# B.E. ELECTRICAL AND ELECTRONICS ENGINEERING

# CURRICULUM & SYLLABI 2024

# (REGULAR PROGRAMME)

## Department of Electrical and Electronics Engineering

## FACULTY OF ENGINEERING


**KARPAGAM ACADEMY OF HIGHER EDUCATION**

**(Deemed to be University)**

**(Established Under Section 3 of UGC Act, 1956)**

**Pollachi Main Road, Eachanari Post,**

**Coimbatore- 641 021, India.**

# KARPAGAM ACADEMY OF HIGHER EDUCATION

*(Deemed to be University Established under Section 3 of UGC Act 1956)*

**Eachanari, Coimbatore-641 021. INDIA**

**FACULTY OF ENGINEERING**

**DEGREE OF BACHELOR OF ENGINEERING / TECHNOLOGY**

**REGULAR PROGRAMME**

**REGULATIONS 2024**

**CHOICE BASED CREDIT SYSTEM**

**These regulations are effective from the academic year 2024 – 2025 and applicable to the candidates admitted to B. E. / B. Tech programmes. during 2024 - 2025 and onwards.**

## 1. ADMISSION

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

Should have passed the Higher Secondary Examination (10+2) prescribed by the State Government / Central Government with Mathematics/ Physics/ Chemistry/ Computer Science/ Electronics/ Information Technology/ Biology/ Informatics Practices/ Biotechnology/ Technical Vocational subject/ Agriculture/ Engineering Graphics/ Business Studies/ Entrepreneurship. (Any of the above three subjects) or any similar Examination of any other institution/ University or authority accepted by the Karpagam Academy of Higher Education as equivalent thereto).

Should have obtained at least 45% marks (40% marks in case of candidates belonging to reserved category) in the above subjects taken together. **(OR)**

Passed min. 3 years Diploma examination with at least 45% marks (40% marks in case of candidates belonging to reserved category) subject to vacancies in the First Year, in case the vacancies at lateral entry are exhausted. (The University will offer suitable bridge courses such as Mathematics, Physics, Engineering drawing, etc., for the students coming from diverse backgroundsto achieve desired learning outcomes of the programme)

### 1.2 Lateral Entry Admission

Candidates who possess Diploma in Engineering / Technology (10+3 or 10+2+2) awarded by the Directorate of Technical Education with passed minimum THREE years / TWO years (Lateral Entry) Diploma examination with at least 45% marks (40% marks in case of candidates belonging to reserved category) in ANY branch of Engineering and Technology are eligible to apply for admission to the third semester of B. E./B. Tech.

**OR**

Passed B.Sc. Degree from a recognized University as defined by UGC, with at least 45% marks (40% marks in case of candidates belonging to reserved category) and passed 10+2 examination with Mathematics as a subject.

**OR**

Passed D.Voc. Stream in the same or allied sector.
(The University will offer suitable bridge courses such as Mathematics, Physics, Engineering

drawing, etc., for the students coming from diverse backgrounds to achieve desired learning outcomes of the programme)

**Eligibility criteria for admission in the third semester is given in the table below.**

<table>
<tr><th>S. No.</th><th>Programme</th><th>Eligibility criteria</th></tr>
<tr><td>1.</td><td>B.E Bio Medical Engineering</td><td rowspan="10">Passed Minimum THREE years / TWO years (Lateral Entry) Diploma examination with at least 45% marks (40% marks in case of candidates belonging to reserved category) in ANY branch of Engineering and Technology.<br><br>OR<br>Passed B.Sc. Degree from a recognized University as defined by UGC, with at least 45% marks (40% marks in case of candidates belonging to reserved category) and passed 10+2 examination with Mathematics as a subject.<br><br>OR<br>Passed D.Voc. Stream in the same or allied sector.<br>(The Universities will offer suitable bridge courses such as Mathematics, Physics, Engineering drawing, etc., for the students coming from diverse backgrounds to achieve desired learning outcomes of the programme)</td></tr>
<tr><td>2</td><td>B. E. Civil Engineering</td></tr>
<tr><td>3.</td><td>B. E. Computer Science and Engineering</td></tr>
<tr><td>4.</td><td>B. E. Computer Science and Engineering (Cyber security)</td></tr>
<tr><td>5.</td><td>B. E. Electrical and Electronics Engineering</td></tr>
<tr><td>6.</td><td>B. E. Electronics and Communications Engineering</td></tr>
<tr><td>7.</td><td>B. E. Mechanical Engineering</td></tr>
<tr><td>8.</td><td>B. Tech. Artificial Intelligence and Data Science</td></tr>
<tr><td>9.</td><td>B. Tech Bio - Technology</td></tr>
<tr><td>10.</td><td>B. Tech Food Technology</td></tr>
</table>

### 1.3 Migration from other University

Candidates who are willing to migrate to Karpagam Academy of Higher Education for admission to their next semester of B. E./B. Tech programme may get admitted from 2nd semester onwards upto 7th semester. The student will be exempted from appearing for Examination of the equivalent courses passed in the earlier programme and will have to appear for courses which he/she has not done during the period of his/her earlier programme. Along with the request letter and mark sheets, he/she has to submit a copy of syllabus of the programme duly attested by the Competent authority, he/she has undergone. Equivalence Certificate shall be provided by the respective Head of the Department of Karpagam Academy of Higher Education.

## 2 . PROGRAMMES OFFERED

A candidate may undergo a programme in any one of the branches of study approved by the University as given below.

**List of B. E. and B. Tech. Degree Programmes**

1. B.E Bio Medical Engineering
2. B. E. Civil Engineering
3. B. E. Computer Science and Engineering
4. B. E. Computer Science and Engineering (Cyber Security)
5. B. E. Electrical and Electronics Engineering
6. B. E. Electronics and Communications Engineering
7. B. E. Mechanical Engineering
8. B.Tech. Artificial Intelligence and Data Science
9. B. Tech. Bio-Technology
10. B. Tech Food Technology

## 3. MODE OF STUDY

### 3.1 Full-Time:

In this mode of study, the candidates are required to attend classes regularly on the specified working days of the University.

**3.2** Change from one programme to another is not permitted.

## 4. STRUCTURE OF PROGRAMMES

**4.1** Every programme will have a curriculum with syllabus consisting of theory and practical courses such as:

(i) General core courses comprising Mathematics, Basic Sciences, Engineering Sciences and Humanities.

(ii) Core courses of Engineering/Technology.

(iii) Elective courses for specialization in related fields.

(iv) Workshop practice, computer practice, engineering graphics, laboratory work, internship, seminar presentation, project work, industrial visits, camps, etc.

Every student is encouraged to participate in at least any one of the following programmes

- NSS / Sports/Physical exercise/NCC/YRC.
- Other Co-Curricular and Extra Curricular activities

## (v) Choice Based Credit System

CBCS is introduced for students admitted in the academic year 2017-18. As per AICTE guidelines, CBCS is an approach in which students opt for courses of their choice. CBCS provides greater flexibility with multiple courses and enable students to undergo additional courses. CBCS is applicable to Full Time Undergraduate & Post Graduate Programmes of study. It provides a choice for students to select from the prescribed courses (Professional core, Professional Electives, Open Electives, Value added courses, Humanity Sciences, Basic sciences & Engineering sciences).

A course designated as hard core for a particular programme of study must invariably be completed by the student to receive the degree in the programme. The Hardcore courses cannot be substituted by another courses. Students can exercise their choice among a set of soft-core courses from the list of Soft core courses specified for each Programme of study. The student should meet the criteria for prerequisites to become eligible to register for that course. The student should request for the course for every semester within the first week of semester. Maximum no of students to be registered in each course shall depend on availability of physical facilities, classroom availability and lab capacity. Registration of already requested courses by students in previous semester is not allowed.

**4.2** Each course is normally assigned certain number of credits.

| | |
|---|---|
| No. of credits per lecture period per week | 1 |
| No. of credits per tutorial period per week | 1 |
| No. of credits for 3 periods of laboratory course per week | 2 |
| No. of credits for 3 periods of project work per week | 2 |
| No. of credits for 2 weeks of field project/internship training during semester vacations | 1 |

**4.3** In every semester, the curriculum shall normally have a blend of theory courses not exceeding 6 and practical courses not exceeding 4.

**4.4** The prescribed credits required for the award of the degree shall be within the limits specified below.

| PROGRAMME | PRESCRIBED CREDIT RANGE |
|---|---|
| B. E./B. Tech. | 160– 165 |

**4.5** The medium of instruction for all Courses, Examinations, Seminar presentations and Project/Thesis reports is English except Tamil/French.

### 4.6 Value Added Course

Besides core courses and elective courses, value added course is introduced. The blend of different courses is so designed that the interested students would be trained, for the holistic development to enhance employment opportunity.

**4.7** Evaluation of the courses comprises of two parts, one is the Continuous Internal Assessment (CIA) and the other one is the End Semester Examination (ESE). Evaluation in a mandatory course may be by Internal Assessment only.

## 5. DURATION OF THE PROGRAMME

**5.1**The prescribed duration of the programme shall be

| Programme | Min. No. of semesters | Max. No. of semesters |
|---|---|---|
| B. E./B. Tech. (HSC Candidates) | 8 | 14 |
| B. E./B. Tech. (Lateral Entry Candidates) | 6 | 12 |

**5.2** Each semester shall normally consist of 90 working days or 540 hours.

**5.3** Additional classes for improvement, conduct of model test, etc., over and above the specified periods shall be arranged, if required. But for the purpose of calculation of attendance requirement for eligibility to appear for the end semester Examinations (as per Clause 11) by the students, 540 hours conducted within the specified academic schedule alone shall be taken into account and the overall percentage of attendance shall be calculated accordingly.

## 6. REQUIREMENTS FOR COMPLETION OF THE SEMESTER

**6.1** Ideally every student is expected to attend all classes and secure 100% attendance. However,in order to allow for certain unavoidable circumstances, the student is expected to attend at least75% of the classes and the conduct of the candidate has been satisfactory during the course.

**6.2** A candidate who has secured attendance between 65% and 74% (both included), due to medical reasons (Hospitalization / Accident / Specific Illness) shall be given exemption from prescribed minimum attendance requirements and shall be permitted to appear for the Examination on the recommendation of the Head of the Department concerned and Dean to condone the lack of attendance. The Head of the Department has to verify and certify the genuineness of the case before recommending to the Dean concerned. However, the candidate has to execute a one-time bond (Stamp paper) with an undertaking from the parent and the student that this situation never arises in the future.

**6.3** Candidates who are not recommended for condonation and those who have less than 65% attendance will not be permitted to proceed to the next semester and have to redo the course. However, they are permitted to write the arrear Examinations, if any.

## 7. CLASS ADVISOR

To help the students in planning their courses of study and for general advice on theacademic programme, the Head of the Department will attach a certain number of students to a teacher of the Department who shall function as Class Advisor for those students throughout their period of study. Such Class Advisors shall advise the students and monitor the courses undergone by the students, check the attendance and progress of the students and counsel them periodically.If necessary, the Class Advisor may display the cumulative attendance particulars in the Department notice board and also discuss with or inform the Parents/Guardian about the progress of the students. Each student shall be provided with course plan for each course at the beginningof each semester.

## 8. CLASS COMMITTEE

**8.1.** Every class shall have a class committee consisting of teachers of the class concerned, Maximum of six student representatives [boys and girls] and the concerned Head of the Department. It is like the 'Quality Circle' with the overall goal of improving the teaching-learning process. The functions of the class committee include

- Clarifying the regulations of the degree programme and the details of rules therein particularly Clause 4 and 5 which should be displayed on Department Notice-Board.
- Informing the student representatives, the details of Regulations regarding weightage used for each assessment. In the case of practical courses (laboratory / drawing / project work / seminar, 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.
- Solving problems experienced by students in the class room and in the laboratories.
- Informing the student representatives, the academic schedule, including the dates of assessments and the syllabus coverage for each assessment.
- Analyzing the performance of the students of the class after each test and finding the ways and means of solving problems, if any.
- Identifying the weak students, if any and requesting the teachers concerned to provide some additional academic support.

**8.2** The class committee for a class under a particular branch is normally constituted by the Head of the Department. However, if the students of different branches are mixed in a class (like the first semester which is generally common to all branches), the class committee is to be constituted by the Dean.

**8.3** The class committee shall be constituted within the first week of each semester.

**8.4** The Chairperson of the Class Committee may convene the meeting of the class committee.

**8.5** The Dean may participate in any Class Committee of the Faculty.

**8.6** The Chairperson is required to prepare the minutes of every meeting, submit the same to Dean through the HOD within two days of the meeting and arrange to circulate it among the students and teachers concerned. If there are some points in the minutes requiring action by the Management, the same shall be brought to the notice of the Registrar by the HOD through Dean.

**8.7** The first meeting of the Class Committee shall be held within one week from the date of commencement of the semester, in order to inform the students about the nature and weightage of assessments within the framework of the regulations. Two subsequent meetings may be held in a semester at suitable intervals. During these meetings the student members representing the entire class, shall meaningfully interact and express their opinions and suggestions of the other students of the class in order to improve the effectiveness of the teaching-learning process.

## 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 teachers handling the common course with one of the nominated as Course Coordinator. The nomination of the Course Coordinator shall be made by the Dean depending upon whether all the teachers teaching the common course belong to a single department or to several departments. The 'Course Committee' shall meet to arrive at a common scheme of evaluation for the test and shall ensure a uniform evaluation of the tests. Where ever feasible, the Course Committee may also prepare a common question paper for the Internal Assessment test(s).

## 10. PROCEDURE FOR AWARDING MARKS FOR INTERNAL ASSESSMENT

**10.1** Every teacher is required to maintain an 'ATTENDANCE AND ASSESSMENT RECORD'(Log book) which consists of attendance marked in each theory or practical or project work class, the test marks and the record of class work (topic covered), separately for each course.

**10.2** Continuous Internal Assessment (CIA): The performance of students in each course will be continuously assessed by the respective teachers as per the guidelines given below:

a. **THEORY COURSES**

| S. No. | CATEGORY | MAXIMUM MARKS |
|---|---|---|
| 1. | Assignment | 5 |
| 2. | Seminar * | 5 |
| 3. | Attendance | 5 |
| 4. | Test – I | 12.5 |
| 5. | Test – II | 12.5 |
| **Continuous Internal Assessment: TOTAL** | | 40 |

*Evaluation shall be made by a committee.

**PATTERN OF TEST QUESTION PAPER (Test I & II)**

| INSTRUCTION | REMARKS |
|---|---|
| **Maximum Marks** | 100 |
| **Duration** | 3 Hours |
| **Part – A** | Question no. 1 to 10 Two Mark Questions, covering two and half units. **(10 x 2= 20 Marks)** |
| **Part- B** | Question 11 to 15 will be of either-or type, covering two and half units of the syllabus. Each Question may have subdivision. **(5 x 16=80 Marks).** |

**b. PRACTICAL COURSES:**

| S. No | CATEGORY | MAXIMUM MARKS |
|---|---|---|
| 1. | Attendance | 5 |
| 2. | Observation work | 5 |
| 3. | Record work | 5 |
| 4. | Internal Practical Assessment | 15 |
| 5. | Viva – Voce [Comprehensive] | 10 |
| **Continuous Internal Assessment: TOTAL** | | 40 |

Every practical exercise / experiment shall be evaluated based on the conduct of exercise/ experiment and records maintained.

c. **INTEGRATED THEORY AND PRACTICAL COURSES**:

The Continuous Internal Assessment for Integrated Theory and Practical Course is awarded for 40 Marks with mark split up similar to regular theory course. But Assignment and Seminar components are replaced by Observation and Record marks.

| S.No. | CATEGORY | MAXIMUM MARKS |
|---|---|---|
| 1. | Observation | 5 |
| 2. | Record | 5 |
| 3. | Attendance | 5 |
| 4. | Test –I | 12.5 |
| 5. | Test –II | 12.5 |
| **Continuous Internal Assessment: TOTAL** | | 40 |

The external evaluation of integrated practical component from End Semester Examination is conducted for 50 Marks and later scaled down to 15 Marks and similarly the external evaluation for integrated theory from End Semester Examination is awarded for 100 Marks and later scaled down to 45 Marks. Hence the external assessment for integrated theory and practical components contribute to 60 Marks.

## 10.3 ATTENDANCE

**Attendance carries a maximum of 5 marks and the distribution is as under:**

| S. No. | Attendance % | Marks |
|---|---|---|
| 1 | 91 and above | 5.0 |
| 2 | 81-90 | 4.0 |
| 3 | 76-80 | 3.0 |

**10.4 PROJECT WORK/ INTERNSHIPS:**

Final year project work will be normally in-house. However, as a special case, if a student is able toget a project from a government organization or private or public sector company, the student may be permitted to do his/her project work in that institution/research organization/industry. REQUIREMENTS FOR APPEARING FOR END SEMESTER EXAMINATION (ESE)

A candidate shall normally be permitted to appear for the ESE of any semester commencing from I semester if he/she has satisfied the semester completion requirements (Subject to Clause 5) and has registered for Examination in all courses of the semester. Registration is mandatory for Semester Examinations as well as arrear Examinations failing which the candidate will not be permitted to attend the next semester. A candidate already appeared for a course in a semester and passed the Examination is not entitled to reappear in the same course of the semester for improvement of grade.

**11. END SEMESTER EXAMINATION**

ESE will be held at the end of each semester for each course, for 100 marks, later scaled down to 60 marks.

**PATTERN OF ESE QUESTION PAPER:**

| INSTRUCTION | REMARKS |
|---|---|
| **Maximum Marks** | 100 |
| **Duration** | 3 Hours |
| **Part – A** | Question no. 1 to 10 Two Mark Questions, covering all the 5 units.<br>**(10 x 2= 20 Marks)** |
| **Part- B** | Question 11 to 15 will be of either or type, covering Five units of the syllabus. Each Question may have subdivision.<br>**(5 x 16=80 Marks).** |

**12. PASSING REQUIREMENTS**

**12.1** Minimum marks to pass: The minimum marks to pass for CIA is 20 (i.e. out of 40 marks). The minimum marks to pass for ESE is 30 (i.e. out of 60 marks). The overall minimum marks to pass for theory/laboratory course is 50 (Sum of his/her score in CIA and ESE) out of 100 marks.

**12.1.1** The minimum marks to pass for Value Added Course /Skill Development is 50 marks out of 100marks. There will be two tests, the first covering 50% of syllabus for 50 marks and the other for 50 marks.

**12.2** If the candidate fails to secure a pass in ESE of a particular course, it is mandatory that candidate shall register and reappear for the Examination in that course during the subsequent semester when Examination is conducted in that course. Further the candidate should continue to register and reappear for the Examination till a pass is secured in such supplementary Examination within the stipulated maximum duration of the programme (Clause 5.1).

The CIA marks obtained by the candidate in his/her first or subsequent appearance were he/she secures a pass shall be retained by the office of the Controller of Examinations and considered valid for all remaining attempts till the candidate secures a pass in his/her ESE.

**12.3** If the candidate fails to secure a pass in CIA of a particular course, it is mandatory that candidate shall register and reappear for the CIA in that course during the subsequent semester when CIA is conducted in that course by the faculty member assigned for that particular course during that semester by the concerned HOD. Further, the candidate should continue to register and reappear for the CIA till a pass is secured in such subsequent Examination within the stipulated maximum duration of the programme (Clause 5.1).

**12.3.1** If a candidate fails to secure a pass in Value Added Course /Skill Development course, he/she has to appear for the tests when course is conducted subsequently.

**12.4 CREDIT TRANSFER THROUGH MOOC**

The MOOC coordinator shall assist the students for the online courses offered by the SWAYAM platform periodically and also monitor their course.

Open Elective Courses shall be considered for the credit transfer. Only courses available in SWAYAM platform (which are totally beyond the scope of the programme under consideration) shall be considered as open elective courses and get completed at any time within the duration of the Programme before the last semester. This is a mandatory requirement for completion of the programme. At least 2 Open Electives (3 credits each) to be completed for the credit transfer.

