkar C.S, Kothari D.P, Ramalingam K, "Power System Transients: A statistical approach", PHI Learning Private Limited, Second Edition, 2010.


**REFERENCES**


1. Naidu M.S and Kamaraju V, "High Voltage Engineering", McGraw Hill Education, Fifth Edition, 2013.
2. Begamudre R.D, "Extra High Voltage AC Transmission Engineering", Wiley Eastern Limited, 1986.
3. James L. Kirtley, "Electric Power Principles: Sources, Conversion, Distribution and use", John Wiley, First Edition, 2020.

| U19EE511 | DESIGN OF ELECTRICAL MACHINES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

After completion of this course, the students will be able to

**Outcomes**

| | | |
|---|---|---|
| CO1 | **(Understand)** Classify and select proper materials for different parts and study the mmf calculation of various electrical machines | K2 |
| CO2 | **(Apply)** Illustrate the design concept of Armature and field system of DC machine | K3 |
| CO3 | **(Apply)** Creatively apply knowledge to design core, yoke, windings and cooling systems of transformers. | K3 |
| CO4 | **(Apply)** Construct the design of stator and rotor of induction machines | K3 |
| CO5 | **(Apply)** Demonstrate the design concept of Armature and field system of Synchronous machine | K3 |

**MODULE – I PRINCIPLES OF ELECTRICAL MACHINE DESIGN** **9**

General design considerations - Major considerations in Electrical Machine Design - Electrical Engineering Materials – Space factor – Magnetic circuit calculation - calculation of field ampere turns - air gap mmf - effect of slot and ventilating duct - active iron length - mmf for teeth - real and apparent flux densities. Various Leakage Flux. - Specific Electrical and Magnetic loadings- Choice of Specific Electrical and Magnetic loadings - - Rating of machines – Standard Specifications.

**MODULE – II DESIGN OF DC MACHINE** **9**

Output Equations – Main Dimensions - Choice of specific loadings – Selection of number of poles – Design of Armature – choice of armature windings. Design of commutator and brushes – design of field. Performance prediction using design values.

**MODULE – III DESIGN OF TRANSFORMER** **9**

Output Equations – Main Dimensions - KVA output for single and three phase transformers – Window space factor – Overall dimensions – Operating characteristics – Regulation – No load current – Temperature rise in Transformers – Design of Tank - Methods of cooling of Transformers.

**MODULE – IV DESIGN OF INDUCTION MOTOR** **9**

Output equation of Induction motor – Main dimensions – Length of air gap- Rules for selecting rotor slots of squirrel cage machines – Design of rotor bars & slots – Design of end rings – Design of wound rotor - Magnetizing current - Short circuit current – Circle diagram - Operating characteristics.

**MODULE – V DESIGN OF SYNCHRONOUS MACHINE** **9**

Output equations – choice of loadings – Design of salient pole machines – Short circuit ratio – shape of pole face – Armature design – Armature parameters – Estimation of air gap length – Design of rotor – Design of damper winding – Determination of full load field mmf – Design of field winding – Design of turbo alternators – Rotor design.

**Total: 45 Hours**

**TEXT BOOKS**


1. Sawhney, A.K., “A Course in Electrical Machine Design”, Dhanpat Rai & Sons, Sixth Edition, 2010.


**REFERENCES**


2. Sen, S.K., “Principles of Electrical Machine Designs with Computer Programs”, Oxford and IBH Publishing Co. Pvt. Ltd., Second Edition, 2009.
3. Deshpande M.V, “Design and Testing of Electrical Machines”, PHI learning Pvt Ltd., 2011.
4. Balbir Singh, “Electrical Machine Design”, Vikas Publishing House Private Limited, Third Edition, 1982.
5. Shanmugasundaram A, Gangadharan G, Palani R, “Electrical Machine Design Data Book”, New Age International Publishers, Reprint, 2011.
6. Agarwal R.K, “Principles of Electrical Machine Design”, S.K. Kataria & Sons, 2009.

| U19EE512 | ELECTRICAL MACHINE ANALYSIS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the principles and concepts of electromagnetic energy conversion methods | K2 |
| CO2 | **(Understand)** Outline the analysis of DC Machines and its dynamic characteristics | K2 |
| CO3 | **(Understand)** Summarize the concepts of Reference Frame Theory and transformation relationships | K2 |
| CO4 | **(Understand)** Illustrate the equivalent circuit and analysis of Induction Machines | K2 |
| CO5 | **(Understand)** Determine the steady state analysis and voltage and torque equation of synchronous machines | K2 |

**MODULE – I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION** **9**

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf - winding inductances and voltage equations

**MODULE – II DC MACHINES** **9**

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt d.c. motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation

**MODULE – III REFERENCE FRAME THEORY** **9**

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference

**MODULE – IV INDUCTION MACHINE** **9**

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics-voltage and torque equations in machine variables and arbitrary reference frame variables

**MODULE – V SYNCHRONOUS MACHINES** **9**

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations)- Generalized theory of rotating
electrical machine and Krons primitive machine.

**Total: 45 Hours**

**TEXT BOOKS**


1. Paul Krause, Oleg Wasyzczuk, Scott Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley & Sons, Third Edition, 2013.


**REFERENCES**


1. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
2. Fitzgerald A.E, Charles Kingsley, Stephan D. Umans, "Electric Machinery", Tata McGraw Hill, Eighteenth Reprint, 2009.
3. R. Krishnan, "Electric Motor and Drives: Modeling, Analysis and Control", Prentice Hall of India, 2001.


| U19EE521 | NON-CONVENTIONAL ENERGY SOURCES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the importance of renewable energy sources | K2 |
| CO2 | **(Understand)** Describe the process of wind energy conversion system | K2 |
| CO3 | **(Understand)** Outline the techniques of Solar PV and Solar Thermal conversion system | K2 |

| | | | |
|---|---|---|---|
| | CO4 | **(Understand)** Illustrate the process of energy conversion from Bio-Mass and Hydro Systems | K2 |
| | CO5 | **(Understand)** Summarize the concepts of energy conversion from tide, OTEC, Hydrogen Production, Fuel Cells and Energy storage systems | K2 |

**MODULE – I RENEWABLE ENERGY SOURCES 9**

Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources.

**MODULE – II WIND ENERGY 9**

Power in the Wind – Types of Wind Power Plants (WPPs) – Components of WPPs – Working of WPPs – Siting of WPPs – Grid integration issues of WPPs.

**MODULE – III SOLAR PV AND THERMAL SYSTEMS 9**

Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds – Thermal Energy storage system with PCM – Solar Photovoltaic systems: Basic Principle of SPV conversion – Types of PV Systems – Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array, PV Module I-V Characteristics, Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking, Applications.

**MODULE – IV BIOMASS ENERGY AND HYDRO ENERGY 9**

Introduction – Bio mass resources – Energy from Bio mass: conversion processes – Biomass Cogeneration – Environmental Benefits. Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Mini/micro hydro power: Classification of hydropower schemes, Classification of water turbine, Turbine theory, Essential components of hydroelectric system.

**MODULE – V OTHER RENEWABLE ENERGY SOURCES 9**

Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC)- Hydrogen Production and Storage- Fuel cell: Principle of working – various types – construction and applications. Energy Storage System – Hybrid Energy Systems

**Total: 45 Hours**

**TEXT BOOKS**


1. Kothari D. P, Singal K. C, Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”, PHI Learning Pvt. Ltd., Second Edition, 2011.
2. Rai G. D, “Non-Conventional Energy Sources”, Khanna Publishers, Fourth Edition, 2009.


**REFERENCES**


1. Mukerjee A. K. and Nivedita Thakur, “Photovoltaic Systems:Analysis and Design”, PHI Learning, 2011.
2. Chetan Singh Solanki, “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning Pvt. Ltd., Third Edition, 2015.
3. Godfrey Boyle, “Renewable energy”, Oxford University Press in association with the Open University, 2004.
4. Shobh Nath Singh, “Non-conventional Energy resources”, Pearson, 2015.


**U19EE522 SOLAR AND WIND ENERGY CONVERSION SYSTEMS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Describe the functions of solar cells | K2 |
| CO2 | **(Understand)** Outline the characteristics and performance of photovoltaic (PV) modules | K2 |
| CO3 | **(Understand)** Explain the manufacturing and design process of PV system | K2 |
| CO4 | **(Understand)** Illustrate the concepts of wind energy conversion systems (WECS) and its design | K2 |
| CO5 | **(Understand)** Discuss the different applications of wind energy | K2 |

**MODULE – I SOLAR CELL FUNDAMENTALS** **9**

Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure.

**MODULE – II PV MODULE PERFORMANCE** **9**

V - I characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature.

**MODULE – III MANUFACTURING OF PV CELLS & DESIGN OF PV SYSTEMS** **9**

Commercial solar cells - Production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells. Design of solar PV systems and cost estimation. Case study of design of solar PV lantern, stand alone PV system - Home lighting and other appliances, solar water pumping systems.

**MODULE – IV WIND ENERGY CONVERSION SYSTEM AND DESIGN** **9**

Wind energy conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics. Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and combine theory; Rotor characteristics; Maximum power coefficient; Prandlt's tip loss Correction

**MODULE – V WIND ENERGY APPLICATION** **9**

Wind pumps: Performance analysis, design concept and testing; Principle of WEG; Stand alone, grid connected and hybrid applications of WECS; Economics of wind energy. Utilization; Wind energy in India; Case studies.

**Total: 45 Hours**

**TEXT BOOKS**


1. Sukhatme, S.P., "Solar Energy", Tata McGraw Hill, Fourth Edition, 2017.
2. Tony Burton, Nick Jenkins, David Sharpe, Ervin Bossanyi, "Wind Energy Handbook", John Wiley & Sons, Second Edition, 2011.


**REFERENCES**


1. Frank Krieth, John F Kreider, "Principles of Solar Energy", John Wiley, New York.
2. Yogi Goswami D, Frank Kreith and Jan F. Kreider, "Principles of Solar Engineering", Taylor and Francis, Second Edition, 1999.
3. Freris L.L., "Wind Energy Conversion Systems", Prentice Hall, 1990.


| **U19EE531** | **ADVANCED CONTROL SYSTEMS** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the concepts of state variable analysis and design in control systems. | K2 |
| CO2 | **(Understand)** Identify the non-linear system analysis in control systems. | K2 |
| CO3 | **(Understand)** Review phase plane and describing function analysis in control systems. | K2 |
| CO4 | **(Apply)** Examine the different Liapunov stability analysis techniques. | K3 |
| CO5 | **(Apply)** Determine the Optimal control techniques used in control systems. | K3 |

**MODULE – I STATE VARIABLE ANALYSIS AND DESIGN** **9**

Introduction, Concept of State, State Variables and State Model, State Models for Linear Continuous – Time Systems, State Variables and Linear Discrete – Time Systems - Diagonalization, Solution of State Equations, Concepts of Controllability and Observability.

**MODULE – II NON-LINEAR SYSTEMS ANALYSIS** **9**

Introduction, Common Nonlinear System Behaviours, Common Nonlinearities in Control Systems, Fundamentals, Describing Functions of Common Nonlinearities, Stability Analysis by Describing Function Method, Concept of Phase Plane Analysis, Construction of Phase Portraits, System Analysis on the Phase Plane.

**MODULE – III PHASE PLANE AND DESCRIBING FUNCTION ANALYSIS 9**

Construction of phase trajectory – Isocline method – Direct or numerical integration – Describing function definition – Computation of amplitude and frequency of oscillation.

**MODULE – IV LIAPUNOV STABILITY ANALYSIS 9**

Stability of Equilibrium State in the Sense of Liapunov; Graphical Representation of Stability; Asymptotic Stability and Instability; Sign-Definiteness of Scalar Function; Second Method of Liapunov; Stability Analysis of Linear Systems; Krasovski's Theorem; Liapunov Function Based on Variable Gradient Method.

**MODULE – V OPTIMAL CONTROL 9**

Formulation of optimal control problem. Minimum time, Minimum energy, minimum fuel problems. State regulator problem. Output regulator problem. Tracking problem, Continuous-Time Linear Regulators.