**13. AWARD OF LETTER GRADES**

**13.1** All assessments of a course will be done on absolute mark basis. However, for the purpose of reporting the performance of a candidate letter grades, each carrying certain number of points will be awarded as per the range of total marks (out of 100) obtained by the candidate in each subject as detailed below:

| Letter grade | Marks Range | Grade Point | Description |
|---|---|---|---|
| O | 91 - 100 | 10 | OUTSTANDING |
| A+ | 81- 90 | 9 | EXCELLENT |
| A | 71-80 | 8 | VERY GOOD |
| B+ | 66- 70 | 7 | GOOD |
| B | 61 – 65 | 6 | ABOVE AVERAGE |
| C | 55 - 60 | 5 | AVERAGE |
| D | 50 - 54 | 4 | PASS |
| RA | <50 | - | REAPPEARANCE |
| AB | | 0 | ABSENT |

**13.2 GRADE SHEET**

After results are declared, Grade sheet will be issued to each student which will contain the following details:

i. The list of courses enrolled during the semester and the grade scored,

ii. The Grade Point Average (**GPA**) for the semester and

iii. The Cumulative Grade Point Average (**CGPA**) of all courses enrolled from first semester onwards.

**GPA** is the ratio of the sum of the products of the number of Credits (**C**) of courses enrolled and the Grade Points (**GP**) corresponding to the grades scored in those courses, taken for all the courses to the sum of the number of credits of all the courses in the semester.

$$\text{GPA} = \frac{\text{Sum of } [C * GP]}{sum\ of\ c}$$

**CGPA** will be calculated in a similar manner, considering all the courses enrolled from First semester. **RA** grade and value added course will be excluded for calculating **GPA** and **CGPA**.

### 13.3 REVALUATION

Revaluation and Re-totaling are allowed on representation. A candidate can apply for revaluation of his/her semester Examination answer paper in a theory course, within 2 weeks from the declaration of results, on payment of a prescribed fee through proper application to the Controller of Examinations through the Head of the Department and Dean. A candidate can applyfor revaluation of answer scripts for not exceeding 5 subjects at a time. The Controller of Examinations will arrange for the revaluation and the results will be intimated to the candidate through the Head of the Department and Dean. Revaluation is not permitted for Supplementary Examinations, Practical Examinations, Technical Seminars, In-plant Training and Project Work.

### 13.4 TRANSPARENCY AND GRIEVANCE COMMITTEE

A student may get the Photostat copy of the answer script on payment of prescribed fee, if he/she wishes. The students can represent the grievance, if any, to the Grievance Committee, which consists of Dean of the Faculty, (if Dean is HoD, the Dean of another Faculty nominated by the University), HoD of the Department concerned, the faculty of the course and Dean from other discipline nominated by the University and the CoE. If the Committee feels that the grievance is genuine, the script may be sent for external valuation; the marks awarded by the External Examiner will be final. The student has to pay prescribed fee for the same.

## 14. ELIGIBILITY FOR AWARD OF DEGREE

**A student shall be declared to be eligible for award of Degree if he/she has**

- Successfully gained the required number of total credits as specified in the curriculum corresponding to his/her programme within the stipulated time.

The award of the degree must be approved by the Board of Management of Karpagam Academy of Higher Education.

## 15. CLASSIFICATION OF THE DEGREE AWARDED

**15.1** A candidate who qualifies for the award of the Degree (vide Clause 15) having passed the Examination in all the courses in his/her first appearance within the specified minimum number

of semesters (vide Clause 5.1) securing a CGPA of not less than **7.5** shall be declared to have passed the Examination in First Class with Distinction.

**15.2** A regular candidate or a lateral entrant is eligible to register forBE(Honors), B.Tech.(Honors). If, he / she has passed all the courses in the first appearance and holds / maintains a CGPA of 7.5 upto VIII Semester, he / she has to take an additional 20 credits by studying online courses through Swayam/NPTEL. Such a candidate is eligible for the award of BE(Honors), B.Tech.(Honors). However, if he / she fails in securing 20 additional credits but maintains CGPA of 8 and above is not eligible for Honors degree but eligible for First class with Distinction.

**15.3**A candidate who qualifies for the award of the Degree (vide Clause 15) having passed the Examination in all the courses within the specified minimum number of semesters (vide Clause 5.1) plus one year (two semesters), securing CGPA of not less than **6.5** shall be declared to have passed the Examination in First Class.

**16.3** All other candidates (not covered in Clauses 17.1 and 17.2) who qualify for the award of the degree (vide Clause 15) shall be declared to have passed the Examination in Second Class.

**16. SUPPLEMENTARY ESE:** After the publication of VIII semester results, if a student has **ONE** arrear in any theory course of the entire programme, he/she will be permitted to apply within 15 days of the publication of results, and appear for supplementary Examination.

## 17. DISCIPLINE

Every student is required to observe discipline and decorous behavior both inside and outside the University and not to indulge in any activity which will tend to bring down the prestige of the University. The erring student will be referred to the Disciplinary Committee constituted by the University, to enquire in to acts of indiscipline and recommend to the University about the disciplinary action to be taken.

If a student indulges in malpractice in any of the ESE/CIA he/she shall be liable for punitive action as prescribed by the University from time to time.

## 18. ADVANCED LEARNERS, ON-DEMAND EXAMINATION

Students

1. Who secure 7.5 CGPA and maintain an attendance of 75% in every semester

2. Clear all the courses in their first appearance itself are referred to as advanced learners. When a student fails to maintain any of the above conditions at any given time, he cannot be an advanced learner further.

When a student fails to maintain any of the above conditions at any given time, he cannot be an advanced learner further. These students can request for an on-demand examination for the courses in their forthcoming semester(s). These students on prior permission can appear for such examinations well in advance and complete the entire courses well before the prescribed period of study and can progress for a

full time Research Project/Internship/Minor Project during the remaining prescribed period of study. The Internal and External examinations will be conducted for these courses as like the other courses. One or more faculty mentors will be allocated based on the number of students/courses enrolled for the on-demand examination.

Also, these advanced learners can also register for online courses from NPTEL/SWAYAM/SWAYAM Plus portals on prior and proper approval from the department. The credits earned from those courses will be transferred to the mark statement of the students.

## 19. REVISION OF REGULATION AND CURRICULUM

The University may from time-to-time revise, amend or change the Regulations, Scheme of Examinations and syllabi, if found necessary on the recommendations of Board of Studies, Academic Council and Board of Management of Karpagam Academy of Higher Education.

## 20. CREDIT TRANSFER THROUGH ONLINE / INTERNATIONAL STUDIES

Students are encouraged to enroll in courses offered by MOOC platforms and international institutions of higher learning, either virtually or in person. The equivalent credits for these courses will be determined by a committee named Subject Equivalency Committee comprising the Dean, Head of Department (HoD), and one faculty member nominated by the Vice Chancellor. The committee's decision will be submitted for ratification/approval by the Board of Studies (BoS) and the Academic Council. Additionally, the equivalent grade points for marks/grades/grade points awarded by various MOOC platforms and international institutions of higher learning will be determined by a committee named Grade Equivalency Committee duly constituted by the Vice-Chancellor. The decisions of this committee will also be submitted for ratification/approval by the Academic Council. This shall be approved to be implemented from the even semester of the academic year 2024-25.

## 21.KARPAGAM INNOVATION AND INCUBATION COUNCIL (KIIC)
## (A Section 8 Company)

Based on the 2019 National Innovation and Startup Policy and the 2019–2023 Tamil Nadu Startup Policy, KIIC has recommended to the KAHE students who are affiliated with the KIIC that it be incorporated in the university Program Regulations 2023-24 and implement from this academic year.

### 21.1 Norms to Student Start-Ups

a) Any (UG/PG /(Ph.D.) Research scholars, student, right from the first year of their programme is allowed to set a startup (or) work part time/ full time in a startup or work as intern in a startup

b) Any (UG/PG / (Ph.D.) Research scholars) student right from the first year of their programme is allowed to earn credit for working on Innovative prototypes/business Models/ Pre incubation(case to case basis). Start Up activities will be evaluated based on the guidelines being given by the expert committee of the KIIC

c) Student Entrepreneurs may use the address of incubation center (KIIC) to register their venture while studying in KAHE.

d) Students engaged in startups affiliated with the KIIC or those who work for them may be exempted

from KAHE's attendance requirements for academic courses under current regulations, up to a maximum of 30% attendance per semester, including claims for ODs and medical emergencies Potential Students who have been incubated at KIIC may be permitted to take their University semester exams even if their attendance is below the minimum acceptable percentage, with the proper authorization from the head of the institution.

(On case-to-case basis depends upon the applicability strength, societal benefits and quality of the Innovation and Subsequent engagement of the students with the/ her business)

e) Any Students Innovators/entrepreneurs are allowed to opt their startup in place mini project /major project, /seminar and summer training etc. (In plant training, Internship, value added Course.). The area in which the student wishes to launch a Startup may be interdisciplinary or multidisciplinary.

f) Student's startups are to be evaluated by Expert committee, formed by KIIC and KAHE.

**21.2 Guide lines to award Credits/ Marks to a Student startup**

Student's startup stages are divided into five phases and these startup phases can be considered equally in place of the course title as mentioned below with the same credits allotted to the course title in a university curriculum.

| Sl. No. | Description/Startup phases | In place of the Subject / Course title | Grades/Credits /Marks |
|---|---|---|---|
| 1 | Idea stage/Problem Identification | Seminar | Same Marks/Credits can be awarded that are listed in the course title's curriculum for the respective startup phases. |
| 2 | Proof of Concept (POC) /Solution development | In-plant training /Internship | |
| 3 | Product Development (Lab scale) /Prototype Model/ Company Registered | Mini Project/ Value added Course | |
| 4 | Validation/Testing | Main Project phase I | |
| 5 | Business Model/Ready for Commercialization/Implementation | Main Project phase II | |

# KARPAGAM ACADEMY OF HIGHER EDUCATION
## FACULTY OF ENGINEERING
## DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
## UG PROGRAM (CBCS) – B.E –EEE (FULL TIME)
## (2024–2025 Batch and onwards)

| Course Code | Name of the course | Category | Outcomes & Specific Outcomes | | Instruction hours/week | | | Credits | Maximum Marks | | | Page No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PO | PSO | L | T | P | | CIA | ESE | Total | |
| | | | | | | | | | 40 | 60 | 100 | |
| **SEMESTER - I** | | | | | | | | | | | | |
| 24BECC101 | Technical English I | HS | 8,9,10,12 | - | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 09 |
| 24BECC102 | Matrices and Calculus | BS | 1,2,3,12 | 2 | 3 | 1 | 0 | 4 | 40 | 60 | 100 | 11 |
| 24BEEE141 | Semiconductor Physics | BS | 1,2,3,6,9, 12 | 2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 13 |
| 24BEEE142 | Electric Circuit Analysis | ES | 1,2,3,4,8,9,10,12 | 1 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 16 |
| 24BECC143 | Programming in C | ES | 1,2,3,4,12 | 2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 18 |
| 24BEMC151 | Women Safety and Security* | MC | - | - | 1 | 0 | 0 | 0 | 100 | 0 | 100 | 21 |
| 24BEMC152 | தமிழர் மரபும் பண்பாடும்* | MC | - | - | 1 | 0 | 0 | 0 | 100 | 0 | 100 | 23 |
| | | | | **Semester Total** | **17** | **1** | **6** | **19** | **400** | **300** | **700** | |
| **SEMESTER - II** | | | | | | | | | | | | |
| 24BECC201 | Technical English II | HS | 8,9,10,12 | 2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 24 |
| 24BECC202A | Graph Theory | BS | 1,2,3,12 | 2 | 3 | 1 | 0 | 4 | 40 | 60 | 100 | 26 |
| 24BEEE241 | Environmental Chemistry | BS | 1,2,3, 4, 6,7,8,9,12 | 2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 28 |
| 24BEEE242 | Electronic Devices and Circuits | ES | 1,2,3,4,8,9,10,12 | 1 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 31 |
| 24BECC243 | Data Structures | ES | 1,2,3,4,5,6,7,12 | 2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 34 |
| 24BEEE244 | Measurements and Instrumentation | ES | 1,2,3,4,6,8,9,10, 12 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 37 |
| 24BECC211 | Communication Skills Laboratory | ES | 5,8,9,10,12 | 2 | 0 | 0 | 2 | 1 | 40 | 60 | 100 | 40 |
| 24BEMC251 | Yoga | MC | - | - | 0 | 0 | 4 | 2 | 100 | 0 | 100 | 42 |
| | | | | **Semester Total** | **18** | **1** | **14** | **26** | **380** | **420** | **800** | |

| Course Code | Name of the course | Category | Outcomes & Specific Outcomes | | Instruction hours/week | | | Credits | Maximum Marks | | | Page No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PO | PSO | L | T | P | | CIA | ESE | Total | |
| | | | | | | | | | 40 | 60 | 100 | |
| **SEMESTER - III** | | | | | | | | | | | | |
| 24BEEE301 | Numerical Methods | BS | 1,2,3,12 | 2 | 3 | 1 | 0 | 4 | 40 | 60 | 100 | 44 |
| 24BEEE302 | Transmission and Distribution | PC | 1,2,3,4,8, 12 | 1,2 | 3 | 1 | 0 | 4 | 40 | 60 | 100 | 46 |
| 24BEEE341 | Digital Electronics | PC | 1,2,3,4,5,8,9,10 ,12 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 48 |
| 24BEEE342 | Linear Integrated Circuits | PC | 1,2,3,4, 8,9,10,12 | 1 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 50 |
| 24BEEE343 | Electrical Machines I | PC | 1,2,3,4, 8,9,10,12 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 53 |
| 24BEEE344 | OOPS and JAVA | PC | 1,2,3,5,9,12 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 55 |
| 24BEEE391 | Internship-I/ Mini project-I | PC | 1,2,3,4,5,6,7,8, 9, 10,11,12 | 1,2 | 0 | 0 | 2 | 1 | 100 | 0 | 100 | 58 |
| 24BEMC351 | Design Thinking | MC | 3,4,7,8,9,10,12 | 2 | 1 | 0 | 0 | 1 | 100 | 0 | 100 | 59 |
| 24BEMC352 | Aptitude and Reasoning | MC | 1,2,3,12 | - | 0 | 0 | 2 | 0 | 100 | 0 | 100 | 61 |
| **Semester Total** | | | | | **19** | **2** | **12** | **26** | **540** | **360** | **900** | |
| | | | | | | | | | | | | |
| **SEMESTER - IV** | | | | | | | | | | | | |
| 24BEEE401 | AI for Electrical Engineers | PC | 1,2,3,4,9,10,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 63 |
| 24BEEE441 | Electrical Machines – II | PC | 1,2,3,4,8,9,10, 12 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 65 |
| 24BEEE442 | Microprocessors and Microcontrollers | PC | 1,2,3,4,8,9,10, 12 | 1 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 67 |
| 24BEEE443 | Web Programming | PC | 1,2,3,5,9 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 69 |
| 24BEEE444 | Power System Analysis and Stability | PC | 1,2,3,4,8,9,10, 12 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 72 |
| 24BEEE4E_ _ | Professional Elective I | PE | - | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | |
| 24BEMC451 | Community Engagement and Social Responsibility | MC | - | 1 | 1 | 0 | 2 | 2 | 100 | 0 | 100 | 74 |
| 24BEMC452 | Foundation of Entrepreneurship | MC | - | 1,2 | 1 | 0 | 0 | 0 | 100 | 0 | 100 | 76 |
| 24BEMC453 | Essence of Traditional Indian Knowledge and Heritage | MC | - | - | 1 | 0 | 0 | 0 | 100 | 0 | 100 | 78 |
| **Semester Total** | | | | | **21** | **0** | **10** | **24** | **540** | **360** | **900** | |

| Course code | Name of the course | Category | Outcomes & Specific Outcomes | | Instruction hours / week | | | Credit(s) | Maximum Marks | | | PAGE NO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PO | PSO | L | T | P | | CIA | ESE | Total | |
| | | | | | | | | | 40 | 60 | 100 | |
| **SEMESTER - V** | | | | | | | | | | | | |
| 24BEEE501 | Renewable Energy Systems | PC | 1,2,3,4,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 79 |
| 24BEEE502 | Electric Vehicle Technology | PC | 1,2,3,4,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 81 |
| 24BEEE541 | Power Electronics | PC | 1,2,3,4,8, 9,10,12 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 83 |
| 24BEEE542 | Embedded Systems and IoT | PC | 1,2,3,4,8,9,10 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 85 |
| 24BEEE543 | Control Systems | PC | 1,2,3,4,5, 8,9,10,12 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 87 |
| 24BEEE5E_ _ | Professional Elective II | PE | - | - | 3 | 0 | 0 | 3 | 40 | 60 | 100 | |
| 24BEEE511 | Internship II/ Mini Project II | PC | 1,2,3,4,5,6,7,8,9, 10,11,12 | - | 0 | 0 | 2 | 1 | 100 | 0 | 100 | 89 |
| 24BESD512 | Skill Development -I (Design and Simulation of Renewable Energy Systems) | SD | 1,2,3,5,9,12 | 1 | 0 | 0 | 2 | 1 | 100 | 0 | 100 | 90 |
| 24BEMC551 | Cryptography and Cyber Security | MC | - | - | 1 | 0 | 0 | 0 | 100 | 0 | 100 | 92 |
| **Semester Total** | | | | | **19** | **0** | **10** | **23** | **540** | **360** | **900** | |
| **SEMESTER - VI** | | | | | | | | | | | | |
| 24BEEE601 | Smart Grid | PC | 1,2,3,4,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 94 |
| 24BEEE602 | Digital Power System Protection | PC | 1,2,3,4,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 96 |
| 24BEEE641 | Industrial Automation | PC | 1,2,3,4,5,8,9,10,12 | 2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 98 |
| 24BEEE642 | Electric Drives and Control | PC | 1,2,3,4,8,9,10 | 1,2 | 3 | 0 | 2 | 4 | 40 | 60 | 100 | 100 |
| 24BEEE6E_ _ | Professional Elective III | PC | - | - | 3 | 0 | 0 | 3 | 40 | 60 | 100 | |
| 24BEEE6E_ _ | Professional Elective IV | PE | - | - | 3 | 0 | 0 | 3 | 40 | 60 | 100 | |
| 24BEEEOE_ | Open Elective I (SWAYAM NPTEL) | OE | | | 0 | 0 | 0 | 3 | 0 | 0 | 100 | |
| 24BEEE691 | Mini Project III | PC | 1,2,3,4,5,6,7,8,9, 10,11,12 | | 0 | 0 | 2 | 1 | 40 | 60 | 100 | 102 |
| 24BEMC651 | Universal Human Values | MC | 6,8,9, 12 | | 2 | 0 | 0 | 2 | 100 | 0 | 100 | 103 |
| 24BESD611 | Skill Development -II (PCB Design) | SD | 1,2,5,9,12 | 1 | 0 | 0 | 2 | 1 | 100 | 0 | 100 | 105 |
| **Semester Total** | | | | | **23** | **0** | **8** | **27** | **480** | **420** | **1000** | |

| Course Code | Name of the course | Category | Outcomes & Specific Outcomes | | Instruction hours/week | | | Credits | Maximum Marks | | | Page No |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PO | PSO | L | T | P | | CIA | ESE | Total | |
| | | | | | | | | | 40 | 60 | 100 | |
| **SEMESTER - VII** | | | | | | | | | | | | |
| 24BEEE701 | Principles of Management and Engineering Ethics | HS | 1,2,3 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 107 |
| 24BEEEOE_ | Open Elective II (SWAYAM NPTEL) | OE | | | 0 | 0 | 0 | 3 | 0 | 0 | 100 | |
| 24BEEE791 | Project Work Phase 1 | PROJ | 1,2,3,4, 5,6,7,8, 9,10.11,12 | 1,2 | 0 | 0 | 8 | 4 | 40 | 60 | 100 | 109 |
| **Semester Total** | | | | | **3** | **0** | **8** | **10** | **80** | **120** | **300** | |
| **SEMESTER - VIII** | | | | | | | | | | | | |
| 24BEEE891 | Project Work Phase-II | PROJ | 1,2,3,4, 5,6,7,8, 9,10.11,12 | 1,2 | 0 | 0 | 16 | 8 | 120 | 180 | 300 | 110 |
| **Semester Total** | | | | | **0** | **0** | **16** | **8** | **120** | **180** | **300** | |
| **Program Total** | | | | | | | | **163** | **3080** | **2520** | **5800** | |

**TOTAL CREDITS: 163**

**PROFESSIONAL ELECTIVE COURSES**

| POWER AND ENERGY ENGINEERING | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Code | Course Title | Category | Outcomes & Specific Outcomes | | Instruction hours/week | | | Credits | Maximum Marks | | | PAGE NO |
| | | | PO | PSO | L | T | P | | CIA | ESE | Total | |
| | | | | | | | | | 40 | 60 | 100 | |
| 24BEEEXXX | Utilization and Conservation of Electrical Energy | PE | 1,2,3,4,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 111 |
| 24BEEEXXX | Under Ground Cable Engineering | PE | 1,2,3,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 113 |
| 24BEEEXXX | Substation Engineering and Automation | PE | 1,2,3,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 115 |
| 24BEEEXXX | Energy Auditing and Management | PE | 1,2,3,6,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 117 |
| 24BEEEXXX | Power Quality | PE | 1,2,3,4,6,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 119 |
| 24BEEEXXX | Power System Operation and Control | PE | 1,2,3,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 121 |
| 24BEEEXXX | Restructured Power Market | PE | 1,2,3,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 123 |
| 24BEEEXXX | Electrical Safety | PE | 1,2,3,6,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 125 |
| **CONVERTERS AND DRIVES** | | | | | | | | | | | | |
| Course Code | Course Title | Category | Outcomes & Specific Outcomes | | Instruction hours/week | | | Credits | Maximum Marks | | | PAGE NO |
| | | | PO | PSO | L | T | P | | CIA | ESE | Total | |
| | | | | | | | | | 40 | 60 | 100 | |
| 24BEEEXXX | Analysis of Electrical Machines | PE | 1,2,3, 8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 127 |
| 24BEEEXXX | Multilevel Power Converters | PE | 1,2,3,5,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 129 |
| 24BEEEXXX | Advanced Electrical Drive Systems | PE | 1,2,3,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 131 |
| 24BEEEXXX | Switch Mode Converters | PE | 1,2,3,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 133 |
| 24BEEEXXX | Power Electronics for Renewable Energy Systems | PE | 1,2,3,4,5,7,8, 12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 135 |
| 24BEEEXXX | Control of Power Electronics Circuits | PE | 1,2,3,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 137 |
| 24BEEEXXX | HVDC and FACTS | PE | 1,2,3,4,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 139 |
| 24BEEEXXX | Digital Control in Power Electronics | PE | 1,2,3,4,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 141 |

| VEHICLE TECHNOLOGY | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Category** | **Outcomes & Specific Outcomes** | | **Instruction hours/week** | | | **Credits** | **Maximum Marks** | | | **PAGE NO** |
| | | | **PO** | **PSO** | **L** | **T** | **P** | | **CIA** | **ESE** | **Total** | |
| | | | | | | | | | **40** | **60** | **100** | |
| 24BEEEXXX | Electric and Hybrid Vehicle Architecture | PE | 1,2,3,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 143 |
| 24BEEEXXX | Design of Power Train for Electric Vehicles | PE | 1,2,3,4,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 145 |
| 24BEEEXXX | Electric Vehicle Design, Mechanics and Control | PE | 1,2,3,4,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 147 |
| 24BEEEXXX | Design of Charging Stations | PE | 1,2,3,4,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 149 |
| 24BEEEXXX | Testing of Electric Vehicles | PE | 1,2,3,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 151 |
| 24BEEEXXX | Grid Integration of Electric Vehicles | PE | 1,2,3,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 153 |
| 24BEEEXXX | Intelligent Control of Electric Vehicles | PE | 1,2,3,4,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 155 |
| 24BEEEXXX | Battery Management System for Electric Vehicles | PE | 1,2,3,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 157 |

| AUTOMATION AND CONTROL | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Category** | **Outcomes & Specific Outcomes** | | **Instruction hours/week** | | | **Credits** | **Maximum Marks** | | | **PAGE NO** |
| | | | **PO** | **PSO** | **L** | **T** | **P** | | **CIA** | **ESE** | **Total** | |
| | | | | | | | | | **40** | **60** | **100** | |
| 24BEEEXXX | Process Modelling and Simulation | PE | 1,2,3,5,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 159 |
| 24BEEEXXX | Computer Control of Processes | PE | 1,2,3,8 | 2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 161 |
| 24BEEEXXX | Non-Linear Control | PE | 1,2,3,8 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 163 |
| 24BEEEXXX | Machine Monitoring System | PE | 1,2,3,8 | 2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 165 |
| 24BEEEXXX | Robotics and Automation | PE | 1,2,3,8 | 2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 167 |
| 24BEEEXXX | Industrial Internet of Things | PE | 1,2,3,8 | 2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 169 |
| 24BEEEXXX | PLC and SCADA | PE | 1,2,3,8,12 | 1,2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 171 |
| 24BEEEXXX | Model Based Control | PE | 1,2,3,4,8 | 2 | 3 | 0 | 0 | 3 | 40 | 60 | 100 | 173 |

**PROGRAMME OUTCOMES:** On successful completion of the programme,

| PO# | PROGRAMME OUTCOMES |
|---|---|
| 1 | **Engineering knowledge:** Apply the Mathematical knowledge and the basics of Science and Engineering to solve the problems pertaining to Electronics and Instrumentation Engineering. |
| 2 | **Problem analysis:** Identify and formulate Electrical and Electronics Engineering problems from research literature and be ability to analyze the problem using first principles of Mathematics and Engineering Sciences. |
| 3 | **Conduct investigations of complex problems:** Come out with solutions for the complex problems and to design system components or process that fulfill the particular needs taking into account public health and safety and the social, cultural and environmental issues. |
| 4 | **Design/development of solutions:** Draw well-founded conclusions applying the knowledge acquired from research and research methods including design of experiments, analysis and interpretation of data and synthesis of information and to arrive at significant conclusion. |
| 5 | **Modern tool usage**: Form, select and apply relevant techniques, resources and Engineering and IT toolsfor Engineering activities like electronic prototyping, modeling and control of systems and also being conscious of the limitations. |
| 6 | **The Engineer and society**: Understand the role and responsibility of the Professional Electrical and Electronics Engineer and to assess societal, health, safety issues based on the reasoning received from the contextual knowledge. |
| 7 | **Environment and sustainability**: Be aware of the impact of professional Engineering solutions in societal and environmental contexts and exhibit the knowledge and the need for Sustainable Development. |
| 8 | **Ethics:** Apply the principles of Professional Ethics to adhere to the norms of the engineering practice and to discharge ethical responsibilities. |
| 9 | **Individual and teamwork:** Function actively and efficiently as an individual or a member/leader of differentteams and multidisciplinary projects. |
| 10 | **Communication:** Communicate efficiently the engineering facts with a wide range of engineering community and others, to understand and prepare reports and design documents; to make effective presentations and to frame and follow instructions. |
| 11 | **Project management and finance:** Demonstrate the acquisition of the body of engineering knowledge, insight and Management Principles and to apply them as member / leader in teams andmultidisciplinary environments. |
| 12 | **Life-long learning:** Recognize the need for self and life-long learning, keeping pace with technologicalchallenges in the broadest sense. |

**PROGRAMME SPECIFIC OUTCOMES:**

| PSO# | PROGRAMME SPECIFIC OUTCOMES |
|---|---|
| 1 | Analyze and design controllers for electrical system using analog and digital circuits and systems. |
| 2 | Use modern tools to solve real time problems in Electric Vehicle technology and Renewable Energy Systems. |

**PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)**

| PEO# | PROGRAMME EDUCATIONAL OBJECTIVES |
|---|---|
| PEO1 | Have successful technical and professional careers in their chosen fields such as circuit theory, Field theory, control theory and computational platforms. |
| PEO2 | Engross in life long process of learning to keep themselves a breast of new developments in the field of Electronics and their applications in power engineering. |

**MAPPING:**

| PEO\PO | 1 | 2 | 3 | 4 | 5 | 4 | 7 | 8 | 9 | 10 | 11 | 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PEO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | ✓ | ✓ | ✓ |
| PEO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | | | ✓ | ✓ |

**SEMESTER-I**

**24BECC101** **TECHNICAL ENGLISH I** **3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks:** Internal**:40** External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** English at 10+2 or equivalent level

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Reacquaint oneself with fundamental reading and writing skills, proper grammar usage, listening, and speaking
- Improve skills in listening and speaking, in expressing oneself formally in writing, and in deducing meaning from what one reads
- Enhance one's receptive (reading and listening) and productive (writing and speaking) language skills

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Replicate grammar usage in reading, speaking, and writing skills K2
- Describe precise transitions while reading, writing, and speaking to enhance communication coherence and clarity K2
- Report the interpretation of linguistic parameters in day-to-day reading, listening, and speaking interactions K2
- Point out errors to restructure paragraphs, compose, compile, and synthesize documents for presentations K2
- Demonstrate proficiency in reading, writing, and critical listening and the ability to interpret and articulate complex ideas persuasively in written and oral forms K3

**UNIT I** **9**

**Grammar** **:** Parts of Speech – Gerunds and infinitives – Sentence Pattern
**Reading** **:** Reading comprehension: (vocabulary, referents, and inferences/conclusions)
**Writing** **:** Business letter – e-mail Writing
**Listening** **:** Listening to different short recordings – Listen to a longer recording
**Speaking** **:** Introduction to Phonetics, Diphthongs

**UNIT II** **9**

**Grammar** **:** Tenses: Simple Tenses – Concord – Types of Sentences
**Reading** **:** Identifying main and secondary information
**Writing** **:** Check lists – Building Itineraries
**Listening** **:** Listening Comprehension – Job Description
**Speaking** **:** Pronunciation – Describing people, places, jobs and things – Asking and answering questions

**UNIT III** **9**

**Grammar** **:** Tenses: Progressive Tenses – Direct and Indirect speech – Concord
**Reading** **:** Identifying, organizing, comparing and Interpreting information
**Writing** **:** Writing Articles – Paragraph Writing

**Listening** : Telephonic conversation
**Speaking** : Stress, Intonation – Self Introduction

**UNIT IV** **9**
**Grammar** : Tenses: Perfect Tenses – Active and Passive voice
**Reading** : Reading Comprehension (Reconstruction, Rewording)
**Writing** : Memo – Notice – Agenda
**Listening** : Critical Listening
**Speaking** : Oral presentation

**UNIT V** **9**
**Grammar** : Tenses: Perfect Continuous Tenses – Reported Speech
**Reading** : Reading Comprehension (Cause and Effect identification)
**Writing** : Creative writing – Copy Writing
**Listening** : Listening and Interpretation of ideas
**Speaking** : Group Discussion

**TOTAL: 45**

**TEXT BOOKS:**

1. Richards J C, Hull J, et al., "Interchange 2 Student's Book", 5th Edition, Cambridge University Press, 2022.
2. Kumar Sanjay and Pushp Latha, "English Language and Communication Skills for Engineers", 1st Edition, Oxford University Press, 2018.

**REFERENCE BOOKS:**

1. Swan Michael and Walter Catherine, "Oxford English Grammar Course", 1st Edition, Oxford University Press, 2019.
2. Sudharshana N P and Savitha C, "English for Engineers", 1st Edition, Cambridge University Press, 2018.
3. Brook-Hart G, "Business Benchmark: Upper intermediate: Business Vantage: Student's Book", 2nd Edition, Cambridge University Press, 2021.

**WEB URLs:**

1. www.onestopenglish.com
2. www.britishcouncil.org
3. www.cambridgeenglish.org/learning-english/

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | - |
| CO2 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | - |
| CO3 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | - |
| CO4 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | - |
| CO5 | - | - | - | - | 2 | - | - | 2 | 2 | 2 | - | 2 | - | - |
| **Average** | **-** | **-** | **-** | **-** | **2** | **-** | **-** | **2** | **2** | **2.8** | **-** | **2** | - | - |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-I**

**24BECC102** **MATRICES AND CALCULUS** **4H-4C**

**Instruction Hours/week: L:3 T:1 P:0** **Marks: Internal:40** External**:60** Total**:100**
**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Nil

**COURSE OBJECTIVES:**
The goal of this course is for students to:

- Provide sufficient knowledge in calculus and matrix algebra in the respective fields
- Find an extremum value for a function of several variables subject to a given constraint.
- Provide knowledge in evaluating double and triple integrals
- Apply mathematical tools to solve second and higher order ODE and PDE with constant coefficients.

**COURSE OUTCOMES:**
Upon completion of this course, the student will be able to:

- Make use of orthogonal transformation to reduce the quadratic form to canonical form K3
- Utilize differential calculus of multivariable to optimization problems K3
- Apply multiple integrals for finding area and volume K3
- Solve the nth order Ordinary Differential Equations (ODE) and Homogeneous equation of Euler's type K3
- Solve the nth order Partial Differential Equations K3

**UNIT I MATRICES** **12**
Eigen values and Eigen vectors of a real matrix– Characteristic equation – Properties of Eigen values and Eigen vectors – Cayley-Hamilton theorem – Diagonalization of matrices by orthogonal transformation – Reduction of a quadratic form to canonical form by orthogonal transformation – Nature of quadratic forms.

**UNIT II DIFFERENTIAL CALCULUS OF MULTIVARIABLE FUNCTIONS** **12**
Partial differentiation – Homogeneous functions and Euler's theorem – Total derivative – Change of variables – Jacobians – Partial differentiation of implicit functions –Applications: Maxima and minima of functions of two variables – Lagrange's method of undetermined multipliers.

**UNIT III MULTIPLE INTEGRALS** **12**
Proper and Improper integrals - Bernoulli's extension formula – Double integrals – Change of order of integration – Double integrals in polar coordinates – Area using double integrals – Evaluation of Triple Integrals

**UNIT IV ORDINARY DIFFERENTIAL EQUATIONS** **12**
Linear differential equation of second and higher order with constant coefficients – Euler-Cauchy linear differential equation – Method of Variation of parameters.

**UNIT V PARTIAL DIFFERENTIAL EQUATIONS** **12**
Homogeneous linear partial differential equations of second and higher order with constant coefficients –

Classification of partial differential equations.

**TOTAL: 45+15**

**TEXT BOOKS:**

1. Hass, Heil and Weir, "Thomas Calculus", 14th Edition, Pearson Education, 2018.
2. Dennis G. Zill, "Advanced Engineering Mathematics", 7th Edition, Jones & Bartlett Learning, 2022.

**REFERENCE BOOKS:**

1. Rogawski, Adams and Franzosa, "Calculus", 4th Edition, W. H. Freeman, 2019.
2. Boyce, DiPrima and Meade, "Elementary Differential Equations and Boundary Value Problems", 12th Edition, John Wiley & Sons, 2021.
3. Alexander Graham, "Matrix Theory and Applications for Scientists and Engineers", 1st Edition, Dover Publications Inc.,2018.

**WEBSITES:**

1. www.classcentral.com/course/matrix-methods-13644
2. www.classcentral.com/course/brilliant-calculus-ii-59290
3. www.classcentral.com/course/differential-equations-engineers-13258

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **CO2** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **Average** | **3** | **2** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **1** | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-I**

**24BEEE141 SEMICONDUCTOR PHYSICS 5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40** External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Nil

**(i) THEORY**

**COURSE OBJECTIVES**

The goal of this course is for students to:

- Instill knowledge on physics of semiconductors, determination of charge carriers and device applications
- Establish a sound grasp of knowledge on different properties of materials such as magnetic and super conducting
- Make the students to understand the nano materials and its applications

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Relate the quantum concepts in electron microscope K2
- Identify the types of semiconductors and its carrier concentration using Hall effect K3
- Outline the basics of crystals, structures and its defects K2
- Utilize magnetic properties for finding B - H Curve K3
- Illustrate the properties of nano materials and its fabrication methods K2

**UNIT I QUANTUM PHYSICS 9**

Black body radiation - Energy Distribution laws (Qualitative): Stefan Boltzmann's law, Wein's Displacement law-Rayleigh Jeans Law. Photo electric effect (Qualitative) – Compton effect (Qualitative) – De Broglie hypothesis - uncertainty principle – physical significance of wave function - Schrödinger's Time dependent wave equation - Schrödinger's Time independent wave equation – Particle in one dimensional box- Scanning Electron Microscope and Transmission Electron Microscope.

**UNIT II SEMICONDUCTORS 9**

Properties of semiconductor, Types: Intrinsic and extrinsic semiconductors – Intrinsic carrier concentration, Dependence of Fermi level on carrier-concentration and temperature (equilibrium carrier statistics), Carrier transport: diffusion and drift - Hall Effect – Determination of Hall coefficient – Applications

**UNIT III CRYSTAL PHYSICS 9**

Classification of solids: Crystalline and amorphous solids – crystal structure - unit cell, primitive cell – seven crystal systems, Bravais lattices, Miller indices – inter-planar distances (Qualitative) - Coordination number and atomic packing factor for Simple Cubic, Body Centered Cubic, Face Centered Cubic– Defects in crystal: Point & Line defect.

**UNIT IV MAGNETIC AND SUPER CONDUCTING MATERIALS** **9**

Magnetic moment, magnetic dipoles - magnetic permeability and susceptibility, types of magnetic materials - Ferromagnetism, Domain Theory, Hysteresis on the basis of domains, hysteresis loss, soft and Hard magnetic materials – Superconductivity – Properties – Meissner effect – Effect of magnetic field – Types of superconductors – BCS theory of superconductivity — Applications of superconductors, cryotron and magnetic levitation.

**UNIT V NANO MATERIALS** **9**

Low-dimensional systems such as quantum wells, wires, and dots – Nanostructures: Synthesis of nanomaterials-top-down approach (Ball milling, Pulsed laser deposition and bottom-up approach (Chemical Vapour Deposition, Physical Vapour Deposition) – Carbon nanotubes: Properties and applications.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS**

1. Determination of Band gap of a semiconductor.
2. Characteristics of photo diode.
3. Viscosity of liquids - Determination of co-efficient of viscosity of a liquid by Poiseuille's flow.
4. Laser- Determination of the wave length of the laser using grating
5. Laser – Determination of Particle size
6. Optical Fiber – Determination of Numerical Aperture and Acceptance angle of the optical fiber
7. Air wedge – Determination of thickness of a thin sheet/wire.

**Total: 45+30**

**TEXT BOOKS:**


1. Bhattacharya D.K. & Poonam T., Engineering Physics, Oxford University Press, (2015).
2. S.O. Pillai, "Solid State Physics", 9th Edition. New Age International Publishers, 2020.
3. B.K. Pandey, S. Chaturvedi, Engineering Physics, Cengage Learning India Pvt. Ltd. 2nd Edition, (2022).
4. S.M. Sze, Kwok K. Ng, Physics of Semiconductor Devices, wiley Publishers, (2006).
5. William T Silfvast, Laser Fundamentals, Cambridge Univ Press. 2012.


**REFERENCES:**


1. Halliday.D. Resnick R. & Walker. J, Principles of Physics, Wiley, 2015.
2. Charles Kittel, Kittel's, Introduction to Solid State Physics, Wiley India Edition, 2019.
3. Donald A. Neamen, Semiconductor Physics and Devices, McGraw Hill Education private limited; 4th edition, (2021).
4. Leszek Malkinski, Advanced Magnetic Materials, Published by InTech, (2012).
5. Michael Shur, Physics of Semiconductor Devices, Published by Pearson Education; First edition, (2019).
6. Kulkarni, Sulabha K, Nanotechnology: Principles and Practices, Springer International Publishing, (2015).
7. R P Khare, Fiber Optics and Optoelectronics, Oxford, 2012


**WEB LINKS:**

1. www.nptel.ac.in/courses/115102025/
2. www.nptel.ac.in/courses/108/108/108108122/
3. www.ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-012-microelectronic-devices-and-circuits-fall-2009/lecture-notes/MIT6_012F09_lec01.pdf

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | - | - | - | - | - | - | 2 | 2 | - | 1 | - | - |
| **CO2** | 3 | 2 | - | - | - | - | - | - | 2 | 2 | - | 1 | - | 1 |
| **CO3** | 3 | 2 | - | - | - | - | - | - | 2 | 2 | - | 1 | - | - |
| **CO4** | 3 | 3 | 2 | - | - | 1 | - | - | 2 | 2 | - | 1 | - | 1 |
| **CO5** | 3 | 2 | - | - | - | - | - | - | - | 1 | - | 1 | - | 1 |
| **Average** | **3** | **2.2** | **2** | **-** | **-** | **1** | **-** | **-** | **2** | **1.8** | **-** | **1** | - | 1 |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-I**

**24BEEE142 ELECTRIC CIRCUIT ANALYSIS 5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks:** Internal**:40** External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Nil

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the concept of circuit elements, electrical connections, laws and networks
- Examine the electrical network using various analysis techniques and network theorems
- Explain the concept of types of AC circuits and its applications.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Compute the electric circuit parameters using Kirchhoff's laws K3
- Utilize the network theorems for calculation of parameters in electric network K3
- Examine the steady state and transient conditions of electrical networks K4
- Compute design parameters of resonance circuit and coupled circuit K3
- Solve three phase circuit for different loads and configurations K3

**UNIT I BASIC CIRCUIT CONCEPTS 10**

Basic electrical parameters – Terminologies – Ohm's law – Kirchhoff's laws – Source transformation – Voltage division – Current division – Series and parallel connections – Classification of circuit elements – Classification of networks – Star delta transformation – Introduction to AC circuits – Analysis of purely resistive, inductive, and capacitive circuits – Analysis of RL, RC, RLC series and parallel circuits.