**Total: 45 Hours**

**TEXT BOOKS**

1. Nagrath I.J, Gopal M, "Control Systems Engineering", New Academic Science, Second Edition, 2020.

**REFERENCES**


1. Gopal M, "Control Systems: Principles and Design", Tata McGraw Hill, Second Edition, 2002.
2. John E. Gibson, "Non-linear Automatic Control", Tata McGraw Hill, 1963.
3. Kuo B.C, "Automatic Control Systems", Prentice Hall, Seventh Edition, 1997.
4. Hasan K. Khalil, "Non-linear systems", Prentice Hall, 2002.


**U19EE532 ADVANCED MICROPROCESSORS AND MICROCONTROLLERS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the ARM registers, instruction pipeline, interrupts and architectures. | K2 |
| CO2 | **(Understand)** Outline the instructions, addressing modes and conditional instructions. | K2 |
| CO3 | **(Understand)** Describe the thumb instructions and software interrupt instructions. | K2 |
| CO4 | **(Apply)** Experiment with C programming to control ARM processors. | K3 |
| CO5 | **(Analyse)** Discuss cache architecture, polices, flushing, MMU, page tables, translational, and access permissions. | K2 |

**MODULE – I ARM ARCHITECTURE 9**

ARM Design Philosophy, Registers, Program Status Register, Instruction Pipeline, Interrupts and Vector Table, Architecture Revision, ARM Processor Families.

**MODULE – II ARM PROGRAMMING MODEL – I 9**

Instruction Set: Data Processing Instructions, Addressing Modes, Branch, Load, Store Instructions, PSR Instructions, Conditional Instructions.

**MODULE – III ARM PROGRAMMING MODEL – II 9**

Thumb Instruction Set: Register Usage, Other Branch Instructions, Data Processing Instructions, Single-Register and Multi Register Load-Store Instructions, Stack, Software Interrupt Instructions

**MODULE – IV ARM PROGRAMMING 9**

Simple C Programs using Function Calls, Pointers, Structures, Integer and Floating Point Arithmetic, Assembly Code using Instruction Scheduling, Register Allocation, Conditional Execution and Loops.

**MODULE – V MEMORY MANAGEMENT 9**

Cache Architecture, Polices, Flushing and Caches, MMU, Page Tables, Translation, Access Permissions, Context Switch.

**Total: 45 Hours**

**TEXT BOOKS**

1. Andrew N.Sloss, Dominic Symes and Chris Wright, " ARM System Developer's Guide : Designing and Optimizing System Software", Morgan Kaufmann Publishers, First edition, 2004.
2. Daniel Tabak, "Advanced Microprocessors", Mc Graw Hill, 1995

**REFERENCES**

1. Jochen Steve Furber, "ARM System-on-Chip Architecture", Addison Wesley Trade Computer Publications, Second Edition, 2000.
2. Jonathan W. Valvano, "Embedded Microcomputer Systems: Real Time Interfacing", Cengage Learning, 2011.

**PROFESSIONAL ELECTIVE – II**

| **U19EE503** | **POWER SYSTEM OPERATION AND CONTROL** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Understand the day-to-day operation of electric power system. | K2 |
| CO2 | **(Analyse)** Analyze the control actions to be implemented on the system to meet the minute-to-minute variation of system demand. | K3 |
| CO3 | **(Apply)** Acquire knowledge on real power-frequency interaction and the significance of power system operation and control. | K3 |
| CO4 | **(Understand)** Understand the reactive power-voltage interaction. | K2 |
| CO5 | **(Apply)** Design SCADA and its application for real time operation. | K3 |

**MODULE – I INTRODUCTION** **9**

An overview of power system operation and control – system load variation – load characteristics – load curves and load-duration curve – load factor – diversity factor – Importance of load forecasting and quadratic and exponential curve fitting techniques of forecasting – plant level and system level controls.

**MODULE – II REAL POWER – FREQUENCY CONTROL** **9**

Load Frequency Control (LFC) of single area system-static and dynamic analysis of uncontrolled and controlled cases – LFC of two area system – tie line modeling – block diagram representation of two area system – static and dynamic analysis – tie line with frequency bias control – state variability model – integration of economic dispatch control with LFC.

**MODULE – III REACTIVE POWER – VOLTAGE CONTROL** **9**

Generation and absorption of reactive power – basics of reactive power control – excitation systems – modeling – static and dynamic analysis – stability compensation – methods of voltage control: tapchanging transformer, SVC (TCR + TSC) and STATCOM – secondary voltage control.

**MODULE – IV UNIT COMMITMENT AND ECONOMIC DISPATCH** **9**

Formulation of economic dispatch problem – I/O cost characterization – incremental cost curve – coordination equations without and with loss (No derivation of loss coefficients) – solution by direct method and λ-iteration method – statement of unit commitment problem – priority-list method – forward dynamic programming.

**MODULE – V Computer Control of Power Systems** **9**

Need of computer control of power systems – concept of energy control centers and functions – PMU – system monitoring, data acquisition and controls – System hardware configurations – SCADA and EMS functions – state estimation problem – measurements and errors – weighted least square estimation – various operating states – state transition diagram.

**Total: 45 Hours**

**TEXT BOOKS**

1. Olle.I.Elgerd, "Electric Energy Systems theory: An introduction", Tata McGraw Hill, 1983.

2. Allen. J. Wood and Bruce F. Wollen berg, “Power Generation, Operation and Control”, John Wiley and Sons, Second Edition, 2005.
3. Abhijit Chakrabarti and Sunita Halder, “Power System Analysis Operation and Control”, PHI learning Pvt. Ltd., New Delhi, Third Edition, 2010.

**REFERENCES**

1. Kothari D.P. and Nagrath I.J, “Power System Engineering”, Tata McGraw Hill, Second Edition, 2008.
2. Hadi Saadat, "Power System Analysis", Tata McGraw Hill, Reprint, Third Edition, 2004.
3. Kundur P, “Power System Stability and Control”, Tata McGraw Hill, Tenth Reprint, 2010.

| **U19EE504** | **HIGH VOLTAGE ENGINEERING** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Realize the causes of over voltage and its protection methods used in Power System | K2 |
| CO2 | **(Understand)** Illustrate the Breakdown mechanism in solid, liquid and gaseous dielectrics. | K2 |
| CO3 | **(Apply)** Identify the suitable methods for generating High Voltage in Laboratory. | K3 |
| CO4 | **(Apply)** Classify the high voltage measurement techniques. | K3 |
| CO5 | **(Analyse)** Summarize the different High Voltage testing methods applied on Electrical apparatus | K4 |

**MODULE – I OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS 9**

Causes of over voltages and its effects on power system – Lightning, switching surges and temporary over voltages, Corona and its effects – Protection against over voltages-Surge Protective Devices (SPD).

**MODULE – II DIELECTRIC BREAKDOWN 9**

Properties of Dielectric materials - Gaseous breakdown in uniform and non-uniform fields – Corona discharges – Vacuum breakdown – Conduction and breakdown in pure and commercial liquids, Maintenance of oil Quality – Breakdown mechanisms in solid and composite dielectrics- Applications of insulating materials in electrical equipments.

**MODULE – III GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS 9**

Generation of High DC voltage: Rectifiers, voltage multipliers, van de graaff generator – Generation of high impulse voltage: single and multistage Marx circuits – Generation of high AC voltages: cascaded transformers, resonant transformer and tesla coil – Generation of switching surges – Generation of impulse currents – Triggering and control of impulse generators.

**MODULE – IV MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS 9**

High Resistance with series ammeter – Dividers, Resistance, Capacitance and Mixed dividers – Peak Voltmeter, Generating Voltmeters – Capacitance Voltage Transformers, Electrostatic Voltmeters – Sphere Gaps – High current shunts – Digital techniques in high voltage measurement.

**MODULE – V HIGH VOLTAGE TESTING OF ELECTRICAL APPARATUS 9**

High voltage testing of electrical power apparatus as per International and Indian standards – Power frequency, impulse voltage and DC testing of Insulators, circuit breakers, bushing, isolators and transformers.

**Total: 45 Hours**

**TEXT BOOKS**

1. Naidu S, Kamaraju V, “High Voltage Engineering”, Tata McGraw Hill, Fifth Edition, 2013.
2. Kuffel E, Zaengl W.S, Kuffel J, “High Voltage Engineering: Fundamentals”, Newnes, Second Edition, 2005.
3. Wadhwa C.L, “High voltage Engineering”, New Age International Publishers, Third Edition, 2010.

**REFERENCES**

1. Alston L.L, “High Voltage Technology”, Oxford University Press, First Edition, 2011.
2. Mazen Abdel-Salam, Hussein Anis, Ahdab A-Morshedy, Roshday Radwan, “High Voltage Engineering: Theory & Practice, Marcel Dekker, Second Edition, 2010.
3. Subir Ray, “An Introduction to High Voltage Engineering”, PHI Learning, Second Edition, 2013.

| U19EE513 | ADVANCED POWER SEMICONDUCTOR DEVICES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Apply)** Select power semiconductor device structures for adjustable speed motor control applications. | K3 |
| CO2 | **(Understand)** Illustrate the static and dynamic characteristics of current controlled power semiconductor devices. | K2 |
| CO3 | **(Understand)** Illustrate the the static and dynamic characteristics of voltage controlled power semiconductor devices. | K2 |
| CO4 | **(Apply)** Select devices for different power electronics applications. | K3 |
| CO5 | **(Understand)** Explain the control and firing circuit for different devices. | K2 |

**MODULE – I INTRODUCTION** **9**

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.

**MODULE – II CURRENT CONTROLLED DEVICES** **9**

BJT's – Construction, static characteristics, switching characteristics; Negative temperature coefficient and secondary breakdown; Power darlington - Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching – Gate and switching characteristics - converter grade and inverter grade and other types – series and parallel operation – comparison of BJT and Thyristor – steady state and dynamic models of BJT & Thyristor.

**MODULE – III VOLTAGE CONTROLLED DEVICES** **9**

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, FCT, RCT and IGCT.

**MODULE – IV FIRING AND PROTECTING CIRCUITS** **9**

Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers.

**MODULE – V THERMAL PROTECTION** **9**

Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance –Electrical analogy of thermal components, heat sink types and design – Mounting types.

**Total: 45 Hours**

**TEXT BOOKS**


1. Muhammad H. Rashid, "Power Electronics Circuits: Devices and Applications", Pearson, Third Edition, 2004.


**REFERENCES**


1. Williams B.W, "Power Electronics: Devices, Drivers and Applications", Macmillan, 1987.
2. Singh M. D. and Khanchandani K. B., "Power Electronics", Tata McGraw Hill, 2013.
3. Ned Mohan, Tore. M. Undeland, William. P. Robbins, "Power Electronics: Converters, Applications and Design", John Wiley India, Third Edition Reprint, 2009.


| U19EE514 | MODERN POWER CONVERTERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Realize the working of Switched Mode Power Supplies | K2 |
| CO2 | **(Understand)** Illustrate the perform and working of DC-AC Converters | K2 |

| | | | |
|---|---|---|---|
| | CO3 | **(Analyze)** Identify the suitable methods for choosing the inverter | K4 |
| | CO4 | **(Apply)** Classify the different types and application of AC-AC converters | K3 |
| | CO5 | **(Analyse)** Summarize the different soft switching techinques used in Modern Power converters | K4 |

**MODULE – I SWITCHED MODE POWER SUPPLIES (SMPS) 9**

DC Power supplies and Classification; Switched mode dc power supplies - with and without isolation, single and multiple outputs; Closed loop control and regulation; Design examples on converter and closed loop performance.

**MODULE – II AC-DC CONVERTERS 9**

Switched mode AC-DC converters. synchronous rectification - single and three phase topologies - switching techniques - high input power factor. reduced input current harmonic distortion. improved efficiency. with and without input-output isolation. performance indices design examples.

**MODULE – III DC-AC CONVERTERS 9**

Multi-level Inversion - concept, classification of multilevel inverters, Principle of operation, main features and analysis of Diode clamped, Flying capacitor and cascaded multilevel inverters; Modulation schemes.

**MODULE – IV AC-AC CONVERTERS WITH AND WITHOUT DC LINK 9**

Matrix converters. Basic topology of matrix converter; Commutation – current path; Modulation techniques - scalar modulation, indirect modulation; Matrix converter as only AC-DC converter; AC-AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter; Performance comparison with matrix converter with DC link converters.

**MODULE – V SOFT-SWITCHING POWER CONVERTERS 9**

Soft switching techniques. ZVS, ZCS, quasi resonance operation; Performance comparison hard switched and soft switched converters.AC-DC converter, DC-DC converter, DC-AC converter.; Resonant DC power supplies.

**Total:45 Hours**

**TEXT BOOKS**


1. Muhammad H. Rashid, “Power Electronics Handbook”, Academic press, Second Edition, 2007.
2. Fang Lin Luo and Fang Lin Luo, “Advanced DC/DC Converters”, CRC Press, 2004


**REFERENCES**


1. Issa Batarseh, “Power Electronic Circuits”, John Wiley and Sons, 2004.
2. Frede Blaabjerg and Zhe Chen, Morgan, “Power Electronics for Modern Wind Turbines, Claypool Publishers series, 2006.
3. Philip T. Krein, “Elements of Power Electronics”, Oxford University Press, Second Edition, 2015.
4. Agarwal, “Power Electronics: Converters, Applications and Design, Prentice Hall, Third Edition, 2000.
5. Umanand L, “Power Electronics: Essentials and Applications”, John Wiley and Sons, 2009.


| **U19EE523** | **DESIGN OF SOLAR PHOTOVOLTAIC SYSTEMS** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the fundamentals of Solar PV Systems | K2 |
| CO2 | **(Understand)** Outline the Components of Solar PV systems | K2 |
| CO3 | **(Apply)** Apply the concepts to model a Stand Alone PV System | K3 |
| CO4 | **(Apply)** Utilize the concepts to design a Grid connected PV System | K3 |
| CO5 | **(Understand)** Explain the Installation and Maintenance techniques of a Solar PV System | K2 |

**MODULE – I INTRODUCTION TO SOLAR PV SYSTEMS 9**

Introduction to Solar Radiation: Optimum orientation of Solar PV modules – Solar related measuring devices. Solar PV Electricity – Introduction of Solar PV Modules – Interconnections of PV Modules.

**MODULE – II COMPONENTS OF SOLAR PV SYSTEMS** **9**

Types of Solar PV systems, Photovoltaic System Components: Introduction to batteries – Charge controller – MPPT – Solar PV inverters – Wires and Cable sizing – Junction Boxes – Combiner Boxes – Fuses

**MODULE – III STAND – ALONE PV SYSTEM** **9**

Preparation of Load Chart – Solar Array Sizing – Battery Bank Sizing – Charge Controller Selection – Inverter Selection

**MODULE – IV GRID – CONNECTED PV SYSTEM** **9**

Assessment of Site condition – Estimation of Annual energy usage – average solar radiation of the site – Required demand – Inverter Selection – Solar Array Sizing – Balance of System (BOS) Selection – Net metering

**MODULE – V INSTALLATION, TROUBLESHOOTING AND SAFETY OF PV SYSTEM** **9**

Preparation and General Consideration for Installation – Installation of Array support structure, Modules, Combiner boxes, AC and DC DB's, Inverter – Maintenance and troubleshooting Solar PV system – Electrical safety – Mechanical Safety – Safety Precautions for Batteries

**Total: 15 Hours**

**TEXT BOOKS**


1. Solanki C.S, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning, 2015.
2. Rai. G.D, "Solar energy utilization", Khanna publishes, 1993.
3. Wenham S.R, Green M.A, Watt M.E, Corkish R, "Applied Photovoltaics", Earthscan, Third Edition, 2011.


**REFERENCES**


1. McNeils, Frenkel, Desai, "Solar & Wind Energy Technologies", Wiley Eastern, 1990
2. Sukhatme S.P, "Solar Energy", Tata McGraw Hill,1987.
3. Eduardo Lorenzo G. Araujo, "Solar Electricity Engineering of Photovoltaic Systems", Progensa,1994


| **U19EE524** | **DISTRIBUTED GENERATION AND MICROGRID** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the various schemes of conventional and nonconventional power generation. | K2 |
| CO2 | **(Understand)** Illustrate the topologies and energy sources of distributed generation. | K2 |
| CO3 | **(Understand)** Outline the requirements for grid interconnection and its impact with NCE sources. | K2 |
| CO4 | **(Understand)** Explain the concepts of power quality management in Smart Grids. | K2 |
| CO5 | **(Understand)** Summarize the fundamental concepts of Microgrid. | K2 |

**MODULE – I INTRODUCTION** **9**

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

**MODULE – II DISTRIBUTED GENERATIONS** **9**

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

**MODULE – III IMPACT OF GRID INTEGRATION** **9**

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

**MODULE – IV BASICS OF A MICROGRID** **9**

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

**MODULE – V CONTROL AND OPERATION OF MICROGRID 9**

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

**Total: 45 Hours**

**TEXT BOOKS**


1. Gharephpetian G.B, Mohammad Mousavi Agah S, "Distributed Generation Systems: Design, Operation and Grid Integration", Butterworth Heinemann, 2017.
2. Chauhan R.K, Chauhan K, "Distributed Energy Resources in Microgrids: Integration, Challenges, Optimization", Academic Press, 2019.


**REFERENCES**


1. Dorin Neacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006.
2. Chetan Singh Solanki, "Solar Photovoltaics", PHI learning Pvt. Ltd., New Delhi,2009.
3. Manwell J.F, McGowan J.G, "Wind Energy Explained, Theory Design and Applications", Wiley publication 2010.
4. Amirnaser Yezdani, Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2010.


| U19EE533 | MICROCONTROLLER BASED SYSTEM DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Outline the architecture of PIC microcontroller | K2 |
| CO2 | **(Understand)** Explain the use of interrupts and timers of PIC microcontroller | K2 |
| CO3 | **(Understand)** Identify the peripheral devices for data communication and transfer | K2 |
| CO4 | **(Understand)** Demonstrate the functional blocks of the ARM processor | K2 |
| CO5 | **(Understand)** Illustrate the architecture of ARM processors | K2 |

**MODULE – I INTRODUCTION TO PIC MICROCONTROLLER 12**

Introduction to PIC Microcontroller–PIC 16C6x and PIC16C7x Architecture–PIC16cxx–- Pipelining - Program Memory considerations – Register File Structure - Instruction Set - Addressing modes – Simple Operations.

**MODULE – II INTERRUPTS AND TIMER 12**

PIC micro controller Interrupts- External Interrupts-Interrupt Programming–Loop time subroutine - Timers-Timer Programming– Front panel I/O-Soft Keys– State machines and key switches– Display of
Constant and Variable strings.

**MODULE – III PERIPHERALS AND INTERFACING 12**

I2C Bus for Peripherals Chip Access – Bus operation – Bus subroutines – Serial EEPROM – Analog to Digital Converter – UART – Baud rate selection – Data handling circuit–Initialization - LCD and keyboard
Interfacing - ADC, DAC, and Sensor Interfacing.

**MODULE – IV INTRODUCTION TO ARM PROCESSOR 12**

ARM Architecture – ARM programmer's model – ARM Development tools- Memory Hierarchy – ARM Assembly Language Programming – Simple Examples – Architectural Support for Operating systems.

**MODULE – V ARM ORGANIZATION 12**

3-Stage Pipeline ARM Organization – 5-Stage Pipeline ARM Organization – ARM Instruction Execution - ARM Implementation – ARM Instruction Set – ARM coprocessor interface – Architectural support for High Level Languages – Embedded ARM Applications.

**Total: 45 Hours**

**TEXT BOOKS**

1. Peatman J.B., “Design with PIC Micro Controllers”, Pearson Education, Third Edition, 2004.
2. Furber S, “ARM System on Chip Architecture”, Addison Wesley trade Computer Publication, 2000.

**REFERENCES**

1. Mazidi M.A, Causey D, McKinlay R, “PIC Microcontroller and Embedded Systems”, Prentice Hall, 2007.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, “ARM Systems Developer’s Guides: Designing & Optimizing System Software”, Elsevier, 2008.

| **U19EE534** | **PLC and SCADA** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Realize the architecture of PLC and different types of I/O devices | K2 |
| CO2 | **(Apply)** Design the HMI screens and I/O functions for the project development | K3 |
| CO3 | **(Apply)** Configure the Variable Frequency Drives for the speed control of Induction Motor | K3 |
| CO4 | **(Apply)** Develop the program for different Pick and Place Applications using Industrial Robot | K3 |
| CO5 | **(Analyse)** Control the PLC, HMI from remote station using SCADA | K4 |

**MODULE – I INTRODUCTION TO PLC** **9**

History and developments in industrial automation - Control elements in industrial automation - Introduction: Basics of PLC, Advantages, Capabilities of PLC, Architecture of PLC, Scan cycle, Types of PLC, Types of sensors and I/O devices, Types of I/O modules, Configuring a PLC – PLC.

**MODULE – II PROGRAMMING OF PLC** **9**

Types of Programming - Ladder Programming – Creating programs using GX Works 2– Configuration of modular PLC and different modules in GX Works 2 platform - Process Control Programs using Relay Ladder Logic - PLC arithmetic functions - Timers and counters – Data transfer, Comparison and Manipulation instructions.

**MODULE – III HMI PROGRAMMING AND INTERFACING** **9**

Necessity and Role in Industrial Automation - New project creation using GT Designer: - Text display – various screen and object creation - Interfacing PLC to HMI- Developing solutions for real time problems.

**MODULE – IV VARIABLE FREQUENCY DRIVES** **9**

Introduction to VFD – Basic v/f concept – Power wiring – Control wiring. Configuration of VFD – Parameter setting — JOG operation – Buffer Memory – Speed Control of Induction Motor.

**MODULE – V SCADA** **9**

Overview – Developer and runtime packages – Architecture – Tools – Tag – Internal & External graphics - Communication Protocols of SCADA.

**Total: 45 Hours**

**TEXT BOOKS**

1. Bolton W, “Programmable Logic Controllers”, Elsevier, 2015.

**REFERENCES**

1. Frank D Petruzella, “Programmable logic controllers”, McGraw Hill, 2016.
2. John R Hackworth and Fredrick D Hackworth Jr., “Programmable Logic Controllers: Programming Methods and Applications”, Pearson Education, 2006.
3. Mitsubishi Electric India PLC, SCADA, SERVO, VFD & ROBOTICS Programming Manuals.

**PROFESSIONAL ELECTIVE – III**

| U19EE505 | HVDC AND EHVAC SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Outline the Basic Concepts of EHV AC and HVDC Transmission Systems | K2 |
| CO2 | **(Understand)** Illustrate basic principle, characteristics of EHVAC Transmission | K2 |
| CO3 | **(Understand)** Explain the need, characteristics and design of Extra high voltage testing | K2 |
| CO4 | **(Understand)** Discuss the concepts of DC link control and HVDC Converters | K2 |
| CO5 | **(Understand)** Describe the concepts of HVDC converters | K2 |

**MODULE – I INTRODUCTION** **9**

Need of EHV transmission, standard transmission voltage, comparison of EHV AC & DC transmission systems and their applications & limitations, surface voltage gradients in conductor, distribution of voltage gradients on sub-conductors, mechanical considerations of transmission lines, modern trends in EHV AC and DC transmission – HVDC and EHVAC lines present in India.

**MODULE – II EHV AC TRANSMISSION** **9**

Corona loss formulas, corona current, audible noise generation and characteristics, corona pulses – their generation and properties, radio interference (RI) effects, over voltage due to switching, ferroresonance, reduction of switching surges on EHV system, principle of half wave transmission.

**MODULE – III EXTRA HIGH VOLTAGE TESTING** **9**

Characteristics and generation of impulse voltage, generation of high AC and DC voltages, measurement of high voltage by sphere gaps and potential dividers. Consideration for Design of EHV Lines: Design factors under steady state limits, EHV line insulation design based upon transient over voltages. Effects of pollution on performance of EHV lines.

**MODULE – IV ANALYSIS OF HVDC CONVERTERS** **9**

Line commutated converter – Analysis of Graetz circuit with and without overlap – Pulse number – Choice of converter configuration – Converter bridge characteristics – Analysis of 12 pulse converters – Analysis of VSC topologies and firing schemes.