**UNIT II NETWORK THEOREMS 9**

Mesh and Nodal analysis – Superposition Theorem – Thevenin's theorem – Norton's theorem – Maximum power transfer theorem – Reciprocity theorem.

**UNIT III RESONANCE AND COUPLED CIRCUITS 9**

Series resonance – Parallel resonance – Frequency response – Quality factor and bandwidth – Self and mutual inductance – Coupling coefficient – Dot rules – Single tuned circuits.

**UNIT IV THREE PHASE CIRCUITS 9**

Introduction to three phase circuits – Three phase star and delta connections – Phase sequence – Line and phase quantities – Analysis of three phase circuits with star and delta connected balanced and unbalanced loads – Two wattmeter method of power and power factor measurements in three phase circuits.

**UNIT V TRANSIENT RESPONSE ANALYSIS** **8**

Introduction to transients – Charging and Discharging a Capacitor – Switching inductive circuits – Laplace and Inverse Laplace transforms – Transient response of RL,RC and RLC circuits with Step and Sinusoidal inputs.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Verification of Ohm's law and Kirchhoff's laws
2. Verification of Nodal analysis and Mesh analysis
3. Verification of Superposition theorem
4. Verification of Thevenin's theorem and Norton's theorem
5. Verification of Maximum power transfer theorem
6. Transient Response of RL and RC circuits

**TOTAL: 45+30=75**

**TEXT BOOKS:**


1. Robert Boylestad L, Brian A. Olivari, "Introductory Circuit Analysis", 14th Edition, Pearson Education, 2022.
2. Thomas L. Floyd, David M. Buchla, "Principles of Electric Circuits", 10th Edition, Pearson Education, 2019.


**REFERENCE BOOKS:**


1. William Hayt H, Jr Jack E. Kemmerly, Jamie D.Phillps and Steven M. Durbin, "Engineering Circuit Analysis", 9th Edition, Tata McGraw Hill, 2020.
2. Kothari D P and Nagrath I J, "Basic Electrical Engineering", 4th Edition, Tata McGraw Hill Education, 2019.
3. Charles K. Alexander and Mathew N. O. Sadiku, "Fundamentals of Electric Circuits", 7th Edition, Tata McGraw Hill, 2022.
4. John Bird, "Electrical Circuit Theory and Technology", 7th Edition, Routledge, 2022.
5. Allan H. Robbins and Wilhelm C Miller, "Circuit Analysis: Theory and Practice", 5th Edition, Cengage Learning India Private Limited, 2012.


**WEB URLs:**

1. www.eie.polyu.edu.hk/~cktse/linear_circuits/main/node1.html
2. www.studysmarter.co.uk/explanations/physics/electricity-and-magnetism/circuit-analysis/
3. www.mit.edu/search/?q=circuit+theory#gsc.tab=0&gsc.q=circuit%20theory&gsc.page=1

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 3 | - |
| **CO2** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 3 | - |
| **CO3** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| **Average** | **3** | **2.2** | **1.2** | **1** | **-** | **-** | **-** | **1** | **1** | **1** | - | **1** | **2.4** | - |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-I**

**24BECC143** **PROGRAMMING IN C** **5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40** External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Nil

**(i) THEORY**

**COURSE OBJECTIVES**

The goal of this course is for students to:

- Understand problem solving using C
- Learn the arrays, strings and functions of C Language
- Develop C Programs using structures, unions and file handling.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Interpret problem solving aspect using C programming K2
- Construct solutions for computational problems by utilizing C constructs to ensure optimized performance and accuracy in program development K3
- Develop applications in C using functions and file handling K2
- Make use of pointers, structures, unions and arrays in C K3
- Solve the real-world problems using programming logics in C K2

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

Overview of computers and programming – Understanding computer systems – Programming logic– Steps in program development – Algorithm – Using pseudocode and flowchart – Types of programming languages – Compiler – Interpreter – Linker – Introduction to C – Structure of C program – Identifiers and Keywords – Data types – Constants and variables – Type conversion – Operators – Expressions. Formatted and Unformatted Input/output functions – Control structures.

**UNIT II ARRAYS AND STRINGS** **9**

Arrays in C – Declaring and initializing arrays in C – Defining and processing 1D and 2D arrays – Inserting and deleting elements of an array – Strings – Defining and initializing strings – Processing of string – Character arithmetic – String manipulation functions and library functions of string.

**UNIT III FUNCTIONS** **9**

Functions – Types of Functions – Function prototypes – Function definition – Function call including passing arguments by value and passing arguments by reference – Passing arrays to functions – Math library functions – Recursive functions – Scope rules (local and global scope) –Storage classes in C.

**UNIT IV POINTERS** **9**

Pointers – Pointer declaration and initialization – Types of pointers – Pointer expressions and arithmetic – Operations on pointers – Passing pointer to a function – Pointer and one-dimensional array – Pointers and strings – Command line arguments – Dynamic memory management functions.

**UNIT V USER DEFINED TYPES AND FILE HANDLING** **9**

User defined types – Enumerator – Typedef - Structures – Declaration of a structure – Accessing structures – Array of Structures – Structures and pointers – Nested structures – Bit fields – Unions – Declaration of a union – Accessing unions – Union vs Structure – files and Binary files – File handling – Text File Input/output – Preprocessor directives.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Create a program using operators and expressions in C.
2. Implement programs using arrays in C.
3. Develop programs to perform sort operations in C.
4. Write programs using functions and storage classes in C.
5. Create programs using pointers and function pointers in C.
6. Develop programs using structures and unions in C.
7. Construct programs using file handling and preprocessor directives in C.

**TOTAL: 45+30**

**TEXT BOOKS:**

1. Brian Kernighan and Dennis Ritchie, "The C Programming Language", 2nd Edition, Pearson, 2015.
2. Behrouz A. Forouzan, Richard F.Gilberg, "Computer Science: A Structured Programming Approach Using C", 3rd Edition, CENGAGE, 2022.

**REFERENCES:**

1. Reema Thareja, "Programming in C", AICTE Edition, Oxford University Press, 2019.
2. Balagurusamy, "Programming in ANSI C", 8th Edition, Mc Graw Hill Education, 2019.
3. Yashwant Kanetkar, "Let Us C", 17th Edition, BPB Publications, 2020.
4. Herbert Schildt, "C: The Complete Reference", 4th Edition, Mc Graw Hill Education, 2019.

**WEB URLs:**

1. https://www.programiz.com/c-programming
2. https://www.geeksforgeeks.org/c-programming-language/
3. https://onlinecourses.nptel.ac.in/noc24_cs02/preview

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - |
| **CO2** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | 1 |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | - | - | - | - | - | - | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - | - | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **Average** | **2.8** | **1.8** | **1** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **1** | **-** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-I**

**24BEMC151** **WOMEN SAFETY AND SECURITY** **1H – 0C**

**Instruction Hours/week: L:1 T:0 P:0** **Marks:** Internal**:100** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Nil

**COURSE OBJECTIVES:**

The goal of this course is for the students to

- Highlight the social construction of gender in Indian society and the role of social institutions in the socialization process.
- Make aware about the practical issues concerning gender and politics.
- Classify the students in engendering national policies and programmes.
- Observe the liability of women and women's work in the context of globalization.
- Acquaint knowledge about the political participation of women and the gendered structures of governance and polity.

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Infer into the basic concepts related to sex, gender, femininity etc.
- Demonstrate the rationale for women's studies
- Compare Gender Equality Issues and Movements in Women's Studies
- Summarize the Social construction of Gender, Gender Roles and Gender stereotyping.
- Illustrate Social Structures, Changing Status of Women in India.

**UNIT I FUNDAMENTAL CONCEPTS OF WOMEN'S STUDIES**

Definition- Objectives of Women's Studies; Importance of Women's Studies; Women's Studies as an Academic Discipline; Role of UGC Centre for Women's Studies

**UNIT II SOCIAL EMPOWERMENT**

Women in Higher Education; Gender issues in Health, Environment, Family welfare Measures, Indecent representation of Women in media; Women in Difficult circumstances; Constitutional.

**UNIT III POLITICAL EMPOWERMENT**

Women leaders in politics-Women in Local Governance- Barriers- Reservation policies- Women's Political Rights, Property Rights - Violence against Women -Women's work

**TEXT BOOKS:**

1. Amy S. Wharton. (2005). "The Sociology of Gender: An Introduction to Theory and Research". (Key Themes in Sociology) Blackwell Publishing, UK, Indian Reprint, Kilaso Books, New Delhi.
2. Devaki Jain and Pam Rajput (Ed). (2003). "Narratives from the Women's Studies Family: Recreating Knowledge, Sage, and New Delhi.
3. Jasbir Jain (Ed). (2005). "Women in Patriarchy: Cross Cultural". Rawat Publication Jaipur.

**SEMESTER-I**

**24BEMC152 தமிழர் மரபும் பண்பாடும் 1H-0 C**

கற்பித்தல் நேரம்/வாரம்: L:1 T:0 P:0 மதிப்பெண்: இடைத்தேர்வு: 100 மொத்தம்:100

**பாடத்திட்ட பயன் விளைவு:**

- வரலாற்றிற்கு முற்பட்ட தமிழகத்தை மாணவர்களுக்கு அறிமுகப்படுத்துதல்
- பழந்தமிழர் பண்பாடு சார்ந்த வாழ்க்கை முறையை மாணவர்கள் அறிய ஊக்குவித்தல்
- தமிழ் மொழியின் பழைமையும், திராவிட மொழிகளில் தமிழ்மொழியின் தனிச்சிறப்பையும் மாணவர்களுக்கு அறிமுகப்படுத்துதல்.
- தமிழர்களின் வாழ்வியல், தமிழர்கலைகள், ஆற்றங்கரைப்பண்பாடுகள் குறித்து மாணவர்கள் அறியச்செய்தல்.
- இந்தியக்குடியுரிமைப்பணி முதலான போட்டித்தேர்வுகளில் விருப்பப்பாடமாக இடம்பெறுகின்ற தமிழ்நாகரிகமும் பண்பாடும் குறித்த முழுமையான அறிமுகம் பெற்றிருத்தல்

**பாடத்திட்டப் பொதுநோக்கம்:**

- இந்தியக்குடியுரிமைப்பணி முதலான போட்டித்தேர்வுகளில், விருப்பப்பாடமாக இடம்பெறுகின்ற, 'தமிழ்இலக்கியவரலாறு' குறித்த முழுமையான அறிமுகம் பெற்றிருத்தல்.
- கல்வெட்டியல், ஓலைச்சுவடியியல் மற்றும் தொல்லியல் சார்ந்த ஆவணத்தேடலுக்குரிய ஆய்வுமனப்பான்மையுடன், இலக்கியங்களை அணுகுதல்.
- தமிழின்வளர்ச்சித்துறையாகிய, 'அறிவியல்தமிழ்'; 'இணையதமிழ்' குறித்த பன்நோக்கு அணுகுமுறையிலான ஆய்வுச்சிந்தனை மேம்பாடு.
- வேலைவாய்ப்புக்குரிய சுயதிறன் மேம்பாட்டுடன், படைப்பாக்கத்திறன் மேம்பாடும் பெற்றிருத்தல் .
- சமுதாய மற்றும் வாழ்வியல் மதிப்புகளைப்பேணுவதற்குக்கருவியாக இலக்கியங்களை நாடுகின்ற மனப்பான்மைவளர்ச்சி. மொழிபெயர்ப்புத்துறை சார்ந்த வேலைவாய்புத்திறன் பெற்றிருத்தல்.

**அலகு:1 தமிழர் மரபு**

மரபு-விளக்கம்-சங்ககால தமிழர் மரபு – திணைப்பகுப்பும் தமிழர் மரபும்-உலகப்பொதுமை – அகத்திணை மரபு – புறத்திணை மரபு- இடைக்காலத்தமிழர் மரபு – பிற்கால மரபும் மாற்றமும் – தற்கால தமிழர்மரபு - வளர்ச்சி.

**அலகு: 2 தமிழர் பண்பாடு**

பண்பாடு – விளக்கம் – பழந்தமிழர் பண்பாடு – இயற்கை சார்ந்த வாழ்வியல் – தமிழர் சமயம் – அரசியல் நிலை–சமூகப் பழக்கவழக்கங்கள் – நம்பிக்கைகள் – வாழ்வியல் அறங்கள் – வணிகம் போன்றவை.

**அலகு:3 தமிழர் கலைகள்**

தமிழகத்தில் கலைகளின் வளர்ச்சி – சிற்பக்கலை வளர்ச்சி –கோயில் கலை – கற்கோவில்கள் - ஓவியக்கலை – அழகுக்கலைகள் - கூத்துக்கலை – மருத்துவக்கலை – நாடகக்கலை– இசைக்கலை போன்றவை.

**அலகு: 4 தமிழர் சமயம்**

பழந்தமிழரின் சமயம் – சங்ககால சமயம் – தொல்காப்பியத்தில் சமயம் – சைவ சமயம் – வைணவம் – தமிழ்ப் பண்பாட்டில் பௌத்தம் – தமிழ்ப் பண்பாட்டில் சமணத்தின் தாக்கம்–தமிழ்ப் பண்பாட்டில் இசுலாம் மற்றும் கிறித்துவ சமயத்தின் தாக்கம்- தமிழர் பண்பாட்டில் விழாக்கள்- கோயில்களும் விழாக்களும்- சமூக ஒருங்கிணைப்பில் விழாக்களின் பங்கு-சங்க இலக்கியத்தில் விழாக்கள் பற்றிய குறிப்புகள்-இடைக்கால இலக்கியங்களில் விழாக்கள் பற்றிய செய்திகள் – விழாக்களின் சமூகப்பங்களிப்பு – தற்காலத்தில் தமிழர் விழாக்கள் - விளையாட்டும் விழாக்களும்.

**அலகு: 5 இலக்கியங்களில் தமிழர் பண்பாட்டுப் பதிவுகள்**

சங்க இலக்கியமும் வாழ்வியலும்-திருக்குறளில் வாழ்வியல் நெறிகள் – இரட்டைக் காப்பியங்களும் வாழ்வியலும் – சிற்றிலக்கியங்களில் வாழ்வியல் பதிவுகள்-இக்கால இலக்கியமும் வாழ்வியலும்.

**பார்வைநூல்கள்:**


1. தமிழ் இலக்கிய வரலாறு – தமிழண்ணல், மீனாட்சி புத்தக நிலையம்- மதுரை-இரண்டாம் பதிப்பு-ஜூலை – 2000.
2. தமிழர் நாகரிகமும் பண்பாடும், அ. தட்சிணாமூர்த்தி, ஐந்திணைப் பதிப்பகம், சென்னை, திருத்திய பதிப்பு – 2022.
3. தமிழர் வரலாறும் பண்பாடும், நா. வானமாமலை, நியூசெஞ்சுரி புக் ஹவுஸ், சென்னை, ஆறாம்பதிப்பு - 2007.
4. தமிழக வரலாறு மக்களும் பண்பாடும், கே.கே. பிள்ளை, உலகத் தமிழராய்ச்சி நிறுவனம், சென்னை.

**SEMESTER-II**

**24BECC201** **TECHNICAL ENGLISH II** **3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks:** Internal**:40** External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Technical English - I

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Acquire the context of grammar and importance of Listening, Speaking, Reading and Writing
- Understand and develop critical Listening, Speaking, Reading, and Writing skills
- Apply students' capability to listen vigilantly, read proficiently, innovative writing, and speak fluently

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Demonstrate the aspects of writing, speaking, reading, and listening with grammar K2
- Refine speaking, listening, reading, and writing skills in the social milieu K2
- Justify the text critically in reading, writing, speaking, and listening K2
- Differentiate grammatical structures in reading and listening and apply the structure in speaking and writing K2
- Adapt writing, reading, listening, and speaking rules in formal and informal situations K3

**UNIT I** **9**

**Grammar** : Prepositions – Adjectives – Adverbs
**Reading** : Reading comprehension: Skimming and Scanning
**Writing** : Letter writing (Formal and Informal) – Letter to Editor
**Listening** : Listening to Business talks – TED Talks

**UNIT II** **9**

**Grammar** : Use of sequence words – Modal Verbs
**Reading** : Mind Mapping (Structured thinking and related ideas)
**Writing** : Interpreting visual materials – Note Making – Recommendations
**Listening** : Listening to specific tasks – Focused Listening – Note Taking.
**Speaking** : Making presentations on given topics – Speaking in formal Situations

**UNIT III** **9**

**Grammar** : Contextual usage of Tenses – Connectives
**Reading** : Cohesion and Coherence in Reading
**Writing** : Paragraph writing: Compare and Contrast – Cause and Effect – Jumbled Sentences
**Listening** : Listening and responding to video lectures
**Speaking** : Role-play – Group Interaction

**UNIT IV** **9**

**Grammar** : WH Questions – Identifying Common Errors
**Reading** : Critical Reading Shifting facts from opinions

**Writing** : Resume writing with cover letter – Free writing
**Listening** : Watching videos or documentaries and answering
**Speaking** : Responding to questions – Mock Interviews

**UNIT V** **9**
**Grammar** : Use of Imperatives – Confusing words in English
**Reading** : Reading and making inference
**Writing** : Essay writing – Report – Proposals
**Listening** : Listening to different accents – Listening to Speeches
**Speaking** : Impromptu Speeches – Describing a process

**TOTAL: 45**

**TEXT BOOKS:**

1. Richards J C, Hull J, et al. "Interchange 3 Student's Book", 5th Edition, Cambridge University Press, 2022.
2. Harding, Keith, and Appleby, Rachel, "International Express: Pre-Intermediate: Student's Book", 3rd Edition, Oxford University Press, 2019.

**REFERENCE BOOKS:**

1. Swan, Michael and Walter Catherine, "Oxford English Grammar Course", 1st Edition, Oxford University Press, 2019.
2. Sudharshana N P and Savitha C, "English for Engineers", 1st Edition, Cambridge University Press, 2018.
3. Brook-Hart G, "Business benchmark: Upper intermediate: Business vantage: Student's book", 2nd Edition, Cambridge University Press, 2021.

**WEBSITE URLs**:

1. www.myenglishpages.com
2. www.cambridgeenglish.org/learning-english/
3. www.eslvideo.com/index.php

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | 1 |
| CO2 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | 1 |
| CO3 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | 1 |
| CO4 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | 1 |
| CO5 | - | - | - | - | 2 | - | - | 2 | 2 | 2 | - | 2 | - | 1 |
| **Average** | **-** | **-** | **-** | **-** | **2** | **-** | **-** | **2** | **2** | **2.8** | **-** | **2** | **-** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-II**

**24BECC202A GRAPH THEORY 4H-4C**

**Instruction Hours/week: L:3 T:1 P:0** **Marks:** Internal**:40** External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Matrices and Calculus

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Provide the basic concepts of graphs
- Impart the knowledge of trees and its properties.
- Afford the adequate knowledge on matrix representation of graphs, coloring and dominating sets.
- Understand the concepts and significance of lattices.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Infer the basic terminologies of directed and undirected graphs K2
- Illustrate the properties of trees, connectivity, fundamentals of circuits, cut-set through algorithms K2
- Apply matrix representation of graphs to explore spectra and energy of graphs K3
- Interpret the coloring and domination of a given graph K2
- Explain Lattice theory and its operations on discrete structural areas of computing K2

**UNIT I GRAPHS** **12**

Graphs: Directed and undirected graphs – Konigsberg bridge problem – Handshaking Theorem– Walk, Trail, Path, Circuit, Cycle, sub graphs, induced and spanning subgraphs, connected graphs, complement of a graph – Euler, Hamiltonian graphs - Isomorphism of graphs.

**UNIT II TREES** **12** Properties of trees – Distance and centers in tree – Rooted and binary tree Spanning trees –Connectivity and separability – Fundamental Circuits and Cut sets – Algorithm on spanning trees: Kruskal's and Prim's Algorithm – Dijkstra's shortest path algorithm.

**UNIT III MATRIX REPRESENTATION OF GRAPHS** **12**

Matrix Representation of Graphs: Adjacency matrix, Incidence matrix, Circuit matrix, Fundamental circuit matrix, Laplacian matrix, rank of these matrices and its properties – Spectra and Energy of Graphs.

**UNIT IV COLORING, COVERING AND PARTITIONING** **12**

Coloring, Covering and Partitioning: Chromatic number – Chromatic Partitioning: Dominating set – Minimal Dominating set – Domination number- Chromatic Polynomial– Matching – Four color theorem (Statement only).

**UNIT V LATTICE THEORY** **12**

Partial ordering – Posets – Lattices as Partial Ordering-Posets – Properties of lattices – Lattices as algebraic systems – Sub lattices – Direct product and homomorphism – Some special lattices.

**Total Hours: 45+15**

**TEXT BOOKS:**


1. Narsingh Deo., "Graph Theory with applications to Engineering and Computer Science", 1st Edition, Prentice Hall Series, 2021.
2. Karin R Saoub., "Graph Theory – An Introduction to Proofs, Algorithms and Applications", 1st Edition, CRC Press, 2021.
3. Kenneth H. Rosen., "Discrete Mathematics and Applications", 7th Edition, Tata McGraw Hill, 2012.


**REFERENCE BOOKS:**


1. Allan Bickle, "Fundamentals of Graph Theory", American Mathematical Society,2020.
2. Lonathan I, Gross, Jay Yellen and Mark Anderson, "Graph Theory and Its Applications", 3rd Edition, CRC press, 2019.
3. Madhumangal Pal, Sovan Samanta and Anita Pal, "Advanced Applications of Graph Theory in Modern Society", IGI Global, 2021.


**WEBSITES:**

1. www.classcentral.com/subject/graph-theory
2. www.nitttrc.edu.in/nptel/courses/video/106106183/lec292.pdf
3. www.digimat.in/nptel/courses/video/106108054/L17.html

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **CO2** | 2 | 1 | - | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **CO4** | 2 | 1 | - | - | - | - | - | - | - | - | - | 1 | - | - |
| **CO5** | 2 | 1 | - | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **Average** | **2.2** | **1.2** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **1** | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-II**

**24BEEE241** **ENVIRONMENTAL CHEMISTRY** **5H-4C**

**(THEORY AND LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks:** Internal**:40** External**:60** Total**:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Nil

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Summarize the importance of water and its treatment processes.
- Create a basic understanding of energy resources, storage devices and pollution eradication.
- Clarify the concepts of corrosion and analytical techniques.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Identify the problems associated with water and appropriate technologies K3
- Infer the alternate energy sources and storage devices K2
- Summarize the problems of environmental pollution and its control measures K2
- Illustrate the types of corrosion and its prevention methods K2
- Demonstrate the principle and working of analytical techniques K3

**UNIT I – WATER AND ITS TREATMENT** **9**

Sources -surface and ground water – problems of over-exploitation - Surface water treatment -Water quality parameters -Alkalinity- Types of alkalinities and determination - Hardness - Types and estimation by EDTA method - Boiler feed water - Requirements - Disadvantages of using hard water in boilers - Internal conditioning (Phosphate, Calgon and Carbonate conditioning methods) - External conditioning - Demineralization process - Desalination - Reverse osmosis.

**UNIT II- ENERGY SOURCES AND STORAGE DEVICES** **9**

Renewable and Non - Renewable resources -Nuclear energy (Fission and fusion)- light water nuclear power plant- Wind energy-Hydroelectric power-Geothermal energy- solar energy conversion - solar cells-Batteries, Types of batteries – primary battery (dry cell) secondary battery (lead acid battery, lithium-ion-battery) fuel cells – $H_2$-$O_2$ fuel cell

**UNIT III-ENVIRONMENTAL POLLUTION** **9**

Definition, causes, effects and control measures of Air pollution, Water pollution, Soil pollution, Noise pollution. Nuclear hazards and human health risks. Solid waste management and control measures of urban, industrial and e-wastes. Role of an individual in prevention of pollution. Case studies

**UNIT IV -CORROSION AND ITS CONTROL** **9**

Chemical corrosion and Electrochemical corrosion - Galvanic corrosion - Differential aeration corrosion- Factors influencing the rate of corrosion-Corrosion control - Sacrificial anode and Impressed current cathodic methods - Corrosion inhibitors - Protective coatings - Organic coatings(Paints - Constituents and functions) - Metallic coatings (Inorganic coatings) - Electroplating (Au) and Electro less plating (Ni).

**UNIT V – ANALYTICAL TECHNIQUES AND APPLICATIONS** **9**

Introduction-Instrumentation and applications of Colorimetry, Flame Photometry, Potentiometry, Conductometry (Strong acid with strong base, Mixture of acids with strong base, precipitation titrations)- Electronic spectroscopy- Vibrational spectroscopy-Atomic Absorption spectroscopy.

## (ii) LABORATORY

**LIST OF EXPERIMENTS (Any 8 Experiments)**

1. Determination of Sodium Carbonate and Sodium Hydrogen Carbonate in a mixture using volumetric titration
2. Determination of Ca / Mg using complexometric titration
3. Determination of chloride content of water
4. Determination of the rate of corrosion by weight loss method
5. Conductometry - Determination of conductance of solutions (strong acid Vs strong base)
6. pH Metry - Determination of Acid/Base
7. Potentiometry - Estimation of iron content in a water sample.

**Total Hours: 45+30**

**TEXT BOOKS:**


1. Anubha Kaushik., and Kaushik, C.P. 7Th Edition, 2021. Perspectives in Environmental Studies. New Age International Pvt. Ltd. Publications, New Delhi.
2. Erach Bharucha, “A Textbook of Environmental Studies for UG Courses” 3rd Edition, University Press India ltd, 2021.
3. P C Jain & Monica Jain, (2022). Engineering Chemistry, 18th edition, Dhanpat Rai Publishing Company


**REFERENCE BOOKS:**


1. C. N. Banwell, (2001) Fundamentals of Molecular Spectroscopy, McGraw-Hill.
2. G.Tyler Miller and Scott Spoolman, “Living in the Environment”, 20th Edition, Cengage Learning, 2021.
3. M. J. Sienko and R. A. Plane,(1976) Chemistry: Principles and Applications. 5thedition, McGraw-Hill Higher Education.


**WEB REFERENCES:**

1. https://www.insightsonindia.com/2013/09/06/environment-biodiversity
2. https://www.nptelvideos.in/2012/11/energy-resources-and-technology.html
3. https://www.bspublications.net/downloads/0523ff2e4a5331_chemistry_ch_01_JNTUK.pdf

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 | - | - | 1 | - | - |
| **CO2** | 2 | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 | - | - | 1 | - | 1 |
| **CO3** | 2 | 1 | - | - | - | 2 | 2 | 2 | 1 | - | - | 1 | - | 1 |
| **CO4** | 2 | 1 | - | - | - | 1 | 1 | 1 | 1 | - | - | 1 | - | - |
| **CO5** | 2 | 1 | - | - | - | 1 | 1 | 1 | 1 | - | - | 1 | - | - |
| **Average** | **2.2** | **1.4** | **1** | **1** | **-** | **1.2** | **1.2** | **1.2** | **1** | **-** | **-** | **1** | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-II**

**24BEEE242 ELECTRONIC DEVICES AND CIRCUITS 5H-4C**

**(THEORY AND LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE–REQUISITES:** Mathematics and Physics at 10th, +2 or equivalent Level

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the working principle of Semiconductor devices and Transistors.
- Summarize the concepts of Special Purpose Electronic devices
- Construct the Feedback Amplifiers and Oscillators excitations and AC with sinusoidal excitations

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Explain the structure of the basic semiconductor diodes K2
- Construct h-parameter models, configuration schemes and biasing circuits for BJTs K3
- Build biasing circuits, models and amplifiers using FET K3
- Describe the construction and the characteristics of opto and special purpose electronic devices K2
- Examine the different types of feedback amplifiers and oscillators K3

**UNIT I SEMICONDUCTOR DIODES AND REGULATED POWER SUPPLY 9**

PN junction Diode: VI characteristics – DC models – Rectifiers: Half wave and Full wave rectifiers – Filters: Inductive and capacitive filters – analysis – LC and pi filters – Zener diode – VI characteristics – Zener Regulator – IC voltage regulators – Regulated DC power supply – Transformer less power supply – SMPS.

**UNIT II BIPOLAR JUNCTION TRANSISTOR AND APPLICATIONS 9**

BJT: modes of operation – characteristics – Thermal runaway – CE – CB – CC configurations – Biasing – Small signal CE Amplifier: analysis using h-parameter model – current gain – voltage gain – Input and Output impedance – Darlington circuit – BJT as switch. Power amplifiers: Class A, Class B, Class AB and Class C.

**UNIT III FIELD EFFECT TRANSISTORS AND APPLICATIONS 9**

JFET and MOSFET: Operation and characteristics – Biasing of JFET and MOSFET – Modelling JFET and MOSFET – Analysis of CS amplifier – Multistage amplifiers: types of coupling – Cascade and cascode amplifiers – Differential Amplifiers: FET differential pair – Common mode and differential mode – Concept of CMRR.

**UNIT IV OPTO AND SPECIAL PURPOSE ELECTRONIC DEVICES 9**

Schottky Barrier diode – Power diode – Varactor diode– LED: OLED – AMOLED – Seven Segment Display – LCD – Photo conductive cells: Photo diodes – Solar cells – Photo Transistors – Opto couplers – Charge Coupled Devices – LASER diodes –Thermistors – Thyristors: SCR – TRIAC and DIAC.

**UNIT V FEEDBACK AMPLIFIERS AND OSCILLATORS 9**

Feedback amplifiers – Principles of feedback in amplifiers – Advantages of negative feedback – Voltage series – Current series – Voltage shunt and current shunt feedback circuits – Analysis – Oscillators – Criteria for oscillation – RC phase shift and Wien bridge oscillator – Hartley – Colpitts and crystal oscillator.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. VI characteristics of PN junction diode and Zener diode
2. Half wave and Full wave Bridge Rectifier
3. Frequency Response of CE Amplifier
4. Characteristics of MOSFET in CS configuration
5. Characteristics of SCR
6. Design of LC & RC oscillator

**TOTAL: 45+30=75**

**TEXT BOOKS:**


1. Robert L Boylestead and Louis Nashelsky, "Electronic Devices and circuit theory", 11th Edition, Pearson Education, 2017.
2. David A Bell, "Electronic Devices and Circuits", 5th Edition, Oxford University Press, 2008.


**REFERENCE BOOKS:**


1. Adel S Sedra and Kenneth C Smith, "Microelectronic Circuits", 7th Edition, Oxford University Press, 2017.
2. Thomas L Floyd, "Electronic Devices", 11th Edition, Pearson Education India, 2018.
3. Millman J Grabel A, "Microelectronics", 2nd Edition, Tata McGraw-Hill Publishing Company Ltd., 2017.


**WEB URLs:**

1. www.electrical4u.com/electrical-engineering-articles/electronics-devices/
2. www.britannica.com/technology/electronics
3. www.sciencedirect.com/topics/nursing-and-health-professions/electronic-device

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| CO2 | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| CO3 | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| CO4 | 2 | 1 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| CO5 | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| **Average** | **2.6** | **1.6** | **1** | **1** | **-** | **-** | **-** | **1** | **1** | **1** | **-** | **1** | **2** | - |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-II**

**24BECC243 DATA STRUCTURES 5H-4C**

**(THEORY AND LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Programming In C

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the concepts of abstract data types
- Learn linear and non-linear data structures
- Understand sorting, searching and hashing algorithms

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Interpret the concepts of linear and non-linear data structures K2
- Identify appropriate linear/non–linear data structure operations for solving a given problem K3
- Experiment with linear and non-linear data structure operations to understand their implementation, performance, and practical applications K3
- Apply searching and sorting algorithms for solving a problem K3
- Develop the application using suitable data structures K4

**UNIT I LISTS** **9**

Abstract Data Types (ADTs) – Elementary Data types – List ADT – Array-based implementation – Linked list implementation – Singly linked lists – Doubly-linked lists – Circularly linked lists –Applications of lists – Polynomial ADT – Multilists – Sparse Matrices.

**UNIT II STACKS AND QUEUES** **9**

Stack ADT – Operations – Applications – Balancing symbols – Evaluating arithmetic expressions – Infix to Postfix conversion – Function calls – Queue ADT – Operations – Circular queue – Deque – Applications of queues.

**UNIT III TREES** **9**

Tree ADT – Tree traversals – Binary tree ADT – Expression trees – Binary search tree ADT– AVL Trees – Red-Black trees – Priority queue (Heaps) – Binary heap.

**UNIT IV MULTIWAY SEARCH TREES AND GRAPHS** **9**

B-Tree – B+ Tree – Tries – Graph definition – Representation of graphs – Types of graphs – Breadth-first traversal – Depth-first traversal – Bi-connectivity – Euler circuits – Topological sort – Dijkstra's algorithm – Minimum spanning tree – Prim's algorithm – Kruskal's algorithm

**UNIT V SEARCHING, SORTING AND HASHING TECHNIQUES** **9**

Searching – Linear search – Binary search – Sorting – Bubble sort – Selection sort – Insertion sort – Shell sort – Quick sort – Merge sort – Heap sort – Radix sort – Hashing – Hash functions – Separate chaining – Open addressing – Rehashing – Extendible hashing.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Implement array implementation of Stack, Queue, and Circular Queue ADTs.
2. Develop the implementation of a singly linked list.
3. Create linked list implementation of stack and linear queue ADTs.
4. Implement the evaluation of postfix expressions and infix to postfix conversion.
5. Develop the implementation of binary search trees and AVL Trees.
6. Implement insertion sort , merge sort and quick sort.
7. Create open addressing (Linear probing and Quadratic probing).

**TOTAL: 45+30**

**TEXT BOOKS:**


1. Mark Allen Weiss, “Data Structures and Algorithm Analysis in C”, 2nd Edition, Pearson Education, 2019.
2. Thomas H. Cormen, Charles E. Leiserson, Ronald L.Rivest, Clifford Stein, “Introduction to Algorithms”, 4th Edition, MIT Press, 2022.


**REFERENCE BOOKS:**


1. Narasimha Karumanchi, “Data Structures and Algorithms Made Easy”, 1st Edition, Career monk Publications, 2019.
2. Langsam, Augenstein and Tanenbaum, “Data Structures Using C and C++”, 2nd Edition, Pearson Education, 2020.
3. Jan Wengrow, “A Common–Sense Guide to Data Structures and Algorithm”, 2nd Edition, O’Reilly Publications, 2020.
4. Yashavant Kanetkar, “Data Structures Through C”, 4th Edition, BPB publications, 2022.


**WEB URLs:**

1. www.nptel.ac.in/courses/106106145
2. www.coursera.org/learn/data-structures
3. www.cs.usfca.edu/~galles/visualization/Algorithms.html

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 2 | 1 | - | - | - | - | - | - | - | - | 1 |
| CO2 | 2 | 2 | 2 | 2 | 1 | - | - | - | - | - | - | - | - | 1 |
| CO3 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | - | - | - | - | - | - | 1 |
| CO4 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | - | - | - | - | - | - | 1 |
| CO5 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | - | - | - | - | 1 | - | 1 |
| **Average** | **3** | **3** | **3** | **2** | **1** | **1** | **1** | **-** | **-** | **-** | **-** | **1** | **-** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-II**

**24BEEE244 MEASUREMENTS AND INSTRUMENTATION 5H-4C**

**(THEORY AND LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks:** Internal**:40** External**:60** Total**:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Electric Circuit Analysis

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the principles, operation and applications of analog and digital measurement system and devices, measuring instruments, waveform generators and signal analyzers.
- Expose the students to the design of bridges for the measurement of resistance, capacitance and inductance
- Deliver the functioning knowledge of various waveform generators, analyzers and display devices

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the fundamental concept of measurement systems, measuring instruments, single generators, and signal analyzers K2
- Describe the construction, working principle, and applications of analog measuring Instruments K2
- Identify the electronic digital measurement techniques and devices. K3
- Distinguish the methods for measuring resistance, inductance, capacitance and other electrical parameters. K4
- Design the circuits to determine electrical parameters using analog and digital devices K4

**UNIT I BASIC CONCEPTS OF MEASUREMENT SYSTEM 9**

General concepts and terminology of measurement systems – Classification and essential requirements of an instrument – Functional elements of an instrument – Static and dynamic characteristics – Errors in measurement – Error analysis – Standards and calibration.

**UNIT II ELECTRICAL MEASUREMENTS 9**

Introduction to electro mechanical instruments – Principles of moving coil – Moving iron – Dynamometer type – Rectifier type – Thermal instruments – Instrument transformers – CT and PT – Electrodynamic Wattmeter – Low Power Factor (LPF) wattmeter – Single and three phase power measurement – Introduction to hall effect wattmeter.

**UNIT III MEASUREMENTS OF R, L AND C 9**

Low, high and precise resistance measurement – Megger – Ohmmeters – DC bridges for resistance measurement – Wheatstone bridge – Kelvin's double bridge – AC bridges – Maxwell's bridge – Schering and Wien's bridges – Detectors in bridge measurement.

**UNIT IV ELECTRONIC AND DIGITAL MEASUREMENTS 9**

Electronic voltmeter – Current measurement with electronic instruments – Analog multi-meters – Digital voltmeter – Digital multi-meters – Digital frequency meters – Digital LCR meter – Q-Meter – Digital wattmeter and energy meters.

**UNIT V SIGNAL GENERATORS AND ANALYZERS 9**

Data loggers and data storage – CRO – DSO – MSO – Function generators – Waveform analyzers – Spectrum analyzers – Clamp meter – Distortion analyzers – Power quality analyzers.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Characteristics of Linear Variable Displacement transducers.
2. Measurement of medium resistance using Wheatstone bridge.
3. Measurement of low resistance using Kelvin's Double bridge.
4. Measurement of capacitance using Schering bridge.
5. Measurement of three phase power and power factor.
6. Measurement of earth resistance using megger.

**TOTAL: 45+30=75**

**TEXT BOOKS:**


1. Shawney A K, "A course in Electrical and Electronic Measurements and Instrumentation", 19th revised edition, Dhanpat Rai and Sons, 2016.
2. David A. Bell, "Electronic Instrumentation and Measurements", 3rd Edition, Oxford University Press India, 2013.


**REFERENCES:**


1. Golding E W and Widdis F C, "Golding's, Electrical Measurements and Measuring Instruments", 6th Edition, MedTech, 2019.
2. Kalsi H S, "Electronic Instrumentation", 3rd Edition, McGraw Hill Education, 2017.
3. Albert D. Helfrick and William D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", 1st Edition, Pearson, 2016.
4. Ernest O Doebelin and Dhanesh N Manik, "Measurements systems Application and Design", 6th Edition, McGraw Hill publication, 2017.


**WEB URLs:**

1. https://archive.nptel.ac.in/courses/108/105/108105153/
2. https://nptel.ac.in/courses/108105153
3. https://web.mit.edu/2.671/

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | - | - | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| CO2 | 2 | 1 | - | - | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| CO3 | 3 | 2 | 1 | - | - | 1 | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| CO4 | 3 | 3 | 2 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 3 | 1 |
| CO5 | 3 | 3 | 2 | 1 | - | 1 | - | 1 | 1 | 1 | - | 1 | 3 | 1 |
| **Average** | **2.6** | **2** | **1.6** | **1** | **-** | **1** | **-** | **1** | **1** | **1** | **-** | **1** | **2.4** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-II**

**24BECC211 COMMUNICATION SKILLS LABORATORY 2H-1C**

**Instruction Hours/week: L:0 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Nil

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Learn different listening techniques for understanding different kinds of audio content
- Build on students' English language skills by engaging them in listening and reading activities
- Improve the communicative competence of learners in listening, speaking, reading and writing

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Identify the context, topic, and pieces of specific information of English through all the four skills K1
- Realize the purpose and clarity of facts and reflect their thoughts, opinions, knowledge through all the language skills K1
- Use effective skimming and scanning and listening techniques and acquire the gist from the context K1
- Practice communication more effectively with their peers, instructors, and colleagues K2
- Illustrate public speaking techniques, business writing, listening as well as professional speaking techniques K3

**LIST OF EXPERIMENTS:**

| S.No. | SKILLS | TOPICS |
|---|---|---|
| 1 | Listening | Dialogues from TV/radio/Ted talk/Podcast |
| 2 | Listening | Listening for gist |
| 3 | Reading | Reading for detail, global understanding |
| 4 | Speaking | Presentations and interactive communication – Pair presentations |
| 5 | Listening | Listen and respond appropriately |
| 6 | Reading | Reading different genres |
| 7 | Writing | Documentary and Movie review |
| 8 | Writing | Informational or Analytical Reports |
| 9 | Speaking | Mock Interview |
| 10 | Speaking | Group Discussion |

**TOTAL: 30**

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | - | - | 3 | - | - | 2 | 3 | 3 | - | 2 | - | 1 |
| CO2 | - | - | - | - | 2 | - | - | 2 | 3 | 3 | - | 3 | - | 1 |
| CO3 | - | - | - | - | 1 | - | - | 2 | 3 | 3 | - | 2 | - | 1 |
| CO4 | - | - | - | - | 1 | - | - | 3 | 2 | 3 | - | 2 | - | 1 |
| CO5 | - | - | - | - | 1 | - | - | 3 | 2 | 3 | - | 3 | - | 1 |
| **Average** | - | - | - | - | **3** | - | - | **3** | **3** | **3** | - | **2** | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-II**

| | | |
|---|---|---|
| **24BEMC251** | **YOGA** | **4H – 2C** |

**Instruction Hours/week: L:0 T:0 P:4** **Marks:** Internal**:100 External:0** Total**:100**

**End Semester Exam:**3 Hours

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Have knowledge of Physical fitness and exercise management to lead better quality life
- Enable to officiate, supervise various sports events and organize sports events
- Acquire the knowledge of Physical Education, Sports and Yoga and understand the purpose and its development
- Gain knowledge to plan, organize and execute sports events.