**MODULE – V HVDC SYSTEM CONTROL** **9**

Types of dc links, converter station, choice of converter configuration and pulse number, effect of source inductance on operation of converters. Principle of DC link control, converter controls characteristics, firing angle control, current and excitation angle control, power control, starting and stopping of DC link.

**Total: 45 Hours**

**TEXT BOOKS**


1. S. Rao, “HVAC and HVDC Transmission, Engineering and Practice”, Khanna Publisher, 1990.
2. Bimbhra P.S, “Power Electronics”, Khanna Publishers, Fifth Edition, 2012.


**REFERENCES**


1. Begamudre R.D, “Extra High Voltage AC Transmission Engineering”, New Academic Science, 2011
2. Padiyar K.R, “HVDC Power Transmission Systems: Technology and System Reactions” New Academic Science, 2011
3. Naidu M.S, Kamaraju V, “High Voltage Engineering”, Tata McGraw Hill, Fourth Edition, 2009.
4. Philip T. Krein, “Elements of Power Electronics” Oxford University Press, 2016.

| U19EE506 | ELECTRICAL ENERGY UTILIZATION AND CONSERVATION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the laws of Illumination and different lighting systems. | K2 |
| CO2 | **(Understand)** Describe the process of utilization of electric energy in heating and welding. | K2 |
| CO3 | **(Understand)** Illustrate the concepts applicable for Electric traction. | K2 |
| CO4 | **(Understand)** Discuss the domestic utilization of Electric energy. | K2 |
| CO5 | **(Understand)** Describe the concepts of energy conservation and management techniques. | K2 |

**MODULE – I ILLUMINATION** **9**

Importance of lighting – properties of good lighting scheme – laws of illumination – photometry – types of lamps – lighting calculations – basic design of illumination schemes for residential, commercial, street lighting, factory lighting and flood lighting – LED lighting and energy efficient lamps.

**MODULE – II HEATING AND WELDING** **9**

Introduction – advantages of electric heating – modes of heat transfer - methods of electric heating - resistance heating – arc furnaces - induction heating – dielectric heating – electric welding – types – resistance welding – arc welding – power supply for arc welding – radiation welding.

**MODULE – III TRACTION** **9**

Merits of electric traction – Requirements of electric traction system – Supply systems – Mechanics of train movement – Traction motors and control – Braking – Recent trends in electric traction.

**MODULE – IV DOMESTIC UTILIZATION OF ELECTRICAL ENERGY** **9**

Domestic utilization of electrical energy – Induction based appliances, Online and OFF-line UPS, Batteries - Power quality aspects – Nonlinear and domestic loads – Domestic Earthing.

**MODULE – V ELEMENTS OF ENERGY CONSERVATION AND MANAGEMENT** **9**

General energy problem – Sector wise energy consumption – Demand supply gap – Energy conservation method – Scope for energy conservation and its benefits – Energy conservation Principle – Maximum energy efficiency – Maximum cost effectiveness – Energy conservation building codes (ECBC), Energy management concept and objectives – Initializing Planning, Leading, Controlling, Promoting, Monitoring and Reporting.

**Total: 45 Hours**

**TEXT BOOKS**


1. Wadhwa, C.L. “Generation, Distribution and Utilization of Electrical Energy”, New Age International Pvt. Ltd, 2003.


**REFERENCES**


1. Uppal S.L, Rao S, “Electrical Power Systems”, Khanna Publishers, New Delhi, Fifteenth Edition, 2014.
2. Partab H, “Art and Science of Utilisation of Electrical Energy”, Dhanpat Rai and Co, New Delhi, 2004.
3. Gupta J. B., “Utilization of Electric Power and Electric Traction”, S. K. Kataria and Sons, 2002.
4. Openshaw Taylor E, “Utilization of Electrical Energy in SI Units”, Orient Longman Pvt. Ltd, 2003.


| U19EE515 | FLEXIBLE AC TRANSMISSION SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the various FACTS controller for power system application. | K2 |
| CO2 | **(Understand)** Describe the concepts of load compensation techniques. | K2 |
| CO3 | **(Understand)** Discuss FACTS devices and the start-of-art of power system. | K2 |
| CO4 | **(Understand)** Explain the performance of steady state & transients of FACTS controllers. | K2 |
| CO5 | **(Understand)** Explain advanced FACTS controllers. | K2 |

**MODULE – I INTRODUCTION** **9**

Real and reactive power control in electrical power transmission lines–loads & system compensation-Uncompensated transmission line–shunt and series compensation.

**MODULE – II STATIC VAR COMPENSATOR** **9**

Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator – TCR – FC – TCR – Modelling of SVC for power flow and fast transient stability– Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping.

**MODULE – III THYRISTOR CONTROLLED SERIES CAPACITOR AND APPLICATIONS** **9**

Operation of the TCSC – Different modes of operation – Modelling of TCSC, Variability reactance model – Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit – Enhancement of system damping.

**MODULE – IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS** **9**

Static Synchronous Compensator Applications: Steady state power transfer-enhancement of transient stability – Prevention of voltage instability. SSSC – Operation of SSSC and the control of power flow – Modelling of SSSC in load flow and transient stability studies – Dynamic voltage restorer.

**MODULE – V ADVANCED FACTS CONTROLLERS** **9**

Interline DVR – Unified Power flow controller (UPFC) – Interline power flow controller (IPFC) – Unified Power quality conditioner (UPQC).

**Total: 45 Hours**

**TEXT BOOKS**

1. Mohan Mathur R, Rajiv K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, 2002.

**REFERENCES**

1. Narain G. Hingorani, Laszio Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers, 2011.
2. T.J.E Miller, “Reactive Power Control in Electric Systems”, Wiley India, 2010.
3. K.R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International. 2008.

| **U19EE516** | **POWER QUALITY** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand**) Explain the concept of utility distribution and industrial electric power quality phenomena. | K2 |
| CO2 | **(Understand)** Discuss the causes and significances of short and long interruptions and their mitigation techniques. | K2 |
| CO3 | **(Understand)** Outline the concepts of voltage sag and transient phenomena. | K2 |
| CO4 | **(Apply)** Explain the root cause, effects and mitigation of waveform distortion and earthing. | K3 |
| CO5 | **(Understand)** Explain the monitoring equipment’s of power quality, assessments and data interpretation for industrial application | K2 |

**MODULE – I BASICS OF POWER QUALITY** **9**

Definitions – Power quality, Voltage quality – Power quality issues: short duration voltage variations, long duration voltage variations – Flicker, Transients, Waveform distortion, Voltage imbalance, Voltage fluctuation, Power frequency variations – Sources and Effects of power quality problems – IEEE and IEC Standards- Computer Business Equipment Manufacturers Associations (CBEMA) curve – ITC curves.

**MODULE – II STUDY ON INTERRUPTIONS** **9**

**Short Interruptions:** Introduction – Origin of short interruptions: Voltage magnitude events due to re-closing, Voltage during the interruption – Monitoring of short interruptions, Adjustable speed drives, electronic equipment’s – Single phase tripping: Voltage during fault and post fault period, Current during fault period. **Long Interruptions:** Definition – Failure,

Outage, Interruption – Origin of interruptions – Causes of long interruptions – Principles of regulating the voltage – Voltage regulating devices.

**MODULE – III VOLTAGE SAG AND TRANSIENTS** **9**

**Voltage Sag:** Introduction – Definition – Magnitude, Duration – Causes of Voltage Sag – Load influence on voltage sags on Adjustable speed drives, Power electronics loads, Sensitive loads – Unbalance and neutral current issues – Overview of mitigation methods. **Transients:** Definition and types – Sources and causes of transients – Principles of over voltage protection – Devices for over voltage protection – Capacitor switching transients – Lightning transients – Transients from load switching.

**MODULE – IV WIRING, GROUNDING AND WAVEFORM DISTORTION:** **9**

Wiring and Grounding: Definitions-wiring and grounding problems-solutions to wiring and grounding problems. Waveform Distortion: Introduction – Definition and terms – Harmonics, Harmonics indices, Inter harmonics, Notching – Voltage Vs Current distortion – Harmonics Vs Transients – Sources and effects of harmonic distortion – System response characteristics.

**MODULE – V POWER QUALITY MONITORING AND SOLUTIONS** **9**

Introduction – Need for power quality monitoring, Evolution of power quality monitoring – Introduction to power quality measurement equipment's – Mitigation and control techniques – Passive and active Filters for Harmonic Reduction.

**Total: 45 Hours**

**TEXT BOOKS**

1. Dugan Roger C., McGranaghan, Mark F. and Beaty, H. Wayne, "Electrical Power Systems Quality", Third Edition, McGraw-Hill, Reprint 2013.

**REFERENCES**

1. Sankaran C., "Power Quality", CRC Press, First Edition, 2002.
2. Bollen Math H.J., "Understanding Power Quality Problems: Voltage Sags and Interruptions", IEEE Press, First Edition, 2000.
3. Arrillaga J., Watson N.R., and Chen S., "Power System Quality Assessment", John Wiley, First Edition, 2000.

| **U19EE525** | **SMART GRID** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the concepts of Smart Grid and its present developments. | K2 |
| CO2 | **(Understand)** Discuss the concepts of different Smart Grid technologies | K2 |
| CO3 | **(Understand)** Explain about smart meters and advanced metering infrastructure. | K2 |
| CO4 | **(Understand)** Describe power quality management in Smart Grids. | K2 |
| CO5 | **(Understand)** Outline the concepts of LAN, WAN and Cloud Computing for Smart Grid applications. | K2 |

**MODULE – I INTRODUCTION TO SMART GRID** **9**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional and Smart Grid, National and International Initiatives in Smart Grid.

**MODULE – II SMART GRID TECHNOLOGIES** **9**

Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management.

**MODULE – III SMART METERS AND ADVANCED METERING INFRASTRUCTURE** **9**

Introduction to Smart Meters, Advanced Metering infrastructure AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit, Intelligent Electronic Devices (IED).

**MODULE – IV POWER QUALITY MANAGEMENT IN SMART GRID** **9**

Power Quality & EMC issues in Smart Grid, Power Quality issues in smart grid systems, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

**MODULE – V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS** **9**

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

**Total: 45 Hours**

**TEXT BOOKS**

1. Stuart Borlase, "Smart Grid: Infrastructure, Technology and Solutions", CRC Press 2012.

**REFERENCES**

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", John Wiley, 2012.
2. Vehbi C. Gungor, Dilan Sahin, Taskin Kocak, Salih Ergut, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, "Smart Grid Technologies: Communication Technologies and Standards" IEEE Transactions on Industrial Informatics, Vol. 7, No. 4, November 2011.
3. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang "Smart Grid – The New and Improved Power Grid: A Survey", IEEE Transaction on Smart Grids, vol. 14, 2012.

| **U19EE526** | **ELECTRIC VEHICLES AND POWER MANAGEMENT** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the basic Concepts of Electric vehicles. | K2 |
| CO2 | **(Understand)** Outline the concept of Transmission system in Hybrid and Electric vehicle | K2 |
| CO3 | **(Understand)** Describe the concepts of electric drives and its controllers. | K2 |
| CO4 | **(Understand)** Illustrate the basic parameters and the characteristics of batteries. | K2 |
| CO5 | **(Understand)** Explain the basic concepts of Energy management system and charging station. | K2 |

**MODULE – I INTRODUCTION** **9**

Comparisons of EV with internal combustion Engine vehicles- Fundamentals of vehicle mechanics - Basic concept of electric traction: Introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

**MODULE – II ARCHITECTURE OF EV'S AND POWER TRAIN COMPONENTS** **9**

Architecture of EV's and HEV's – Power train components and sizing, Gears, Clutches, Transmission and Brakes- Fundamentals of regenerative braking.

**MODULE – III ELECTRIC PROPULSION UNIT** **9**

Introduction to electric components used in hybrid and electric vehicles - Configuration and control of Induction Motor drives – PMSM drives – BLDC motor drives.

**MODULE – IV BATTERY BASED ENERGY STORAGE SYSTEM** **9**

Introduction to Energy Storage Requirements in and Electric Vehicles – Battery Basics, Different types, Battery Parameters, Battery modelling, Traction Batteries – Battery management system.

**MODULE – V ALTERNATIVE ENERGY STORAGE SYSTEMS** **9**

Fuel cell based energy storage – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors - Hybridization of different energy storage devices.

**Total: 45 Hours**

**TEXT BOOKS**

1. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011.

**REFERENCES**


1. James Larminie, “Electric Vehicle Technology Explained”, John Wiley & Sons, 2003.
2. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals”, CRC Press, 2010.
3. Emadi, A. (Ed.), Miller, J., Ehsani, M., “Vehicular Electric Power Systems” Boca Raton, CRC Press, 2003.
4. Sheldon S. Williamson, “Energy Management Strategies for Electric and Plug – in Hybrid Electric Vehicles”, Springer, 2013.


| U19EE535 | VIRTUAL INSTRUMENTATION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Identify the need of Virtual Instrumentation. | K2 |
| CO2 | **(Understand)** Explain the basic programming techniques used in Virtual Instrumentation. | K2 |
| CO3 | **(Apply)** Apply the concepts of data acquisition basics in instrument interfaces | K3 |
| CO4 | **(Apply)** Examine the graphical programming environment in Virtual Instrumentation. | K3 |
| CO5 | **(Apply)** Utilize the Virtual Instrumentation concepts in analysis tools and simple applications. | K3 |

**MODULE – I REVIEW OF DIGITAL INSTRUMENTATION 9**

Historical perspective, Need of VI, Advantages of VI, Define VI, block diagram & architecture of VI, data flow techniques, graphical programming in data flow, comparison with conventional programming.

**MODULE – II PROGRAMMING TECHNIQUES 9**

VIS & Sub VIS, loops & charts, arrays, clusters, graphs, case & sequence structures, formula modes, local and global variable, string & file input.

**MODULE – III DATA ACQUISITION BASICS AND COMMON INSTRUMENT INTERFACES 9**

ADC, DAC, DIO, Counters & timers, PC Hardware structure, timing, interrupts, DMA, Software and Hardware Installation. Current loop, Rs 232C/Rs 485, GPIB, System basics, interface basics : USB, PCMCIA, VXI, SCXI, PXI etc, networking basics for office & industrial application VISA & IVI, image acquisition & processing, Motion Control.

**MODULE – IV GRAPHICAL PROGRAMMING ENVIRONMENT IN VI 9**

Concepts of graphical programming – Lab-view software – Concept of VIs and sub VIs – Display types – Digital – Analog – Chart – Oscilloscope types – Loops – Case and sequence structures – Types of data – Arrays – Formulate nodes – Local and Global variables – String and file I/O.

**MODULE – V ANALYSIS TOOLS AND SIMPLE APPLICATIONS IN VI 9**

Fourier transform - Power spectrum - Correlation – Windowing and filtering tools – Simple temperature indicator – ON/OFF controller – P-I-D controller - CRO emulation - Simulation of a simple second order system – Generation of HTML page.

**Total: 45 Hours**

**TEXT BOOKS**


1. Gary W. Johnson, G., LabVIEW Graphical Programming, Tata McGraw Hill, 2006.


**REFERENCES**


1. Sokoloft, L., “Basic Concepts of LabVIEW 4, Prentice Hall Inc. 2004.
2. Wells, L.K. and Travis, J., LabVIEW for Everyone, Prentice Hall Inc. 1996.
3. Gupta S., Gupta, J.P., “PC Interfacing for Data Acquisition and Process Control, Instrument Society of America,1988.
4. Gary Johnson, “Labview Graphical Programming”, Tata McGraw Hill, Second Edition, 1997.

| U19EE536 | PROCESS CONTROL AND INSTRUMENTATION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Discuss the importance of different functional elements used in Process control. | K2 |
| CO2 | **(Understand)** Classify the different types of controllers and the final control elements in Process control. | K2 |
| CO3 | **(Apply)** Determine the Process control techniques applied in Temperature measurement. | K3 |
| CO4 | **(Apply)** Apply the Process control techniques for measuring the pressure. | K3 |
| CO5 | **(Apply)** Explain the concepts applied for Flow measurement using Process control. | K3 |

**MODULE – I INTRODUCTION TO PROCESS CONTROL** **9**

Steady state system - Process control - Feedback control - Transient response - Proportional control - Integral control - Block diagram - Parts of control system. Need for control and automation - Steady state and dynamic system - control logic - servo and regulatory - control - block diagrams - control structures.

**MODULE – II CONTROLLERS AND FINAL CONTROL ELEMENTS** **9**

Actual and Ideal controller - Pneumatic controller mechanism of proportional control - Proportional integral (PI) control - Proportional derivative (PD) control - Proportional integral derivative (PID) control. Control valve - Control valve characteristics. Transfer functions of P - On-off - PI - PD - PID control - Motivation for addition of integral and derivative modes - Block diagram of chemical reactor control system.

**MODULE – III TEMPERATURE MEASUREMENT AND CONTROL** **9**

Scales - Expansion thermometers like constant volume gas - Mercury in glass - Bimetallic - Filled system thermometer like pressure spring thermometer - Static accuracy of thermometer - Dip effect in thermometer - Errors in thermometer of liquid and gas filled type like cross ambient effect - Head effect - Methods of compensation - Thermoelectric temperature measurement: Thermo couples - Laws of thermo electricity - Pyrometers: Laws of radiation. Radiation pyrometer - Photo electric pyrometers - Optical pyrometers - Errors in optical pyrometers.

**MODULE – IV PRESSURE MEASUREMENT AND CONTROL** **9**

Liquid column manometer - Enlarged lag manometer - Inclined tube manometer - Ring manometer - Tilting U tube manometer - Bourdon gauge - Bellows - Bellows differential pressure gauge - Vacuum Measurement: Ionization gauge - Pirani vacuum gauge - Thermocouple vacuum gauge - McLeod gauge.

**MODULE – V FLOW MEASUREMENT AND CONTROL** **9**

Head flow meter - Orifice plate - Flow nozzle - Venturi tube - pitot tube - Differential pressure meter - Electric type head flow meter - Bellows type meter - Rotameter - Piston type area meter - Positive displacement meter.

**Total: 45 Hours**

**TEXT BOOKS**


1. Seborg, D.E., Edgar T.F., Mellichamp D.A., “Process Dynamics and Control”, John Wiley, 2004.


**REFERENCES**


1. Johnson D Curtis, “Instrumentation Technology”, Prentice Hall India, Seventh Edition, 2002.
2. Bob Connel, “Process Instrumentation Applications Manual”, Tata McGraw Hill, 1996.
3. Edgar, T.F. & D.M. Himmelblau, “Optimization of Chemical Processes”, Tata McGraw Hill, 1988.
4. Shinskey, F.G., “Process Control Systems: Applications, Design and Tuning”, Tata McGraw Hill, Third Edition 1988.

## PROFESSIONAL ELECTIVE – IV

| U19EE507 | POWER SYSTEM PLANNING AND RELIABILITY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Describe the concepts of load forecasting. | K2 |
| CO2 | **(Understand)** Discuss reliability analysis of ISO and interconnected systems. | K2 |
| CO3 | **(Understand)** Explain the concepts of Contingency analysis and Probabilistic Load flow analysis. | K2 |
| CO4 | **(Understand)** Outline the concepts of Expansion planning. | K2 |
| CO5 | **(Understand)** Discuss the fundamental concepts of the Distribution system planning. | K2 |

**MODULE – I LOAD FORECASTING** **9**

Objectives of forecasting – Load growth patterns and their importance in planning – Load forecasting Based on discounted multiple regression technique – Weather sensitive load forecasting Determination of annual forecasting – Use of AI in load forecasting.

**MODULE – II GENERATION SYSTEM RELIABILITY ANALYSIS** **9**

Probabilistic generation and load models – Determination of LOLP and expected value of demand not served – Determination of reliability of ISO and interconnected generation systems – Reliability indices.

**MODULE – III TRANSMISSION SYSTEM RELIABILITY ANALYSIS** **9**

Deterministic contingency analysis – Probabilistic load flow – Fuzzy load flow probabilistic transmission system reliability analysis – Determination of reliability indices like LOLP and expected value of demand not served.

**MODULE – IV EXPANSION PLANNING** **9**

Basic concepts on expansion planning – Procedure followed for integrate transmission system planning, current practice in India – Capacitor placement problem in transmission system and radial distributions system.

**MODULE – V DISTRIBUTION SYSTEM PLANNING OVERVIEW** **9**

Introduction – Sub transmission lines and distribution substations – Design of primary and secondary systems – distribution system protection and coordination of protective devices.

**Total: 45 Hours**

**TEXT BOOK**

1. Roy Billinton, Ronald N. Allan, “Reliability Evaluation of Power System”, Springer Publication.

**REFERENCES**

1. Sullivan R.L, “Power System Planning”, Tata McGraw Hill, 1989.
2. Wang X, McDonald J.R, “Modern Power System Planning”, Tata McGraw Hill, 1994.
3. Turan Gonen, “Electrical Power Distribution Engineering”, CRC Press, Third Edition, 2014.

| U19EE508 | RESTRUCTURED POWER SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the concepts of restructuring of power industry. | K2 |
| CO2 | **(Understand)** Illustrate the basics of congestion management. | K2 |
| CO3 | **(Understand)** Discuss locational margin prices and financial transmission rights | K2 |
| CO4 | **(Understand)** Explain the significance of ancillary services and pricing of transmission network. | K2 |
| CO5 | **(Understand)** Explain the framework of Indian power sector. | K2 |

**MODULE – I INTRODUCTION** **9**

Reasons for restructuring - Understanding the restructuring process - objectives of deregulation of various power systems across the world - Consumer behaviour - Supplier behaviour - Market equilibrium - Short-run and Long-run costs - Various costs of production. The Philosophy of Market Models: Market models based on contractual arrangements - Market architecture.

**MODULE – II TRANSMISSION CONGESTION MANAGEMENT** **9**

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance, Features, and Classification of congestion management – Calculation of ATC - Non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method.

**MODULE – III LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS** **9**

Fundamentals of locational marginal pricing - Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation - ACOPF model for LMP calculation - Risk Hedging Functionality of financial Transmission Rights - FTR issuance process - Treatment of revenue shortfall - Secondary trading of FTRs - Flow Gate rights - FTR and market power.

**MODULE – IV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK** **9**

Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - How to obtain ancillary service – Co-optimization of energy and reserve services - Transmission pricing – Principles – Classification – Rolled in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Merits and demerits of different paradigm.

**MODULE – V MARKET EVOLUTION** **9**

US markets: PJM market - The Nordic power market - Reforms in Indian power sector: Framework of Indian power sector - Reform initiatives - availability based tariff (ABT) – Indian Electricity Act - Open Access issues - Power exchange

**Total: 45 Hours**

**TEXT BOOK**

1. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, “Restructured Electrical Power Systems: Operation, Trading and Volatility”, CRC Press 2001.

**REFERENCES**


1. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, “Operation of restructured power systems”, Kluwer Academic Publishers, 2001.
2. Paranjothi S.R., “Modern Power Systems” New Age International, 2017.
3. Sally Hunt, “Making competition work in electricity”, John Willey and Sons Inc. 2002.


| **U19EE517** | **APPLICATION OF POWER ELECTRONICS TO POWER SYSTEMS** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand) U**nderstand the basic converter circuits used in day electric power system. | K2 |
| CO2 | **(Analyse)** Analyze the control actions to be implemented on the system to meet the system demand. | K3 |
| CO3 | **(Apply)** Acquire knowledge on modelling and analysis of FACTS controllers | K3 |
| CO4 | **(Understand)** Realize the harmonics created due to various load and its impact | K2 |
| CO5 | **(Apply)** Apply the different harmonic mitigation techniques to improve power quality of the power system | K3 |

**MODULE – I INTRODUCTION** **9**

Power Converter Circuits: Rectifier, Inverter, Chopper and Cycloconverter and its applications in Power System

**MODULE – II STEADY STATE AND DYNAMIC PROBLEMS IN AC SYSTEMS** **9**

Flexible AC transmission systems (FACTS), Principles of series and shunt compensation, Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC),

**MODULE – III MODELLING AND ANALYSIS OF FACTS CONTROLLERS** **9**

Control strategies to improve system stability, Power Quality problems in distribution systems

**MODULE – IV HARMONICS** **9**

Harmonics creating loads, modelling, harmonic propagation, Series and parallel resonances, harmonic power flow

**MODULE – V MITIGATION OF HARMONICS** **9**

Mitigation of harmonics, filters, passive filters, Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker, Mitigation of power quality problems using power electronic conditioners, IEEE standards, HVDC Converters and their characteristics, Control of the converters (CC and CEA), Parallel and series operation of converters.