**COURSE OUTCOMES:**

At the end of this course, the students will be able to:

- Practice physical activities and yoga for strength, flexibility and relaxation. K2
- Use techniques for increasing concentration and decreasing anxiety for stronger academic performance. K2
- Perform yoga exercises in various combination and forms. K2
- Improve personal fitness through participation in sports and yoga activities. K2
- Follow sound nutritional practices for maintaining good health and physical performance. K2

**UNIT I INTRODUCTION TO PHYSICAL FITNESS**

Explain importance of physical education - Describe importance of Physical Fitness & Wellness - Explain the components of physical fitness - Demonstrate healthy life style - Prevent health threats by changing life style.

**UNIT II FUNDAMENTALS OF ANATOMY & PHYSIOLOGY IN SPORTS & YOGA**

Explain importance of anatomy and physiology - Describe effects of exercise in various body systems - Describe concept of correct posture - Explain corrective measures for posture deformities.

**UNIT III YOGA & PRANAYAMA**

Explain importance of yoga - Perform various pranayama for increasing concentration - Use meditation and other relaxation techniques for improving concentration

Yoga Practices:Thandasana Chakrasana (sideways) Vruchasana Thirikonasana Varasana

**TEXT BOOKS:**

1. Ajmer Singh, Modern Trends and Physical Education class 11 & class 12, Kalyani Publication, New Delhi ISBN: 9789327264319.
2. B.K.S. Iyengar, Light on Yoga, Thomson's Publication, New Delhi ISBN: 8172235011 V.K.Sharma, Health and Physical Education, NCERT Books; Class11,12 Saraswati House Publication, New Delhi

**REFERENCE BOOKS:**


1. Acharya Yatendra, Yoga and Stress Management, Fingerprint Publishing ISBN: 938905303X
2. Swami Vivekanand, Patanjali Yoga Sutras, Fingerprint Publishing ISBN 9389567351.
3. Ramdev, Pranayam Rahasya, Patanjali-Divya Prakashan, Haridwar ISBN: 9788189235017
4. Ramdev, Yoga its Philosophy & Practice, Divya Prakashan, Haridwar.


**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | 1 |
| CO2 | - | - | - | - | 2 | - | - | 2 | 2 | 3 | - | 2 | - | 1 |
| CO3 | - | - | - | - | 1 | - | - | 2 | 2 | 3 | - | 2 | - | 1 |
| CO4 | - | - | - | - | 1 | - | - | 3 | 2 | 3 | - | 2 | - | 1 |
| CO5 | - | - | - | - | 1 | - | - | 3 | 2 | 3 | - | 2 | - | 1 |
| **Average** | - | - | - | - | **1.4** | - | - | **2.6** | **2** | **3** | - | **2** | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-III**

**24BEEE301 NUMERICAL METHODS 4H-4C**

**Instruction Hours/week: L:3 T:1 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Inculcate the basic concepts of solving algebraic and transcendental equations.
- Understand the numerical techniques of interpolation in various intervals
- Provide the knowledge of numerical differentiation and integration
- Provide the knowledge of solving ordinary differential equations and partial differential equations numerically.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Solve the systems of linear and nonlinear equations by iterative methods K3
- Make use of interpolation methods for finding the missing terms K3
- Apply numerical methods for finding differentiation and integration of a given function K3
- Solve ordinary differential equations using Euler's, Taylor's, Runge Kutta and Milne Thomson's method K3
- Utilize implicit and explicit methods in heat and wave equations K3

**UNIT I SOLUTION OF EQUATIONS** **12**

Regular Falsi Method - Newton Raphson method for solving algebraic and transcendental equations - Solution of system of linear equations - Gauss elimination method - Gauss Jordan method -Gauss Seidel method.

**UNIT II INTERPOLATION** **12**

Interpolations with unequal intervals-Lagrange's interpolation -Newton's divided interpolation - Interpolation with equal intervals-Newton's forward and backward interpolation.

**UNIT III NUMERICAL DIFFERENTIATION AND INTEGRATION** **12**

Approximation of derivatives using Newton's forward and backward interpolation - Numerical integration using Trapezoidal, Simpson's 1/3 and 3/8 rule

**UNIT IV NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS** **12**

Single step method- Euler's method-Taylor's series method-Fourth order Runge – Kutta method –Multi step method-Milne's predictor corrector method

**UNIT V NUMERICAL SOLUTIONS OF PARTIAL DIFFERENTIAL EQUATIONS** **12**

Solutions of one-dimensional heat equation by Bender-Schmidt and Crank Nicholson methods – Numerical solutions of one-dimensional wave equation by explicit method

**Total hours:45+15**

**TEXT BOOKS:**

1. Steven C.Chapra, Raymond P.Canale, Numerical Methods for Engineers,8th Edition , Tata McGraw Hill Education, 2021.
2. Curtis F. Gerald and Patrick O. Wheatley, Applied Numerical Analysis, Addison Wesley, Thirteenth Edition,2004.

**REFERENCE BOOKS:**

1. Richard L. Burden and J. Douglas Faires, Numerical Methods, 4th Edition, Brooks/Cole 2012.
2. Boyce, Di Prima and Meade, "Elementary Differential Equations and Boundary value problem", 12th Edition, John Wiley & Sons, 2021.
3. Steven Chapra, "Applied Numerical Methods with MATLAB", 5th Edition, Mcgraw-Hill Education, 2022.

**WEBSITES:**

1. www.classcentral.com/course/numerical-methods-engineers-32822
2. http://www.infocobuild.com/education/audio-video-courses/mathematics/numerical-analysis-iit- madras.html
3. http://www.infocobuild.com/education/audio-video-courses/mathematics/NumericalMethods-Finite Difference-IIT-Roorkee/lecture-06.html
4. https://nptel.ac.in/courses/108106083
5. www.mathworld.wolfram.com

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| CO2 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| CO3 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| CO4 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| CO5 | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **Average** | **3** | **2** | **1** | - | - | - | - | - | - | - | - | **1** | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-III**

**24BEEE302 TRANSMISSION AND DISTRIBUTION 4H-4C**

**Instruction Hours/week: L:3 T:1 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electric Circuit Analysis

**COURSE OBJECTIVES**

The goal of this course is for students to:

- Design and analyze the passive elements in various power transmission systems.
- Learn the classification of the Transmission lines in different constraints.
- Acquire the knowledge of voltage distribution in insulator strings and cables.

**COURSE OUTCOMES**

Upon completion of this course, the student will be able to:

- Explain the concept of HVDC transmission and its comparison with AC transmission K2
- Analyze the performance of transmission lines and corona depending on the category K4
- Examine the potential distribution over a string of suspension insulators, stress and sag in overhead lines K4
- Compare overhead lines and underground cables based on capacitance, insulation resistance, and current rating K4
- Solve voltages in distributors of concentrated and distributed loads K3

**UNIT I LINE PARAMETERS 12**

Overview of power system layout – Electrical constants – Resistance, Inductance and capacitance of Single and 3Phase lines – Bundled conductor lines – Double circuit three phase lines – Concept of GMD and GMR – Effects of earth on line capacitance – Skin effect – Proximity effect –Transposition,

**UNIT II MODELLING AND PERFORMANCE OF TRANSMISSION LINES 12**

Short and medium transmission lines – Phasor diagrams – Nominal T and Pi methods - Line regulation – Efficiency – Rigorous solution for long line – ABCD constants – Ferranti effect – Tuned power lines – Surge impedance and surge impedance loading – Corona – Factors affecting corona

**UNIT III MECHANICAL DESIGN OF OVERHEAD LINES AND LINE INSULATORS 12**

Insulators – Types – Potential distribution over a string of suspension insulators – Methods of increasing string efficiency – Testing of insulators – Typical Configuration of Line Supports and Conductor Types – Stress and Sag in overhead lines – causes – Sag tension calculation – Vibration and dampers

**UNIT IV UNDERGROUND CABLES 12**

Underground cables types – Capacitance and insulation resistance – Sheath effects – Grading – Heating –Current rating – Comparison between overhead lines and underground cables.

**UNIT V DISTRIBUTION SYSTEMS** **12**

Substations and its Types – Typical Key Diagram of a 11kV / 400V Substation – Feeders – distributors and service mains – Radial and ring main systems – Calculation of voltage in distributors with concentrated and distributed loads – AC single phase and three phase systems – Introduction to Substation automation.

**TOTAL: 60**

**TEXT BOOKS:**

1. Wadhwa C L, "Electrical Power Systems", 7th Edition, New Age International, 2022.
2. Mehta V K and Rohit Mehta, "Principles of Power System", 3rd Edition, S Chand & Company Ltd., 2013.

**REFERENCE BOOKS:**

1. Soni M L, Gupta P V, Bhatnagar U S and Chakrabarthi A, "A Text Book on Power System Engineering", 2nd Edition, Dhanpat Rai & Co, 2013.
2. Uppal S L, "Electrical Power Systems",15th Edition, Khanna Publishers, New Delhi, 2009
3. D.P. Kothari and I.J. Nagrath, "Power System Engineering", 3rd Edition, McGraw-Hill, 2019.
4. Singh, Sri N. "Electric power generation: transmission and distribution", 2nd Edition, PHI Pvt. Ltd., 2008.

**WEB URLs:**

1. https://nptel.ac.in/courses/108/102/108102047/
2. https://nptel.ac.in/content/storage2/courses/108105053/pdf/L-2(TB)(ET)((EE)NPTEL).pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | - | - | - | - | - | 1 | - | - | - | 1 | - | - |
| CO2 | 3 | 3 | 2 | 1 | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| CO3 | 3 | 3 | 2 | 1 | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| CO4 | 3 | 3 | 2 | 1 | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| CO5 | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **Average** | **2.8** | **2.4** | **1.8** | **1** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **1** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-III**

**24BEEE341 DIGITAL ELECTRONICS 5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Basic understanding of diode and transistor operation

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Acquire the foundational concepts of digital systems, including Boolean algebra, and demonstrating its applications in digital circuit design
- Understand the design procedures for combinational and sequential circuits
- Apply the design of memory circuits in semiconductor memories and related technology

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the Boolean concepts and theorems in simplifying Boolean expressions K2
- Build various combinational digital circuits using logic gates K3
- Develop various synchronous and asynchronous circuits using flip-flops K3
- Construct digital circuits using semiconductor memories and related technology K3
- Model digital circuits using Verilog HDL K3

**UNIT I NUMBER SYSTEMS AND DIGITAL LOGIC FUNCTIONS MINIMIZATION 9**

Review of Number systems – Complements – Signed and Unsigned representation – Error detection and correction codes – Code conversions – Digital logic functions minimization using K-map and Quine McCluskey method.

**UNIT II COMBINATIONAL CIRCUITS 9**

Design and Analysis of Combinational circuits – Full adders and subtractors – BCD adders and subtractors – multiplexers and de-multiplexers – Code converters – Encoders and Decoders – Carry look ahead adder – Function realization using multiplexers and de-multiplexers.

**UNIT III SEQUENTIAL CIRCUITS 9**

Introduction to sequential circuits – Latch – Flip-flops: SR – JK – D – T – Level triggering and edge triggering – Design of synchronous sequential circuits – Counters – Asynchronous and synchronous type – Modulo counters – Shift registers – Johnson and ring counter – Design of asynchronous sequential circuits – Moore and Mealy models – Counters – State diagram – State reduction – State assignment.

**UNIT IV DIGITAL LOGIC FAMILIES AND MEMORIES** **9**

Introduction – Operation – Characteristics of digital logic family – Comparison of RTL – DTL and MOS families – Memories – ROM – RAM – EPROM – EEPROM – PAL and PLA.

**UNIT V INTRODUCTION TO Verilog HDL** **9**

Introduction – Implementation of Multiplexers (8:1) – De-multiplexers – Encoders (8 to 3) – Decoders (2 to 4) – D flip-flop using behavioral description – Structural description – Implementation of full adder 4bit counters using structural description.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Design and implementation of Adders and Subtractors
2. Design and implementation of Encoders and Decoders
3. Design and implementation of Multiplexer and De-multiplexer
4. Verification and operation of Flip-flops
5. Design and implementation of counters
6. Simulation of Adder, Subtractor, Multiplexer and Demultiplexer using Verilog HDL

**TOTAL: 45+30=75**

**TEXT BOOKS:**


1. Thomas L Floyd, "Digital fundamentals", 11th Edition, Pearson Education Limited, 2018.
2. Donald P Leach, Albert Paul Malvino, Goutam Sha, "Digital Principles and Applications", 6th Edition, Tata McGraw Hill, 2017.


**REFERENCES:**


1. Donald D Givone, "Digital Principles and Design", 13th Edition, Tata McGraw Hill, 2017.
2. Morris Mano M, "Digital Logic and Computer Design", 6th Edition, Prentice Hall of India, 2018.
3. Tocci R J, Neal S. Widmer, "Digital Systems: Principles and Applications", 12th Edition, Pearson Education Asia, 2017.
4. Mano M, Michael D Ciletti, "Digital Design: With an Introduction to the Verilog HDL, VHDL, and System Verilog", 6th Edition, Pearson Education, 2022.


**WEB URLs:**

1. https://www.asic-world.com/
2. https://onlinecourses.nptel.ac.in/noc21_ee75/preview
3. https://www.eduhk.hk/has/phys/de/

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | - | - | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| CO2 | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| CO3 | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| CO4 | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 2 |
| CO5 | 3 | 2 | 1 | 1 | 1 | - | - | 1 | 1 | 1 | - | 1 | 2 | 2 |
| **Average** | **2.8** | **1.8** | **1** | **1** | 1 | **-** | **-** | **1** | **1** | **1** | **-** | **1** | **1.4** | **2** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-III**

| | | |
|---|---|---|
| **24BEEE342** | **LINEAR INTEGRATED CIRCUITS (THEORY AND LABORATORY)** | **5H-4C** |

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electric Circuit Analysis

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Provide students with a comprehensive understanding of operational amplifier characteristics, including their limitations, stability, and operational principles.
- Enable students to design and analyze various linear and non-linear applications of operational amplifiers, such as active filters, waveform generators, and voltage regulators.
- Familiarize students with the operation and practical applications of special function ICs, including timers, voltage-controlled oscillators, and phase-locked loops, in electronic circuit design and signal processing.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the fundamental characteristics and specifications of operational amplifiers. K2
- Apply operational amplifiers in various linear circuit configurations. K3
- Analyze non-linear applications and single power supply operational amplifiers. K4
- Categorize voltage regulator circuits and data converters. K4
- Inspect special function integrated circuits in practical applications. K4

**UNIT I OPERATIONAL AMPLIFIER CHARACTERISTICS 9**

Classification of IC – Functional Block Diagram – Symbol – Characteristics of an ideal operational amplifier – Internal circuit diagram of IC 741 – Open loop gain – CMRR – DC characteristics – AC characteristics – Transfer characteristics.

**UNIT II LINEAR APPLICATIONS OF OPERATIONAL AMPLIFIERS 9**

Inverting and Non-inverting amplifiers – Voltage follower – Summing amplifier – Differential amplifier – Instrumentation amplifier – Integrator and Differentiator – Practical considerations – Voltage to Current and Current to Voltage converters – Sinusoidal oscillators – RC phase shift oscillator – Wein bridge oscillator.

**UNIT III NON-LINEAR APPLICATIONS OF OPERATIONAL AMPLIFIERS 9**

Comparator – Zero crossing detector – Window detector – Sample and hold circuit – Clipper and Clamper – Regenerative comparator – Precision diode – Half and Full wave rectifiers – Logarithmic – Exponential amplifiers – Square and Triangular waveform generators – Active filters – Design of first order low pass – High pass and Band stop Butterworth filters.

**UNIT IV IC VOLTAGE REGULATORS AND CONVERTERS 9**

Fixed and adjustable three terminal regulators – LM78XX – LM79XX – LM317 – Switching regulators – IC 723 general purpose voltage regulators – DAC/ADC performance characteristics – Digital to Analog Converters: Binary weighted – R-2R Ladder types – Analog to digital converters: Successive approximation – Flash Type.

**UNIT V SPECIAL FUNCTION ICS 9**

555 Timer Functional block diagram and description – Monostable and Astable operation – Applications – PLL Functional Block diagram – Principle of operation – Building blocks of PLL – Characteristics Lock and Capture ranges – 566 Voltage Controlled Oscillator – Applications – Frequency synthesis – FSK demodulator – Motor speed control.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Design and Implementation of Inverting, Non inverting Amplifier and Voltage Follower.
2. Design and Implementation of Differentiator, Integrator, Subtractor, Summer.
3. Design and Implementation of Comparator circuits: Zero crossing detector, Window detector using op-amp.
4. Design and Implementation of Schmitt trigger using op-amp.
5. Design and Implementation of first order low pass and high pass filters using op-amp.
6. Design and Implementation of Monostable and Astable Multivibrators using IC 555.

**TOTAL: 45+30=75**

**TEXT BOOKS:**


1. Roy Choudhury Shail Jain, “Linear Integrated Circuits”, 5th Edition, New Age International, New Delhi, 2018.
2. Gayakward A R, “Op-Amps and Linear Integrated circuits”, 4th Edition, Prentice Hall of India, New Delhi, 2021.


**REFERENCES:**


1. Coughlin F R, and Driscoll F F, “Operational Amplifiers and Linear Integrated Circuits”, 6th Edition, Prentice Hall of India, New Delhi, 2010.
2. Michael Jacob J, "Applications and Design with Analog Integrated Circuits", 2nd Edition, Prentice Hall of India, New Delhi, 2010.
3. K. Lal Kishore, “Operational Amplifiers and Linear Integrated Circuits”, 1st Edition, Pearson Education, New Delhi, 2013.
4. Adel Sedra, Kenneth. C Smith, “Microelectronic Circuits”, 7th Edition, Oxford University Press, New Delhi, 2014.


**WEB URLs:**

1. https://onlinecourses.nptel.ac.in/noc24_ee73/preview
2. https://www.digimat.in/nptel/courses/video/108108111/L01.html
3. https://nptel.ac.in/courses/108108111

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | - | - | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| CO2 | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| CO3 | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| CO4 | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| CO5 | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | - |
| **Average** | **2.8** | **2.4** | **1.75** | **1** | **-** | **-** | **-** | **1** | **1** | **1** | **-** | **1** | **1.4** | **-** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-III**

**24BEEE343 ELECTRICAL MACHINES I 5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week:L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE- REQUISITES**: Electric circuit Analysis

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the concept of construction, working principle and applications of DC machines
- Analyze the performance characteristics, testing and speed control of DC machines
- Deliberate the working of auto transformer and three phase transformers.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the laws governing the electromechanical energy conversion for singly and multiple excited systems K2
- Describe the construction and working principle of DC machines and Transformers K2
- Identify various methods of starting and speed control of DC machines K3
- Compute various performance parameters of the DC machine by conducting suitable tests K4
- Analyze the performance characteristics of the transformers under various operating conditions through proper testing K4

**UNIT I MAGNETIC CIRCUITS AND ELETROMECHANICAL ENERGY CONVERSION 9**

Review of Magnetic circuits –Law governing magnetic circuits – Flux linkage, Inductance – Statically and Dynamically induced EMF – Hysteresis and Eddy Current losses – Energy in magnetic system – Field energy and co energy-force and torque equations – Singly and multiply excited magnetic field systems.