**Total: 45 Hours**

**TEXT BOOKS**

1. N.G. Hingorani, Laszlo Gyugyi, “Understanding FACTS”, IEEE Press, 2000.

**REFERENCES**

1. K.R. Padiyar, “FACTS controllers in Power Transmission and Distribution”, New Age International publishers, New Delhi, 2007.
2. K.R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, New Delhi, 1999.
3. E. F. Fuchs, Mohammad A.S. Masoum, “Power Quality in Power Systems and Electrical Machines”, Elsevier Academic Press 2008.

| **U19EE518** | **MICROCONTROLLER APPLICATIONS IN POWER ELECTRONICS** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the architecture of the Microprocessor. | K2 |
| CO2 | **(Understand)** Discuss the interfacing peripheral ICs in Microprocessor | K2 |
| CO3 | **(Apply)** Describe the operation of Microprocessor in closed loop system. | K3 |
| CO4 | **(Understand)** Illustrate the various firing schemes of Power Electronic Converters using Microprocessor. | K2 |
| CO5 | **(Understand)** Explain the various microprocessor based drive controller. | K2 |

**MODULE – I INTRODUCTION** **9**

Hardware Architecture, pinouts – Functional Building Blocks of Processor – Memory organization – I/O ports and data transfer concepts – Timing Diagram – Interrupts.

**MODULE – II PERIPHERAL INTERFACING** **9**

Study on need – Architecture - configuration and interfacing with ICs: 8255, 8259, 8254, 8279, - A/D and D/A converters & Interfacing with 8085 & 8051.

**MODULE – III MICROCONTROLLERS IN CLOSED LOOP CONTROL SCHEMES** **9**

Importance of measurement and sensing in closed loop control - Measurement of voltage - current - speed - power and power factor using microprocessors - Per-unit representation of variables in digital domain - data representation in fixed point and floating point form - round-off errors – Implementation of P - PI and PID controllers using microprocessors.

**MODULE – IV FIRING SCHEME FOR CONVERTERS** **9**

Firing schemes for single phase and three phase rectifiers-3-phase AC choppers - firing at variable frequency environments - Firing scheme for DC choppers - voltage and current commutation. Inverters - types of pulse width modulation techniques - their implementation.

**MODULE – V MICROPROCESSOR BASED DRIVE CONTROLLER** **9**

Microprocessor application of the firing schemes to the control of DC drive - induction motors - synchronous motors and other special machines - Application in Electrical Traction. Typical applications in the control of power electronic converters for power supplies and electric motor drives: Stepper motor control - DC motor control - AC motor control

**Total:45 Hours**

**TEXT BOOKS**

1. Douglas V. Hall, “Microprocessors and Interfacing: Programming and Hardware”, Tata McGraw Hill, Eleventh Edition, 2003.
2. Bimbra P.S, “Power Electronics”, Khanna Publishers, Third Edition, 2003.

**REFERENCES**

1. Krishna Kant, “Microprocessor and Microcontrollers”, Eastern Company Edition, Prentice Hall of India, 2007.
2. Douglas V. Hall, “Microprocessor and Interfacing”, Tata McGraw Hill, 2016.
3. Singh M.D, Khanchandani K.B, “Power Electronics”, Tata McGraw Hill, 2013.
4. Philip T. Krein, “Elements of Power Electronics”, Oxford University Press, 2004.

| U19EE527 | SOLAR AND ENERGY STORAGE SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course- the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the basics of solar modules and PV system. | K2 |
| CO2 | **(Understand)** Illustrate the operation of standalone photovoltaic systems. | K2 |
| CO3 | **(Understand)** Discuss the operation of grid connected PV systems and its related issues. | K2 |
| CO4 | **(Understand)** Describe the various solar energy storage systems. | K2 |
| CO5 | **(Understand)** Explain some of the applications of solar energy. | K2 |

**MODULE – I INTRODUCTION** **9**

Characteristics of sunlight – semiconductors and P-N junctions – behaviour of solar cells – cell properties – Photovoltaic (PV) cell interconnection.

**MODULE – II STANDALONE PV SYSTEMS** **9**

Solar modules – storage systems – power conditioning and regulation – MPPT – Protection – Standalone PV systems design – sizing.

**MODULE – III GRID CONNECTED PV SYSTEMS** **9**

PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance – International PV programs.

**MODULE – IV ENERGY STORAGE SYSTEMS** **9**

Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage.

**MODULE – V APPLICATIONS** **9**

Water pumping – battery chargers – solar car – direct-drive applications – space – telecommunications.

**Total: 45 Hours**

**TEXT BOOKS**

1. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, “Applied Photovoltaics”, 2007, Earthscan, UK.

**REFERENCES**

1. Solanki C.S., “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning Pvt. Ltd., 2015.
2. Eduardo Lorenzo G. Araujo, “Solar electricity engineering of photovoltaic systems”, Progensa,1994.

3. Frank S. Barnes & Jonah G. Levine, “Large Energy storage Systems Handbook”, CRC Press, 2011.
4. McNeils, Frenkel, Desai, “Solar & Wind Energy Technologies”, Wiley Eastern, 1990.
5. S.P. Sukhatme , “Solar Energy”, Tata McGraw Hill,1987.

| U19EE528 | GRID INTEGRATION OF RENEWABLE ENERGY SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Illustrate the concepts of power systems, their operation and control focussed on the issues related to the integration of distributed renewable generation into the network and its advancements. | K2 |
| CO2 | **(Understand)** Explain the concepts of energy storage for various applications and various factors affecting it. | K2 |
| CO3 | **(Apply)** Apply various concepts in integrating various forms of energy to the grid. | K3 |
| CO4 | **(Apply)** Choose appropriate power system equipment used for integration. | K3 |
| CO5 | **(Apply)** Make use of detailed knowledge about power quality and its management along with approaches for grid stabilization. | K3 |

**MODULE – I DYNAMICS OF DISTRIBUTED GENERATION SYSTEMS 9**

Power system operation: Introduction on electric grid – Supply guarantees- power quality and Stability- Introduction to renewable energy grid integration – concept of mini/micro grids and smart grids; Wind- Solar- Biomass power generation profiles- generation electric features- Load scheduling.

**MODULE – II ENERGY STORAGE 9**

Mechanical Systems – Electrochemical Systems – Electrical Systems – Thermal Systems – Energy storage for power system applications – Grid Side and Demand side management with Renewables – Other factors.

**MODULE – III GRID INTEGRATION OF PHOTOVOLTAIC SYSTEMS 9**

Requirements for photovoltaic systems - Interconnection requirements - Power Quality – Anti-island - Structure of PV inverters - Detection of island – Structure – Investors and modulation – Control – Island detection and MPPT – Introduction – Passive Methods – Active methods – MPPT.

**MODULE – IV GRID INTEGRATION OF WIND SYSTEMS 9**

Requirements for wind systems - Grid Codes for wind turbines - Control of active power - Control of the reactive power - Frequency Control - Operating Range - LVRT - Future trends -Wind Turbines structures - Configuration turbine - Topology converters -Turbine Control.

**MODULE – V ADVANCEMENTS IN GRID INTEGRATION 9**

The electric vehicle in the grid - Load management - HVDC interconnection - STATCOM and filters Assets - FACTS and UPFC.

**Total: 45 Hours**

**TEXT BOOKS**

1. Kersting W. H, “Distribution System Modeling and Analysis”, Second Edition, CRC Press, 2004.
2. Vittal V. and Ayyanar R, “Grid Integration and Dynamic Impact of Wind Energy”, Springer, 2012.

**REFERENCES**

1. Keyhani A, “Design of Smart Power Grid Renewable Energy Systems”, Wiley IEEE Press, 2011.
2. Muhannad H. R, “Power Electronics: Circuits, Devices and Applications”, Pearson Prentice Hall, 2004.
3. Gellings C. W, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press, First Edition, 2009.
4. Teodorescu R. Liserre M. Rodriguez P, “Grid Converters for Photovoltaic and Wind Power Systems”, Wiley-IEEE Press, First Edition, 2011.

| U19EE537 | NANO ELECTRONICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Identify the different nanaotechnology and nano particles. | K2 |
| CO2 | **(Understand)** Describe the fundamental concepts of nanoelectronic devices. | K2 |
| CO3 | **(Apply)** Explain suitable techniques for implementing Quantum Transport Devices. | K3 |
| CO4 | **(Understand)** Discuss the construction and principles of Carbon Nano Tubes. | K2 |
| CO5 | **(Apply)** Explain different Molecular Electronic circuits for the implementation of MEMS, RAM and Storage. | K3 |

**MODULE – I INTRODUCTION TO NANOTECHNOLOGY** **9**

Background to nanotechnology: Types of nanotechnology and nanomachines – periodic table – atomic structure – molecules and phases – energy – molecular and atomic size – surface and dimensional space – top down and bottom up; Molecular Nanotechnology: Electron microscope – scanning electron microscope – atomic force microscope – scanning tunnelling microscope – Nano manipulator – Nano tweezers – atom manipulation – Nano dots – self-assembly – dip pen nanolithography. Nanomaterial: preparation – plasma arcing – chemical vapour deposition – sol-gels – electro deposition – ball milling – applications of nanomaterial;

**MODULE – II FUNDAMENTALS OF NANOELECTRONICS** **9**

Fundamentals of logic devices:- Requirements – dynamic properties – threshold gates; physical limits to computations; concepts of logic devices:- classifications – two terminal devices – field effect devices – coulomb blockade devices – spintronics – quantum cellular automata – quantum computing – DNA computer; performance of information processing systems;- basic binary operations, measure of performance processing capability of biological neurons – performance estimation for the human brain. Ultimate computation - power dissipation limit – dissipation in reversible computation – the ultimate computer.

**MODULE – III SILICON MOSFETs & QUANTUM TRANSPORT DEVICES** **9**

Silicon MOSFETS - Novel materials and alternate concepts - fundamentals of MOSFET Devices - scaling rules – silicon-dioxide based gate dielectrics – metal gates – junctions & contacts – advanced MOSFET concepts. Quantum transport devices based on resonant tunnelling - Electron tunneling – resonant tunneling diodes – resonant tunneling devices; Single electron devices for logic applications - Single electron devices – applications of single electron devices to logic circuits.

**MODULE – IV CARBON NANOTUBES** **9**

Carbon Nanotube: Fullerenes - types of nanotubes – formation of nanotubes – assemblies – purification of carbon nanotubes – electronic properties – synthesis of carbon nanotubes – carbon nanotube interconnects – carbon nanotube FETs – Nanotube for memory applications – prospects of an all carbon nanotube nanoelectronics.

**MODULE – V MOLECULAR ELECTRONICS** **9**

Electrodes & contacts – functions – molecular electronic devices – first test systems – simulation and circuit design – fabrication; Future applications: MEMS – robots – random access memory – mass storage devices.

**Total: 45 Hours**

**TEXT BOOKS**


1. Raguse, “Nanotechnology: Basic Science and Emerging Technologies”, Chapman & Hall / CRC, 2002.
2. T. Pradeep, “NANO: The Essentials – Understanding Nanoscience and Nanotechnology”, TMH, 2007.
3. Rainer Waser (Ed.), Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley-VCH, 2003.


**REFERENCES**

1. Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, “Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications”, Cambridge University Press, 2011.
2. Supriyo Datta, “Lessons from Nanoelectronics: A New Perspective on Transport”, World Scientific, 2012.
3. George W. Hanson, “Fundamentals of Nanoelectronics”, Pearson, 2009.
4. Mircea Dragoman, Daniela Dragoman, “Nanoelectronics: principles and devices”, CRC Press, 2006.

| U19EE538 | EMBEDDED NETWORKED SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the serial and parallel communication protocol related to embedded networking. | K2 |
| CO2 | **(Apply)** Explain CAN and USB network protocols | K3 |
| CO3 | **(Understand)** Illustrate the concepts of Ethernet communication. | K2 |
| CO4 | **(Understand)** Outline different network topologies | K2 |
| CO5 | **(Apply)** Utilize the wireless protocols in Real world interfacing. | K3 |

**MODULE – I EMBEDDED COMMUNICATION PROTOCOLS** **9**

Introduction, Serial/Parallel communication: Serial communication protocols - RS232 standard – RS485, – Synchronous Serial Protocols: Serial Peripheral Interface (SPI), Inter Integrated Circuits (I2C), PC Parallel port programming, ISA/PCI Bus protocols, Fire wire.

**MODULE – II USB AND CAN BUS** **9**

USB bus: Introduction – Speed Identification on the bus – USB States, USB bus communication: Packets –Data flow types, A simple application with USB: Inkjet printer, CAN Bus: Introduction - Frames –Bit stuffing –Types of errors –Nominal Bit Timing – CAN Interface –A simple application with CAN: Telephone exchange.

**MODULE – III ETHERNET BASICS** **9**

Elements of a network – Inside Ethernet – Building a Network: Hardware options – Cables, Connections and network speed – Design choices: Selecting components –Ethernet Controllers – Using the internet in local and internet communications – Inside the Internet protocol.

**MODULE – IV EMBEDDED ETHERNET** **9**

Exchanging messages using UDP and TCP, serving web pages with Dynamic Data, serving web pages that respond to user Input, Email for Embedded Systems, Using FTP, Keeping Devices and Network secure.

**MODULE – V WIRELESS EMBEDDED NETWORKING** **9**

Wireless sensor networks: Introduction – Applications – Network Topology – Localization – Time Synchronization, Energy efficient MAC protocols: SMAC, Energy efficient and robust routing, Data Centric routing.

**Total: 45 Hours**

**TEXT BOOKS**

1. Raj Kamal, “Embedded Systems: Architecture, Programming and Design”, McGraw Hill, Third Edition, 2017.
2. Jan Axelson, “Embedded Ethernet and Internet Complete: Designing and Programming Small Devices for Networking”, Lakeview Research, First Edition, 2003.

**REFERENCES**

1. Richard Zurawski, “Embedded Systems Handbook: Networked Embedded Systems (Industrial Information Technology)”, CRC Press, Second Edition, 2017.

**PROFESSIONAL ELECTIVE – V**

| U19EE509 | DIGITAL PROTECTION OF POWER SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain the need of digital protection and power system components. | K2 |
| CO2 | **(Understand)** Describe the functional characteristics of different relays used for Transmission lines. | K2 |
| CO3 | **(Apply)** Explain the functioning of various relays applicable to Synchronous Generator / Transformer. | K3 |
| CO4 | **(Apply)** Determine various applications of numerical relay along with their functions. | K3 |
| CO5 | **(Analyse)** Analyse the modern digital protection algorithm for various protection schemes. | K4 |

**MODULE – I BASICS OF DIGITAL PROTECTION SYSTEM 9**

Need for Power System Protection - Digital Protection: State of Art - Power System Components - Protective Schemes – Electro Mechanical Relays - Static Relays - Dual input comparator - Multi input comparator - Pilot relaying schemes

**MODULE – II DIGITAL PROTECTION OF TRANSMISSION LINE 9**

Protection scheme of transmission line - Distance Relays - Travelling wave relays - Digital protection scheme based on fundamental signal - Digital protection of EHV/UHV Transmission line based upon Travelling wave Phenomena - New relaying scheme using amplitude comparison.

**MODULE – III DIGITAL PROTECTION OF SYNCHRONOUS GENERATOR / TRANSFORMER 9**

Introduction - Faults in synchronous generator - Protection schemes for synchronous generator - Digital Protection Synchronous generator - Faults in Transformer - Schemes used for transformer protection - Digital protection of Transformer.

**MODULE – IV APPLICATION OF NUMERICAL RELAY 9**

Numerical Relaying Algorithm - Data Acquisition System (DAS) - Mann Morrison technique - Differential Equation technique - Discrete Fourier Transform Technique – Block pulse function technique - Numerical Over current Protection – Numerical Distance Protection - Numerical Differential protection.

**MODULE – V ADVANCEMENTS IN DIGITAL PROTECTION 9**

Introduction - Gas Insulated Substation/switchgear (GIS) - Frequency relaying and Load shedding - Adaptive protection – Integrated protection and control - Relay reliability - Advantages of fast fault clearing

**Total: 45 Hours**

**TEXT BOOKS**


1. Singh L.P, "Digital Protection: Protective Relaying from Electromechanical to Microprocessor", New Age International Ltd., New Delhi, 2004.


**REFERENCES**


1. Badri Ram, Vishwakarma D.N, "Power System Protection and Switchgear", Tata McGraw Hill publishing company Ltd., New Delhi, 2011.
2. Ravindranath B and Chander M, "Power System Protection and Switchgear", New Age International Pvt. Ltd., New Delhi, 2011.
3. Wadhwa C.L, "Electrical Power Systems", New Age International Pvt. Ltd., 6th Edition, 2011.
4. Stanley H. Horowitz and Arun G. Phadke, "Power System Relaying", John Wiley and Sons Ltd., 3rd Edition, 2013
5. Bhavesh Bhalja, R.P. Maheswari, Nilesh G. Chothani, "Protection and Switch Gear", Oxford University Press, 2011.


**U19EE510 AI APPLICATIONS TO POWER SYSTEMS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Outline the basics of Artificial Intelligence and its necessity | K2 |
| CO2 | **(Understand)** Illustrate the knowledge based systems with examples | K2 |
| CO3 | **(Understand)** Explain the concept of pattern recognition and its applications | K2 |

CO4 **(Understand)** Classify the artificial neural networks and explain learning procedure K2

CO5 **(Apply)** Build expert systems for certain applications K3

**MODULE – I INTRODUCTION TO ARTIFICIAL INTELLIGENCE 9**

Definition – Applications – Components of an AI program – Production system – Problem Characteristics – Overview of searching techniques – Knowledge representation – Knowledge representation issues and overview – Representing knowledge using rules – Procedural versus declarative knowledge – Logic programming – forward versus backward reasoning – Matching – Control knowledge.

**MODULE – II STATISTICAL REASONING 9**

Probability and Daye's theorem – Certainty factor and rule based systems – Baysian Networks – Dampster Shafer theorem – Semantic nets and frames – Script – Examples of knowledge based systems.

**MODULE – III PATTERN RECOGNITION 9**

Introduction – Automatic pattern recognition scheme – Design Concepts – Methodologies – Concepts of Classifier – Concept of feature selection – Feature selection based on means and covariances. Statistical classifier design algorithms – Increment – Correction and LMSE algorithms – Applications.

**MODULE – IV ARTIFICIAL NEURAL NETWORKS 9**

Biological Neuron - Neural Net - use of neural nets - applications - Perception - Idea of single layer and multilayer neural nets - back propagation - Hopfield nets - Supervised and unsupervised learning.

**MODULE – V EXPERT SYSTEMS 9**

Introduction – Study of some popular expert systems – Expert System building tools and Shells - Design of Expert Systems.

**Total: 45 Hours**

**TEXT BOOKS**


1. Rajendra Akerkar, “Introduction to Artificial Intelligence”, PHI Learning, Second Edition, 2014.
2. Kevin Warwick, Arthur Ekwue, Raj Aggarwal, “Artificial Intelligence Techniques in Power Systems”, IET, 1997.


**REFERENCES**


1. Yong-Hua Song, Allan Johns, Raj Aggarwal,” Computational Intelligence Applications to Power Systems”, Springer, 1996.
2. Laurene Fausett, “Fundamentals of Neural Networks Architectures, Algorithms, and Applications”, PHI, 1994.
3. Almotaz Y. Abdelaziz, Shady Hossam Eldeen Abdel Aleem, Anamika Yadav, “Artificial Intelligence Applications in Electrical Transmission and Distribution Systems Protection”, CRC Press, First Edition, 2021.
4. Weerakom Ongsakul, Voo Ngoc Diu, “Artificial Intelligence in Power System Optimization”, CRC Press, 2013.


| U19EE519 | MICRO ELECTRO MECHANICAL SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

CO1 **(Understand)** Explain the basic concepts and components of Micro Electro Mechanical Systems K2

CO2 **(Understand)** Describe the construction and operation of electrostatic, thermal and magnetic sensors used in Micro Electro Mechanical Systems K2

CO3 **(Understand)** Illustrate the construction and operation of piezoelectric sensors and its applications in Micro Electro Mechanical Systems K2

CO4 **(Understand)** Distinguish the different micromachining process in Micro Electro Mechanical Systems K2

CO5 **(Understand)** Outline the importance of polymers and optical based sensors in Micro Electro Mechanical Systems K2

**MODULE – I INTRODUCTION** **9**

Intrinsic Characteristics of Micro systems – Energy Domains and Transducers – Sensors and Actuators – Silicon based MEMS processes – MEMS Materials – Review of Electrical and Mechanical concepts in MEMS – Introduction to Micro system Fabrication processes

**MODULE – II SENSORS AND ACTUATORS – I** **9**

Electrostatic sensors – Parallel plate capacitors – Applications – Interdigitated Finger capacitor – Comb drive devices – Micro Grippers – Micro Motors - Thermal Sensing and Actuation – Thermal expansion – Thermal couples – Thermal resistors – Thermal Bimorph - Applications – Magnetic Actuators – Micromagnetic components

**MODULE – III SENSORS AND ACTUATORS – II** **9**

Piezoresistive sensors – Piezoresistive sensor materials - Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials

**MODULE – IV MICROMACHINING** **9**

Silicon Anisotropic Etching – Anisotrophic Wet Etching – Dry Etching of Silicon – Plasma Etching – Deep Reaction Ion Etching (DRIE) – Isotropic Wet Etching – Gas Phase Etchants – Case studies –Basic surface micro machining processes – Structural and Sacrificial Materials – Acceleration of sacrificial Etch – Striction and Antistriction methods – LIGA Process - Assembly of 3D MEMS – Foundry process.

**MODULE – V POLYMER AND OPTICAL MEMS** **9**

Polymers in MEMS – Polimide - SU-8 - Liquid Crystal Polymer (LCP) – PDMS – PMMA – Parylene – Fluorocarbon - Application to Acceleration, Pressure, Flow and Tactile sensors- Optical MEMS – Lenses and Mirrors – Actuators for Active Optical MEMS

**Total: 45 Hours**

**TEXT BOOKS**


1. Chang Liu, “Foundations of MEMS”, Pearson, First Edition, 2012.
2. Stephen D Senturia, “Microsystem Design”, Springer Publication, 2001.
3. Tai-Ran Hsu, “MEMS & Microsystems Design and Manufacture”, Tata McGraw Hill, Eighth Reprint, 2002.


**REFERENCES**


1. Nadim Maluf, Kirt Williams, “An Introduction to Micro Electro Mechanical System Design”, Artech House, Second Edition, 2004.
2. Mohamed Gad-el-Hak, “The MEMS Handbook”, CRC press, 2002.
3. James J. Allen, “Micro Electro Mechanical System Design”, CRC Press, 2005.
4. Thomas M. Adams, Richard A. Layton, “Introductory MEMS: Fabrication and Application”, Springer, 2014.


| **U19EE520** | **SWITCHED MODE POWER CONVERSION** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

CO1 **(Understand)** Explain the operation of push-pull converters and bridge converters. K2

CO2 **(Understand)** Discuss the steady state characteristics of isolated bridge converters. K2

CO3 **(Understand)** Explain the performance of DC-DC Converters. K2

CO4 **(Apply)** Determine the frequency domain analysis and compare performance of various controllers. K3

CO5 **(Analyse)** Analyse the performance of various resonant converters. K4

**MODULE – I SINGLE-SWITCH ISOLATED CONVERTERS** **9**

Requirement for isolation in the switch-mode converters, transformer connection, Forward and flyback converters, power circuit and steady-state analysis. Push-Pull Converters-Power circuit and steady-state analysis, utilization of magnetic circuits in single switch and push-pull topologies.