**UNIT II DC GENERATOR 9**

Construction and principle of operation – Lap and wave windings - EMF equation - Methods of excitation – Types of DC generators – No load and load characteristics - Armature reaction, effects and remedies – Commutation Interpoles – Compensating winding – Losses and efficiency – Power flow diagram – Applications of DC generators.

**UNIT III DC MOTOR 9**

Principle of operation – Back EMF –Classification of DC motors - Performance characteristics of shunt, series and compound motors – Torque equation – Power developed by armature – Speed control of DC motors – Starting methods of DC motor – Losses and efficiency – Testing of various DC machines – Swinburne's test – Hopkinson's test – Separation of losses.

**UNIT IV SINGLE PHASE TRANSFORMER** **9**

Construction and principle of operation – EMF equation and Transformation ratio – Equivalent circuit – Phasor diagrams – Voltage regulation – Losses and efficiency — Testing – Polarity test – Open circuit and short circuit tests – Sumpner's test – Separation of core losses– Applications.

**UNIT V AUTOTRANSFORMER AND THREE PHASE TRANSFORMER** **9**

Construction and working of auto transformer – Comparison with two winding transformers – All day efficiency – Applications of autotransformer – Three Phase Transformer – Construction – Types of connections – Off load and on load tap changing of transformers – Scott connection – Parallel operation.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. No load and load characteristics of DC shunt generator and determination of critical resistance
2. Load test and Speed control of DC shunt motor
3. Load test on DC series motor
4. Predetermination of performance of DC machine using Swinburne's test
5. Pre-determination of performance of single phase transformer from equivalent circuit
6. Load test on three phase transformer

**TOTAL: 45+30=75**

**TEXT BOOKS:**


1. I. J. Nagrath and D. P. Kothari, "Electric Machines", 5th Edition, Tata McGraw Hill Education, 2017.
2. Rohit Mehta and V.K. Mehta, "Principles of Electrical Machines", 1st Edition (Reprint), S. Chand and Company Ltd., 2019.


**REFERENCES:**


1. Fitzgerald A E, Charles Kingsley Jr and Stephen D Umans, "Electric Machinery", 7th Edition, Tata McGraw Hill, New Delhi, 2020.
2. Bimbhra P S, "Electrical Machinery", 2nd Edition, Khanna Publishers, 2021.
3. Gupta B.R, "Fundamentals of Electrical Machines", 3rd Edition, New Age International Publishers, 2015.
4. Bhattacharya S K, "Electrical Machines", 4th Edition, Tata McGraw Hill Education, 2017.


**WEB URLs:**

1. https://archive.nptel.ac.in/courses/108/105/108105131/
2. https://www.iitp.ac.in/~siva/2022/ee280/DC_Machines.pdf
3. https://www.iitgoa.ac.in/~ssd/EE%20211%20Lecture%20Slides_2021.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | - | - | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| CO2 | 2 | 1 | - | - | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| CO3 | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| CO4 | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| CO5 | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **Average** | **2.6** | **2** | **1.6** | **1** | **-** | **-** | **-** | **1** | **1** | **1** | **-** | **1** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-III**

**24BEEE344 OOPS AND JAVA 5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week:L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PREREQUISITES:** C Programming

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course for students is to

- Learn the fundamental concepts of Java programming
- Acquire the knowledge of inheritance, abstraction, exception and package in Java
- Obtain the knowledge of Java Collection API, Multithreading, JDBC and Lambda expression in Java

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to

- Infer the fundamental concepts, architecture, and features of Java Programming K2
- Solve programming challenges using object-oriented paradigms K3
- Build applications using multi-tasking mechanisms, and exception handling strategies K3
- Construct robust and efficient Java applications using JDBC, lambda expressions and interface K3
- Develop Java applications by amalgamating object-oriented design, collection usage and advanced data manipulation. K3

**UNIT I INTRODUCTION TO JAVA 9**

History of Java – Features of Java – Java Architecture – Comments – Data Types – Variables – Operators – Type Conversion and Casting – Flow Control Statements – Reading Input from keyboard – Command Line Arguments – Using Scanner Class – Arrays – Classes and Objects – UML Class diagram – Methods – Constructors – static variables and Methods – this Keyword – Encapsulation – Concept of Access Control.

**UNIT II INHERITANCE 9**

Inheritance – Types of Inheritance – Super and Sub Classes – super keyword – final class and methods – Object class –Polymorphism – Types of polymorphism – Method Overloading – Constructor Overloading – Method Overriding – Dynamic Method Dispatching – garbage collection – String class – String Buffer class –String Builder class.

**UNIT III DATA ABSTRACTION** **9**

Packages – Introduction to Packages – User Defined Packages – Accessing Packages – Abstract classes and Methods – Interface – Defining an interface – implementing interfaces – extending interfaces – Multiple Inheritance Using Interface – Exception Handling – Errors vs Exceptions – Exception hierarchy – usage of try – catch – throw – throws and finally – built in exceptions – user defined exceptions.

**UNIT IV COLLECTION API AND LAMBDA** **9**

Introduction to wrapper classes – Predefined wrapper classes – Conversion of types – Concept of Auto boxing and unboxing – Java Collections API – Introduction to Collection – Generics – List implementations – Set implementations – Map implementations – Functional Interfaces – Lambda Expressions – Accessing local variables – Accessing class variables – Predicates – Functions – Suppliers – Consumers – Stream API – Filter – Sorted – Map – Reduce – Count – Parallel Streams.

**UNIT V JDBC AND MULTITHREADING** **9**

JDBC – Introduction to JDBC – Establishing connection – Executing query – Processing results – Prepared Statement – Callable Statement – Transactions – Meta Data objects – Multithreading: Introduction to Multithreading – Process Vs Thread –Thread life cycle – Thread class – Runnable Interface – Thread creation – Thread control and priorities – Thread synchronization.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Develop programs using flow control statements and arrays to manage execution flow and data organization effectively.
2. Implement programs using inheritance and polymorphism to promote code reusability and dynamic method binding.
3. Develop programs incorporating packages, abstract classes, and interfaces to structure code modularly and enforce abstraction.
4. Implement programs using exception handling mechanisms to ensure robust error detection and graceful recovery.
5. Create programs using the Collection API to manage groups of objects with flexibility and high performance.
6. Implement programs using JDBC to establish and manage database connections for data persistence and retrieval.
7. Develop programs using multithreading to achieve concurrent execution and improve application performance.

**TOTAL : 45+30**

**TEXT BOOKS**


1. Herbert Scheldt, " Java: The Complete Reference", 12th edition, Tata McGraw-Hill, 2022.
2. Cay S Horstmann and Gary Cornell, "Core Java: Volume I – Fundamentals", 12th edition, Prentice Hall, 2021.

**REFERENCE BOOKS**


1. David Flanagan and Benjamin Evans, "Java in Nutshell", 8th edition, O'Reilly Media, 2022.
2. Kathy Sierra, Bert Bates, Trisha Gee, "Head First Java ", 3rd edition, O'Reilly Media, Inc, 2022.


**WEB URLs:**

1. www.https://docs.oracle.com/javase/tutorial/java/nutsandbolts
2. www. https://javabeginner.com/learn-java
3. www. https://dev.java/learn

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | - | - | 2 | - | - | - | 1 | - | - | 1 | 2 | 2 |
| CO2 | 3 | 2 | 1 | - | 2 | - | - | - | 1 | - | - | 1 | 2 | 2 |
| CO3 | 3 | 2 | 1 | - | 2 | - | - | - | 1 | - | - | 1 | 2 | 2 |
| CO4 | 3 | 2 | 1 | - | 2 | - | - | - | 1 | - | - | 1 | 2 | 2 |
| CO5 | 3 | 2 | 1 | - | 2 | - | - | - | 1 | - | - | 1 | 2 | 2 |
| **Average** | **2.8** | **1.8** | **1** | **-** | **2** | **-** | **-** | **-** | **1** | **-** | **-** | **1** | **2** | **2** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-III**

**24BEEE391 INTERNSHIP-I/MINI PROJECT-I 2H-1C**

**Instruction Hours/week: L:0 T:0 P:2** **Marks: Internal:100 External:0 :Total:100**

**COURSE OBJECTIVES:**

The goal of this course for students is to

- Bridge the gap between academia and industry in providing an industry exposure for satisfying local industrial needs.
- Enable the students to get connected with Industry / Laboratory / Research Institute.
- Get practical knowledge on production process in the industry and develop skills to solve related problems.
- Develop skills to carry out research in the research Institutes / Laboratories.
- Learn the design methodologies and documentation process.

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Gain knowledge on various tools used in industry.
- Know recent technological advancement happening in industry.
- Gain the knowledge in System-level design processes, verification and validation techniques, manufacturing and production processes in the firm or research facilities in the Laboratory/Research Institute.
- Analysis of industrial / research problems and their solutions.
- Documentation of system specifications, design methodologies, process parameters, testing parameters and results and preparing of technical report and presentation. The students individually undergo training in reputed Firms/ Research Institutes / Laboratories for the specified duration. After the completion of training, a detailed report should be submitted within ten days from the commencement of next semester.

**TOTAL HOURS :30**

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 1 | 3 | - | - | 1 | 3 | 3 | 3 | 3 | - | - |
| CO2 | - | 3 | 3 | 3 | 3 | - | 2 | 1 | 3 | 3 | 3 | 3 | 2 | - |
| CO3 | - | - | 3 | 3 | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | - | 3 |
| CO4 | - | - | - | - | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | 2 | 3 |
| CO5 | - | - | - | - | 3 | 3 | - | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| **Average** | **3** | **3** | **2.7** | **2.3** | **3** | **3** | **2** | **1** | **3** | **3** | **3** | **3** | **2** | **3** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-III**

**24BEMC351 DESIGN THINKING 1H - 1C**

**Instruction Hours/week: L:1 T:0 P:0** **Marks:** Internal**:100** External**:0** Total**:100**

**End Semester Exam:**3 Hours

**PREREQUISITES: Nil**

**COURSE OBJECTIVES:**

The goal of this course for students is to

- Illustrate design thinking concepts and principles
- Utilize design thinking methods in every stage of the problem
- Identify the different phases of design thinking
- Plan for various product and service communication in design thinking
- Interpret the use of tools for the design process

**COURSE OUTCOMES:**

At the end of this course, students will be able to

- Recognize the design thinking process, tool and theories.
- Identify the types of users and the requirement of customers.
- Follow the stages of prototyping the product.
- Replicate design thinking in product and service design.
- Customize existing products by utilizing design thinking strategies.

**UNIT 1 -INTRODUCTION** **6**

Understanding Design thinking and tools - Human-Centric Design Process - Design Thinking Process-DT Activity with case studies.

**UNIT-2 EMPATHISE WITH USERS** **6**

Five Whys - Needs of user - Types of user research -Customer Journey Mapping - Observational Research

**UNIT-3 PROTOTYPING** **6**

Ideas to presentable concepts - Scenario-based Prototyping – Testing prototypes - Usability and ergonomic testing - Rapid prototyping.

**UNIT-4 PRODUCT AND SERVICE DESIGN** **6**

Product Design - Interaction Design- Service Design - Communication Design - Transportation Design.

**UNIT-5 DESIGN AND INNOVATION** **6**

DT for strategic innovations - Extreme Competition - Experience design - Standardization - Humanization - Creative Culture.

**TOTAL HOURS: 30**

**TEXT BOOKS:**

1. Bala Ramadurai, "Karmic Design Thinking", 2020.
2. Christian Mueller-Roterberg, “Handbook of Design thinking”, Amazon Digital Services LLC - KDP Print US, 2018.

**REFERENCE BOOKS:**


1. Tim Brown, “Change by Design”, Harper Business Publisher, 2019
2. Hasso Plattner, Christoph Meinel and Larry Leifer, "Design Thinking: Understand –Improve – Apply", Springer, 2011
3. Idris Mootee, "Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School", John Wiley & Sons 2013.


**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | - | - | 2 | 1 | - | - | 1 | 1 | 2 | 1 | - | 2 | - | 1 |
| **CO2** | - | - | 2 | 1 | - | - | 1 | 1 | 2 | 1 | - | 2 | - | 1 |
| **CO3** | - | - | 2 | 1 | - | - | 1 | 1 | 2 | 1 | - | 2 | - | 1 |
| **CO4** | - | - | 2 | 1 | - | - | 1 | 1 | 2 | 1 | - | 2 | - | 1 |
| **CO5** | - | - | 2 | 1 | - | - | 1 | 1 | 2 | 1 | - | 2 | - | 1 |
| **Average** | **-** | **-** | **2** | **1** | **-** | **-** | **1** | **1** | **2** | **1** | **-** | **2** | **-** | **1** |

**1 - Low, 2 - Medium, 3 - High, ‘-' - No Correlation**

**SEMESTER-III**

**24BEMC352 APTITUDE AND REASONING 2H-0 C**

**Instruction Hours/week: L:0 T:0 P:2** **Marks: Internal:100 External:0 Total:100**

**End Semester Exam:**3 Hours

**PREREQUISITE: Nil**

**COURSE OBJECTIVES:**

The goal of this course for students is to

- Categorize, apply, and use thought processes to distinguish between concepts of Quantitative methods.
- Prepare and explain the fundamentals related to various possibilities and probabilities related to quantitative aptitude.
- Critically evaluate numerous possibilities related to puzzles.
- Understand and solve puzzle-related questions from specific and other competitive tests.
- Solve questions related to Time and distance and time and work etc.

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Explain the basics of quantitative ability.
- Solve questions related to Logarithm, Permutation and Combinations, Probability, Basic Accountancy, Time, Speed, distance, work, Ratio and area etc.
- Utilize satisfactory competency in Verbal Reasoning Questions.
- Solve campus placements aptitude papers covering Quantitative Ability and verbal skills.
- Apply Quantitative and Verbal reasoning in puzzle-related questions.

**UNIT - I Quantitative Ability (Basic Mathematics)**

1.1. Number Systems
1.2. LCM and HCF
1.3. Decimal Fractions
1.4. Simplification
1.5. Square Roots and Cube Roots
1.6. Problems on Ages
1.7. Surds & Indices
1.8. Percentages

**UNIT – II Quantitative Ability (Applied & Engineering Mathematics)**

2.1. Logarithm
2.2. Permutation and Combinations
2.3 Probability
2.4 Profit and Loss
2.5 Simple and Compound Interest
2.6. Time, Speed and Distance
2.7. Time & Work
2.8. Ratio and Proportion
2.9. Area

2.10 Mixtures and Allegation

**UNIT – III Verbal - Aptitude**

1.1 Words
1.2 Idioms
1.3 Phrases in Context
1.4 Reading comprehension techniques
1.5 Narrative sequencing
1.6 Data interpretation

**TEXT BOOKS:**

1. A Modern Approach to Verbal & Non-Verbal Reasoning by R S Agarwal
2. Analytical and Logical Reasoning By Sijwali B S

**REFERENCE BOOKS:**

1. Quantitative aptitude for Competitive Examination by R S Agarwal
2. Analytical and Logical Reasoning for CAT and other management entrance tests by Sijwali B S
3. Quantitative Aptitude by Competitive Examinations by Abhijit Guha 4th edition

**WEBLINKS:**

1. https://prepinsta.com/
2. https://www.indiabix.com/
3. https://www.javatpoint.com/

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | - | - | - | - | 3 | - | - |
| **CO2** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 3 | - | - |
| **CO3** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 3 | - | - |
| **CO4** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 3 | - | - |
| **CO5** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | 3 | - | - |
| **Average** | **2.8** | **1.8** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | - | - | **3** | - | - |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-IV**

**24BEEE401 AI FOR ELECTRICAL ENGINEERS 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Power system and Control system

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Provide insights into the fundamental concepts of artificial intelligent techniques.
- Apply AI techniques to find solutions for real-world problems in electrical engineering.
- Interpret AI algorithms in electrical domains.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Summarize AI techniques in classical problems K2
- Interpret AI algorithms in getting optimum solution for complex problems in power system and control system. K2
- Apply the neural network for solving classification problems K3
- Model the hybrid intelligent algorithms for typical electrical engineering applications K3
- Analyze the fuzzy logic algorithms in control system problems K4

**UNIT I ARTIFICIAL INTELLIGENCE 9**

Artificial Intelligence: Concept – History and Progress of AI – AI and the world – Applications of AI -Agents – Knowledge based systems – Classical problem solving methods and heuristic search techniques.

**UNIT II ARTIFICIAL NEURAL NETWORK 9**

Fundamental concepts – Basic models and Learning rules – Single layer and multi-layer feed forward and feedback networks – Supervised and Unsupervised learning – Reinforcement learning – Support Vector Machine.

**UNIT III FUZZY LOGIC 9**

Fuzzy logic: Introduction to classical sets – Properties, operations and relations – Introduction to fuzzy sets – Fuzzy versus crisp – Membership functions – Fuzzy set operations – Properties of fuzzy sets – Fuzzy cartesian product – Defuzzification methods – Fuzzy Logic Controller.

**UNIT IV APPLICATION OF AI IN POWER SYSTEM 9**

Application of AI in voltage control – Load forecasting – Forecasting of wind and solar energy – Economic load dispatch – Transformer oil lifetime prediction – Identification – classification and diagnosis of faults in transmission lines – Power system security assessment – Maintenance scheduling of electric power transmission network – Load flow studies

**UNIT V APPLICATION OF AI IN CONTROL SYSTEM** **9**

Application of AI in load frequency control of single area and two area system – Energy management in Microgrid – Speed control of DC and AC motors – Reactive power control – Optimized controllers in industrial plants.

**TOTAL: 45**

**TEXT BOOKS**


1. S. Rajasekaran and G. A.V. Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms", 2nd Edition, PHI Learning Pvt. Ltd, New Delhi, 2013.
2. Ankur Choudhary, Arun Prakash Agrawal, Rajasvaran Logeswaran, Bhuvan Unhelkar, Applications of Artificial Intelligence and Machine Learning, Lecture Notes in Electrical Engineering , Springer publishers, 2021.


**REFERENCE BOOKS**


1. S. N. Sivanandam, S. Sumathi, S. N. Deepa, "Soft computing techniques", Wiley Publications, 3rd Edition 2018.
2. Kevin Warwick, Arthur Ekwue, Rag Aggarwal, Artificial Intelligence Techniques in Power Systems, Institution of Engineering and Technology, 1997.
3. A. K. Bhargava, "Fuzzy Set Theory Fuzzy Logic and Their Applications", S. Chand, 2013.
4. P.D.Wasserman, "Neural Computing Theory & Practice", Van Nostrand Reinhold, New York, 1989.
5. Deepak Khemani, A first course in Artificial Intelligence, McGraw Hill Education Pvt. Ltd., New Delhi,2013


**WEB URLs:**

1. https://www.geeksforgeeks.org/artificial-intelligence/
2. https://archive.nptel.ac.in/courses/127/105/127105006/
3. https://in.mathworks.com/products/fuzzy-logic.html
4. https://www.matlabexpo.com/content/
5. https://www.geeksforgeeks.org/applications-of-ai/

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | - | 1 | 1 | - | 2 | - | - |
| **CO2** | 2 | 1 | - | - | - | - | - | - | 1 | 1 | - | 2 | 1 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | - | 1 | 1 | - | 2 | 1 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | - | 1 | 1 | - | 2 | 1 | 1 |
| **CO5** | 3 | 3 | 2 | 1 | - | - | - | - | 1 | 1 | - | 2 | 1 | 1 |
| **Average** | **2.6** | **1.8** | **1.3** | **1** | **-** | **-** | **-** | **-** | **1** | **1** | **-** | **2** | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-IV**

**24BEEE441 ELECTRICAL MACHINES – II 5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electrical Machines-I

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Explain the construction, principle of operation and performance of three phase induction motor and synchronous Machines
- Perceive the starting and speed control methods of AC machines
- Possess knowledge on the construction, principle of operation, control and performance of special machines

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the construction, operation and types of induction machines and synchronous machines. K2
- Categorize the different methods to start and control the speed of three phase of induction motor. K4
- Analyze the performance of three phase induction machines and single phase induction machines K4
- Interpret the necessity and conditions for parallel operation of synchronous machines. K2
- Outline the construction, operation and applications of special purpose machines. K2

**UNIT I THREE PHASE INDUCTION MOTOR 9**

Construction – Types – Rotating Magnetic Field – Principle of Operation – Torque equation – Slip – Characteristics – Equivalent Circuit – Phasor Diagram – Losses and efficiency – Starting methods – Cogging and Crawling – No load and blocked rotor test – Circle diagram.