**MODULE – II ISOLATED BRIDGE CONVERTERS 9**

Half bridge and full-bridge converters, Power circuit and steady state analysis, utilization of magnetic circuits and comparison with previous topologies.

**MODULE – III DYNAMIC ANALYSIS OF DC-DC CONVERTERS 9**

Formulation of dynamic equation of buck and boost converters, averaged circuit models, linearization technique, small-signal model and converter transfer functions.

**MODULE – IV CONTROLLER DESIGN 9**

Review of frequency-domain analysis of linear time-invariant systems, concept of bode plot, phase and gain margins, bandwidth, controller specifications, proportional (P), proportional plus integral (PI), proportional plus integral plus integral controller (PID), selection of controller parameters.

**MODULE – V RESONANT CONVERTERS 9**

Classification of Resonant Converters-Basic resonant circuits- Series resonant circuit-parallel resonant circuits- Resonant switches. Concept of Zero voltage switching, principle of operation, analysis of M-type and L-type Buck or boost Converters. Concept of Zero current switching, principle of operation, analysis of M-type and L-type Buck or boost Converters.

**Total: 45 Hours**

**TEXT BOOKS**


1. V. Ramanarayanan, “Course material on Switched mode power conversion”, IISc, Bangalore, 2007.


**REFERENCES**


1. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics: Converters, Applications and Design”, Wiley-India, Third Edition, 2009.
2. Prof. V. Ramanarayanan and Prof. L. Umanand's course on Switched mode power conversion is available at: http://nptel.ac.in/courses/108108036/
4. Bimbhra P.S, “Power Electronics”, Khanna Publishers, Third Edition, 2003.
5. Umanand L, “Power Electronics: Essentials and Applications”, Wiley-India, 2009.


| U19EE529 | POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEM | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Explain about the stand alone and grid connected renewable energy systems. | K2 |
| CO2 | **(Understand)** Describe the fundamental principle and operation of Electrical Machines. | K2 |
| CO3 | **(Understand)** Illustrate the basic concept of various power converters. | K2 |
| CO4 | **(Apply)** Apply various operating modes of wind electrical generators and solar energy systems. | K3 |
| CO5 | **(Apply)** Develop maximum power point tracking algorithm. | K3 |

**MODULE – I INTRODUCTION 9**

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

**MODULE – II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9**

Review of reference theory fundamentals – principle of operation and analysis of IG, PMSG, SCIG and DFIG.

**MODULE – III POWER CONVERTERS FOR SOLAR PV SYSTEMS 9**

Block diagram of solar photo voltaic system: line commutated converters (inversion-mode) – Boost and buck – boost converters – selection of inverter, battery sizing, array sizing – standalone PV systems – Grid tied and grid interactive inverters – grid connection issues.

**MODULE – IV ANALYSIS OF WIND ENERGY SYSTEMS** **9**

Standalone operation of fixed and variable speed wind energy conversion systems – Grid connection Issues -Grid integrated PMSG, SCIG Based WECS.

**MODULE – V HYBRID RENEWABLE ENERGY SYSTEMS** **9**

Need for Hybrid Systems – Range and type of Hybrid systems – Case studies of Wind and PV – Maximum Power Point Tracking (MPPT) – Power Electronic System for on-board charging

**Total: 45 Hours**

**TEXT BOOKS**


1. Bhadra S. N, Kastha D, Banerjee S, “Wind Electrical Systems”, Oxford University Press, 2005.
2. Khan B.H, “Non-conventional Energy sources”, Tata McGraw Hill, 2009.


**REFERENCES**


1. Rashid. M. H, “Power Electronics Hand book”, Academic press, 2001.
2. Ion Boldea, “Variable speed generators”, Taylor & Francis group, 2006.
3. Rai. G.D, “Non-conventional energy sources”, Khanna publishes, 1993.
4. Gray, L. Johnson, “Wind energy system”, Prentice Hall linc, 1995.
5. Andrzej M. Trzynnadlowski, ‘Introduction to Modern Power Electronics’, Wiley India, Second Edition, 2012.


| **U19EE530** | **ENERGY CONSERVATION PRACTICES** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Summarize the concept of energy conservation and industrial energy management | K2 |
| CO2 | **(Apply)** Identify various energy conservation methods in electrical utilities and best operating practices. | K3 |
| CO3 | **(Apply)** Develop the concept of lighting system for all applications aong with various energy conservation measures. | K3 |
| CO4 | **(Apply)** Select traction motor, discuss their energy performance and basic applications in railways and aircraft electrical system. | K3 |
| CO5 | **(Analyse)** Explain the process, technology and application of electrolytic process. | K4 |

**MODULE – I INTRODUCTION TO ENERGY CONSERVATION** **9**

Need for electrical energy conservation - methods – energy efficient equipment – energy management – energy auditing - Features of Energy Conservation Act – Economics of power factor improvement – design for improvement of power factor using power capacitors – DSM techniques

**MODULE – II ENERGY CONSERVATION IN ELECTRICAL SYSTEM** **9**

Energy Conservation potential in motors – Pumps – Fans and Compressors – Refrigeration and HVAC system, operation and maintenance practices for electrical energy conservation – Case studies.

**MODULE – III ENERGY CONSERVATION IN LIGHTING SYSTEM** **9**

Laws of illumination – Calculation of illumination – Street lighting and Flood lighting – MSCP – Choice of Lighting – Different types of illumination sources and Energy efficiency – Control of Lighting – Lighting standards for industry and Commercial – Energy conservation measures for lighting.

**MODULE – IV ELECTRIC TRACTION** **9**

Characteristics of traction motors – Choice of an Electric Motor – Control of traction motors – Systems of railway electrification – Power and Energy output from driving axles – Specific Energy output and consumption – Braking methods – Current collection systems – Recent trends in electric traction – Introduction to Aircraft electrical system.

**MODULE – V ELECTROLYTIC PROCESS AND STORAGE OF ELECTRICITY** **9**

Electrolysis – simple problems involving Faraday's laws of electrolysis - Electroplating – Nickel iron batteries – Lead acid Batteries – components and materials - capacity rating of batteries – battery chargers – Method of charging and maintenance – Case studies.

**Total: 45 Hours**

**TEXT BOOKS**

1. Gupta J.B., "Utilization of Electric Power and Electric Traction", S.K. Kataria & Sons, 2012.

**REFERENCES**


1. Chakrabarti A., Soni M.L., Gupta P.V. and Bhatnagar U.S., "A Textbook on Power System Engineering", Dhanpat Rai & Co., 2010.
2. Taylor E. Openshaw, "Utilization of Electrical Energy", Orient Longman, 2006.
3. Amlan Chakrabarti, "Energy Engineering and Management", PHI, Second Edition, 2018.
4. Suryanarayana N.V, "Utilisation of Electric power", New Age International Limited, Reprint, 2005.
5. CB Smith, "Energy Management Principles", Elsevier, Second Edition, 2016.


| U19EE539 | ELECTRIC VEHICLE MECHANICS AND CONTROL | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Understand the architecture and dynamics of EVs and HEVs | K2 |
| CO2 | **(Analyze)** Design an EV for standard drive cycle | K3 |
| CO3 | **(Understand)** Understand the electrical motors' characteristics and its application for vehicle dynamics | K3 |
| CO4 | **(Understand)** Understand and workout the energy requirements and energy sources for EV application | K3 |
| CO5 | **(Understand)** Understand the mode of operation and control architecture | K3 |

**MODULE I ELECTRIC VEHICLE ARCHITECTURE** **9**

History of evolution of Electric Vehicles - Series parallel architecture of Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

**MODULE II MECHANICS OF ELECTRIC VEHICLES** **9**

Fundamentals of vehicle mechanics - tractive force, power and energy requirements for standard drive cycles of EV's - motor torque and power rating and battery capacity.

**MODULE III CONTROL OF DC AND AC MOTOR DRIVES** **9**

Speed control for constant torque, constant HP operation of all electric motors - DC/DC chopper based four quadrant operation of DC motor drives, inverter-based V/f Operation (motoring and braking) of induction motor drives, vector control operation of Induction motor and PMSM, Brushless DC motor drives, Switched reluctance motor (SRM) drives.

**MODULE IV ENERGY STORAGE SYSTEMS** **9**

**Battery:** Principle of operation, types, models, SOC of battery, Traction Batteries and their capacity for standard drive cycles. **Alternate sources:** Fuel cells, Ultra capacitors, Fly wheels.

**MODULE V HYBRID VEHICLE CONTROL STRATEGY** **9**

HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode - series parallel mode.

**Total: 45 Hours**

**TEXT BOOKS**

1. Iqbal Husain, "Electric and Hybrid Electric Vehicles", CRC Press, 2011.

**REFERENCES**

1. Wei Liu, "Hybrid Electric Vehicle System Modeling and Control", Second Edition, WILEY, 2017.
2. James Larminie and John Lowry, "Electric Vehicle Technology Explained", Second Edition 2012.
3. Christopher D Rahn, Chao-Yang Wang, "Battery Systems Engineering", Wiley, 2013.

| U19EE540 | CONTROL OF ELECTRICAL MACHINES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Outcomes**

After completion of this course, the students will be able to

| | | |
|---|---|---|
| CO1 | **(Understand)** Discuss the operation of Electrical control circuit elements, solenoids, contactors and interlocking arrangement | K2 |
| CO2 | **(Apply)** Identify control circuits for DC motor acceleration control, speed control, direction control, braking control and jogging using contactors | K3 |
| CO3 | **(Apply)** Explain control circuits for acceleration and braking using contactors suitable for AC motor | K3 |
| CO4 | **(Apply)** Examine the control circuits for special industrial applications | K3 |
| CO5 | **(Apply)** Utilize PLC Programming logics for automation circuits | K3 |

**MODULE – I CONTROL CIRCUIT COMPONENTS** **9**

Introduction - Limitations of Manual Control- Magnetic Control - Control circuit components – MCCB, MCB – Types of contactors – Ratings – Relays - Voltage relay, DC series current relay, frequency response relay, latching relay and phase failure relay – Overload relay - Time Delay Relays- Limit Switches - Pressure Switches, Remote control operation and interlocking of drives - Control Transformer

**MODULE – II CONTROL OF DC MOTORS** **9**

Staring and characteristics of DC motors- Reversing of DC Motors- Jogging Operation of Motor- Dynamic Breaking of Motor- Principles of DC Motor Acceleration – Types of Starters for Automatic Acceleration - Current Limit Acceleration Starters - Definite Timer Acceleration Starters – Plugging Circuit for DC Motor.

**MODULE – III AC MOTOR CONTROL CIRCUITS** **9**

Motor current at start and during acceleration – No load speed and final speed of motor – DOL starter – Automatic auto transformer starter – open circuit and closed circuit transition– Star/Delta starter – Starter for two speed two winding motor – Reversing the direction of rotation of induction motor – Dynamic Braking – Three step rotor resistance starter for wound induction motor – Secondary frequency acceleration starter.

**MODULE – IV INDUSTRIAL CONTROL CIRCUITS** **9**

Planner machine control – Skip hoist control – Automatic control of a water pump – Control of electric oven – Control of air compressor – Control of overhead crane – control of conveyor system – Control of elevator - Trouble spots in control circuits – General procedure for trouble shooting.

**MODULE – V PROGRAMMABLE LOGIC CONTROLLER AUTOMATION** **9**

Types of automation – PLC Introduction – Block diagram of PLC – principle of operation – modes of operation – PLC scan – memory organization – input – output module – schematic and wiring diagram – Types of Programming Devices – Comparison between hardwire control system and PLC System – PLC Types – Criteria for selection of suitable PLC – Applications of PLC for motor control.

**Total: 45 Hours**

**TEXT BOOKS**

1. Bhattacharya S.K, Brijinder Singh, “Control of Machines”, New Age International Publishers, Revised Second Edition, 2006.

**REFERENCES**

1. Srivastava, “Exploring Programmable Logic controllers with Application”, BPB Publications, 2004.
2. Stephen L. Herman, “Industrial Motor Control”, Cengage Learning, 2020.
3. Ned Mohan, “Advanced Electric Drives”, Wiley, 2014.