**UNIT II SINGLE PHASE INDUCTION MOTOR 9**

Construction – Principle of Operation – Double Revolving Field Theory – Equivalent Circuit – Methods of Starting – Types of single phase induction motor – No load and blocked rotor test – Universal Motor.

**UNIT III SYNCHRONOUS GENERATOR 9**

Construction – Types – Winding Factors – EMF Equation – Armature Reaction – Voltage Regulation; EMF – MMF and ZPF Methods – Parallel Operation – Synchronization – Synchronizing power – Two reaction theory – Slip test – Phasor Diagrams – Voltage Regulation.

**UNIT IV SYNCHRONOUS MOTOR** **9**

Principle of Operation – Methods of Starting – Phasor Diagrams – Power Flow Equations – Effect of Varying load angle and excitation – V and Inverted V Curves – Synchronous Condenser – Hunting and Suppression Techniques.

**UNIT V SPECIAL MACHINES** **9**

Construction and principle of operation of Stepper motors – Permanent magnet DC motors – Brushless DC motors – Permanent Magnet Synchronous Motors – Switched Reluctance Motors – Linear Induction motors and their Applications – Energy Efficient Machines.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS**

1. Determination of equivalent circuit parameters of three phase induction motor
2. Regulation of 3-phase alternator by EMF method
3. Determination of V and inverted V curves of 3-phase synchronous machine
4. Load test on single phase induction motor
5. Load Test on 3-phase Alternator and determination its voltage regulation
6. Load Test and Speed control of 3-Phase Induction Motors

**TOTAL=45+30=75**

**TEXT BOOKS:**

1. D P Kothari, I J Nagrath, "Electric Machines", 5th Edition, McGrawHill Education (India) Private Limited, New Delhi, 2017
2. Dr. P. S.Bimbhra , "Electrical Machinery, Theory: Performance & Applications", 7th Edition, Khanna Publishers, 2021

**REFERENCE BOOKS:**

1. A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, "Electric Machinery", 6th Edition, McGraw Hill publishing Company Ltd, 2017.
2. Stephen J. Chapman, "Electric Machinery Fundamentals", 4th Edition, McGraw Hill Education Pvt. Ltd, 2017.
3. Ramu Krishnan, "Permanent Magnet Synchronous and Brushless DC Motor Drives", 1st Edition CRC Press, 2009.

**WEB URLs:**

1. https://nptel.ac.in/courses/108/105/108105131/
2. https://nptel.ac.in/courses/108/106/108106072/
3. https://www.site.uottawa.ca/~rhabash/ELG2331SPM.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO2** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO3** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO4** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **Average** | **2.8** | **2.4** | **1.6** | **1** | **-** | **-** | **-** | **1** | **1** | **1** | **-** | **1** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-IV**

**24BEEE442 MICROPROCESSORS AND MICROCONTROLLERS 5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week:L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Digital Electronics and C Programming

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Comprehend the organization of registers, system bus and memory in basic computer architecture
- Impart knowledge about the architecture of Intel 8086 microprocessor, Intel 8051 microcontroller and ARM7TDMI Core, and interfacing of IO devices with Intel 8051
- Develop 8086 ALP, 8051 ALP and 8051 embedded C programming skills and Intel 8051 applications

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Interpret the fundamentals of computer architecture and architecture of Intel 8086 microprocessor, Intel 8051 microcontroller and ARM7TDMI core. K2
- Develop 8086 ALP, 8051 ALP and 8051 embedded C code using respective instruction sets and syntaxes K3
- Identify the suitable hardware and programming modules for the given specification K3
- Build interface schemes of basic IO devices, sensors and actuators with Intel 8051 K3
- Construct simple embedded applications using Intel 8051 K3

**UNIT I INTRODUCTION TO COMPUTER ARCHITECTURE 9**

Terminology: Microprocessor, Microcontroller and Microcomputer – Basic building blocks of a microprocessor – Memory mapping schemes – Outline to computer architectures and comparisons: Von Neumann – Harvard – CISC and RISC – Data flow path – Polling and Interrupt concept – DMA operation – Software development tools.

**UNIT II ARCHITECTURE OF INTEL 8086 MICROPROCESSOR 9**

Intel 8086 microprocessor: Features – Architecture – CPU signals – 2-stage Pipeline – Memory segmentation – Registers – Logical and physical address – Physical address generation – Memory banking concept – Addressing modes – Instruction set – 8086 Assembly Language Program.

**UNIT III ARCHITECTURE OF INTEL 8051 9**

Intel 8051 microcontroller: Features – Functional block diagram and control signals – External program memory and data memory interfacing with 8051 – 8051 Internal RAM Memory organization and Memory mapping of Special Function Registers (SFRs) – 8051 Machine cycle – Addressing modes and Instruction set of Intel 8051 – 8051 Assembly Language Program (ALP).

**UNIT IV PROGRAMMING OF 8051 PERIPHERALS** **9**

Working and Programming of 8051 peripherals using embedded C: IO Ports – Timer/Counter – Interrupt controller and full duplex UART – Power control modes: Idle mode and Power down mode – Architecture of ARM7TDMI Core – Operating modes.

**UNIT V PROGRAMMING OF I/O DEVICES WITH 8051** **9**

Working, Interfacing and programming of basic IO devices: Monochrome LED – Tricolor LED – Push button switch – Seven segment display – Matrix keyboard – Working, Interfacing and programming of basic sensors and actuators: Temperature sensor – LDR sensor – Ultrasonic sensor – Relay ON/OFF control – Buzzer – Stepper motor and Servo motor – 8051 applications: Speed control of DC motor – Automatic Street light control system, RFID based attendance system.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. 8086 Assembly Language Programs: Addition, Subtraction, Multiplication and division
2. 8086 Assembly Language Programs: String manipulations, BIOS Interrupt call
3. 8051 Assembly Language Programs: Addition, Subtraction, Multiplication and division
4. 8051 Embedded C Program: Interfacing of Switch, LED and Buzzer with 8051
5. 8051 Embedded C Program: 8051 Serial UART programming
6. Stepper motor control using 8051 microcontrollers
7. Temperature monitoring and control using 8051 microcontrollers with ADC0809

**TOTAL: 45+30=75**

**TEXT BOOKS:**


1. Muhammad Ali Mazidi, Janice G. Mazidi, Rolin, D. McKinlay, "The 8051 Microcontroller and Embedded Systems: Using Assembly and C", 2nd Edition, Pearson Education Limited, 2019.
2. Douglas V Hall, "Microprocessors and Interfacing", 3rd edition, Tata McGraw Hill Education, 2017.


**REFERENCE BOOKS:**


1. Muhammad Tahir, Kashif Javed, "ARM Microprocessor Systems", 1st Edition, CRC Press, 2017.
2. Soumitra Kumar Mandal, "Microprocessors and Microcontrollers Architecture, Programming and Interfacing Using 8085, 8086 and 8051", 3rd Edition, Tata McGraw Hill Education, 2017.
3. Krishna Kant, "Microprocessors and Microcontrollers – Architecture, Programming and system design 8085, 8086, 8051, 8096" 2nd Edition, PHI Learning Private Limited, 2014.


**WEB URLs:**

1. https://edge.edx.org/c4x/BITSPilani/EEE231/asset/8086_family_Users_Manual_1_.pdf
2. https://web.mit.edu/6.115/www/document/8051.pdf
3. https://www.microchip.com/en-us/

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| **CO2** | 3 | 2 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| **CO3** | 3 | 2 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| **CO4** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| **CO5** | 3 | 2 | - | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 1 | - |
| **Average** | **2.8** | **2** | **2** | **1** | - | - | - | **1** | **1** | **1** | - | **1** | **1** | - |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-IV**

**24BEEE443 WEB PROGRAMMING 5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE REQUISITES:** Java Programming

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the fundamental and advanced concepts of HTML, CSS, Bootstrap, and JavaScript.
- Develop dynamic web applications using Servlets and JSP within an MVC framework.
- Implement ORM using Hibernate for efficient database interaction in web applications.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Explain the principles of HTML, CSS, and Bootstrap along with JavaScript features to design interactive web pages. K2
- Apply JavaScript features for creating dynamic web pages and integrating them with server-side technologies like Servlets. K3
- Implement Servlets and JSP for developing robust web applications with effective session management. K3
- Integrate web applications using JSP, Servlets, and database adhering to the MVC architecture. K3
- Apply ORM concepts using Hibernate for efficient database interaction in web applications that integrate Servlets and JSP. K3

**UNIT I – HTML, CSS, and Bootstrap** **9**

HTML: Introduction to HTML and its elements - Layout tags - Semantic tags – Application tags – Logical tags - Introduction to HTML5 and its new features. CSS: Introduction to CSS – Styles and Stylesheets – Formatting with CSS – Links and Lists – CSS Box Model – CSS3 – CSS Preprocessors. Bootstrap: Introduction to Bootstrap – Formatting and styling using Bootstrap – Bootstrap Grid System – Creating responsive designs with Bootstrap.

**UNIT II – Advanced JavaScript** **9**

JavaScript: Introduction to JavaScript – JavaScript functions and objects – JavaScript validations of HTML form - Regular expressions – ES6+ features: let, const, arrow functions, template literals, destructuring, spread/rest operators – modules – Asynchronous programming: Callbacks – Promises – Async/await – Event handling – Error handling – AJAX and Fetch API: Working with AJAX and the Fetch API for asynchronous data fetching.

**UNIT III – Servlets** **9**

Servlets: Introduction to MVC - Features of MVC - Components of MVC. Servlet Introduction - Servlet Life Cycle - Types of Servlet - Servlet Configuration with Deployment Descriptor - Working with ServletContext and ServletConfig Object - Attributes in Servlet - Response and Redirection using Request Dispatcher - sendRedirect Method - Session Tracking: using Cookies, HTTPSession - Performing CRUD (Create, Read, Update, Delete) operation using Servlet with JDBC.

**UNIT IV – JSP** **9**

JSP: Introduction to JSP - Comparison with Servlet - JSP Architecture - JSP Life Cycle - Scripting Elements - Directives - Action Tags - Implicit Objects - JavaBeans in JSP - Expression Language (EL) - JSP Standard Tag Libraries (JSTL) Core Tags - Session Management - Exception Handling - Performing CRUD (Create, Read, Update, Delete) operation using JSP and Servlet with JDBC.

**UNIT V – Object/Relational Mapping (ORM) with Hibernate** **9**

Object/Relational Mapping (ORM): Approaches to ORM – Introduction to Hibernate – Hibernate API – Working with objects – Hibernate with annotations – Querying in Hibernate – Hibernate Query Language (HQL) – Criteria queries – Creating queries with native SQL – Basic O/R mapping – Collection mapping – Association mappings – Inheritance mapping – Developing web application by integrating Servlet, JSP and Hibernate.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Develop static web pages using HTML.
2. Create an HTML-based web page to demonstrate the use of inline, internal, and external CSS.
3. Develop web pages using HTML and CSS Flexbox.
4. Create dynamic web pages using JavaScript.
5. Implement a web page that includes JavaScript code to demonstrate arrays, strings, and JSON.
6. Write JavaScript code to work with Promises, Async/Await, and Modules.
7. Develop a responsive website using Bootstrap components.

**TOTAL: 45+30**

**TEXT BOOKS:**


1. Randy Connolly, Ricardo Hoar, “Fundamentals of Web Development”, Pearson Education, 2018.
2. Budi Kurniawan, “Servlet & JSP: A Tutorial, Second Edition”, Brainy Software, 2014.
3. Christian Bauer, Gavin King, “Java Persistence with Hibernate”, Manning Publications, 2015.


**REFERENCE BOOKS:**


1. Jim Keogh, “J2EE: The complete Reference”, McGraw-Hill, 2017.
2. Julie C. Meloni, “HTML, CSS, and JavaScript All in One”, Sams Publishing, 2021

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | 2 | - | - | - | 1 | - | - | - | 2 | 2 |
| **CO2** | 3 | 2 | 1 | - | 2 | - | - | - | 1 | - | - | - | 2 | 2 |
| **CO3** | 3 | 2 | 1 | - | 2 | - | - | - | 1 | - | - | - | 2 | 2 |
| **CO4** | 3 | 2 | 1 | - | 2 | - | - | - | 1 | - | - | - | 2 | 2 |
| **CO5** | 3 | 2 | 1 | - | 2 | - | - | - | 1 | - | - | - | 2 | 2 |
| **Average** | **2.8** | **1.8** | **1** | **-** | **2** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **2** | **2** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-IV**

**24BEEE444 POWER SYSTEM ANALYSIS AND STABILITY (THEORY & LABORATORY) 5H-4C**

**Instruction Hours/week:L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electric Circuits, Transmission and Distribution

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the role of per unit quantities and formulation of network matrices and apply iterative techniques for power flow analysis
- Perform fault analysis on Transmission line models and Generators
- Study about the various methods for analyzing power system stability

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Analyze the power system network using single line diagram with the help of per-unit Representation K4
- Perform load flow computations and analyze the load flow results K4
- Examine the impact of symmetrical faults in power system K4
- Make use of sequence components to do unsymmetrical fault analysis K3
- Identify the nature of stability in power system K3

**UNIT I POWER SYSTEM NETWORK MODELING 10**

Introduction – Per phase Analysis – Representation of power system–Single line diagram– Impedance and reactance diagram Per unit system – Change of base – Primitive matrix- Bus incidence matrix – Formation of Y bus using direct inspection and singular transformation method – Bus Impedance matrix –Bus building algorithm (without mutual coupling)

**UNIT II POWER FLOW ANALYSIS 9**

Necessity of power flow studies -Bus classification – Power flow Equation – Power flow solution using Gauss Seidel method – Handling of Voltage controlled buses – Power Flow Solution by Newton Raphson method – Computation of slack bus power and line flows .

**UNIT III SYMMETRICAL FAULT ANALYSIS 8**

Classification of faults – Short circuit capacity – Symmetrical short circuit analysis using Kirchhoff's laws and Thevenin's theorem –Balanced fault analysis using bus impedance matrix –Selection of circuit breakers

**UNIT IV UNSYMMETRICAL FAULT ANALYSIS 9**

Symmetrical components – Sequence impedances – Sequence networks – Analysis of unsymmetrical faults using sequence networks: LG, LL and LLG – unsymmetrical fault in power system.

**UNIT V STABILITY ANALYSIS** **9**

Classification of power system stability – Steady state stability – Swing equation for SMIB system – Solution of swing equation by Euler's and fourth order Runge-Kutta method –Transient stability – Factors affecting transient stability – Equal area criterion – Critical clearing angle and time.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Computation of line parameters and modeling of transmission lines.
2. Formation of bus admittance matrix (Y-bus) using singular transformation method.
3. Determination of a bus impedance matrix (Z-bus) using building algorithm.
4. Power flow solution by using Gauss Seidel method.
5. Fault analysis using bus impedance matrix.
6. Transient stability analysis of power systems.

**TOTAL=45+30=75**

**TEXT BOOKS**


1. Kothari D.P. and Nagrath I.J., "Power System Engineering", 3rd edition, McGraw Hill, 2019
2. John J. Grainger, William D. Stevenson, Jr, "Power System Analysis", McGraw Hill, 2017.


**REFERENCE BOOKS**


1. Hadi Saadat, "Power System Analysis", 21st reprint, McGraw Hill, 2009.
2. Gupta B R, "Power System Analysis and Design", Reprint edition, S. Chand Company Ltd., 2007.
3. Prabha Kundur," Power System Stability and Control", Indian edition, McGraw Hill, 2006.
4. Kothari D P, Nagrath I J, Saket R K," Modern Power System Analysis",5th edition, McGraw Hill, 2022.


**WEB URLs:**

1. https://nptel.ac.in/courses/108/102/108102047/
2. https://nptel.ac.in/courses/108/107/108107112/
3. https://web.engr.oregonstate.edu/~webbky/ESE470_files/Section%207%20Fault%20Analysis.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO2** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO3** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO4** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO5** | 3 | 3 | 2 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **Average** | **3** | **3** | **2** | **1** | **-** | **-** | **-** | **1** | **1** | **1** | **-** | **1** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-IV**

**24BEMC451 COMMUNITY ENGAGEMENT AND SOCIAL RESPONSIBILITY 3H-2C**

**Instruction Hours/week: L:1 T:0 P:2** **Marks: Internal:100 External:0 Total:100**

**PRE-REQUISITE:** Nil

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Achieve socio economic development through active community engagement.
- Improve the quality of both teaching and research for better understanding of issues in the society.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Explain the role of community engagement in the development of the nation. K2
- Understand the social problems, social contribution of community networking and various government schemes supporting the community engagement. K2
- Understand the role of Indian citizens towards community development by adopting a village and carrying out the field work K2

**UNIT I INTRODUCTION** **5**

Concept, Ethics and Spectrum of Community engagement- Local Community-Appreciation of rural society-Rural and local economy and livelihood – Rural development programs and Rural institutions

**UNIT II SOCIAL PROBLEMS** **5**

Inequality in America- The Working Poor and Hunger- Homelessness- Inequity in Education- Racism- Crime and Punishment- Refugees and Immigration- Social contribution of community networking-Contribution of self-help groups- Various government schemes

**UNIT III FIELD WORK** **20**

Spreading awareness about the electrical safety, government schemes in renewable energy, Skill development for employment opportunities.

**TOTAL : 30 hours**

**TEXT BOOK:**

1. Principles of Community Engagement, 2nd Edition, NIH Publication No. 11-7782, Printed June 2011

**REFERENCE BOOK:**

1. Community Engagement, Social Responsibility and Social Work Profession Emerging Scope and Social by R. B. S. Verma, Atul Pratap Singh , Jitendra K. Verma, Jan 2016.

**WEB SITES:**

1. https://onlinecourses.swayam2.ac.in/ugc23_ge04/preview

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | - | - | - | - | - | 2 | 1 | 1 | 1 | 1 | - | 1 | - | - |
| **CO2** | - | - | - | - | - | 2 | 1 | 1 | 1 | 1 | - | 1 | - | - |
| **CO3** | - | - | - | - | - | 2 | 1 | 1 | 1 | 1 | - | 1 | - | - |
| **Average** | **-** | **-** | **-** | **-** | **-** | **2** | **1** | **1** | **1** | **1** | **-** | **1** | **-** | **-** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-IV**

**24BEMC452 FOUNDATION OF ENTREPRENEURSHIP 1H-0 C**

**Instruction Hours/week: L:1 T:0 P:0** **Marks: Internal:100 External:0 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Nil

**COURSE OBJECTIVES:**

- Equip and develop the learners' entrepreneurial skills and qualities essential to undertake business.
- Impart the learners' entrepreneurial competencies needed for managing business efficiently and effectively.
- Understand basic concepts in the area of entrepreneurship
- Develop personal creativity and entrepreneurial initiative
- Adopt the key steps in the elaboration of business idea

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Gain entrepreneurial competence to run the business efficiently.
- Undertake businesses in the entrepreneurial environment
- Prepare business plans and undertake feasible projects.
- Be efficient in launching and develop their business ventures successfully
- Monitor the business effectively towards growth and development

**UNIT I ENTREPRENEURAL COMPETENCE**

Entrepreneurship concept – Entrepreneurship as a Career – Entrepreneurial Personality - Characteristics of Successful Entrepreneurs – Knowledge and Skills of an Entrepreneur.

**UNIT II ENTREPRENEURAL ENVIRONMENT**

Business Environment - Role of Family and Society - Entrepreneurship Development

**UNIT III BUSINESS PLAN PREPARATION**

Sources of Product for Business - Prefeasibility Study - Criteria for Selection of Product - Ownership

**UNIT IV LAUNCHING OF SMALL BUSINESS**

Finance and Human Resource Mobilization - Operations Planning - Market and Channel Selection - Growth Strategies

**UNIT V MANAGEMENT OF SMALL BUSINESS**

Monitoring and Evaluation of Business - Effective Management of small Business - Case Studies.

**TEXT BOOKS:**

1. S.S. Khanka, Entrepreneurial Development, S. Chand and Company Limited, New Delhi, 2016.
2. R.D. Hisrich, Entrepreneurship, Tata McGraw Hill, New Delhi, 2018.

**REFERENCE BOOKS:**

1. Rajeev Roy, Entrepreneurship, Oxford University Press, 2nd Edition, 2011.
2. Donald F Kuratko, T.V Rao. Entrepreneurship: A South Asian perspective. Cengage Learning, 2012.

**SEMESTER-IV**

**24BEMC453 ESSENCE OF TRADITIONAL INDIAN KNOWLEDGE AND HERITAGE 1H-0C**

**Instruction Hours/week: L:1 T:0 P:0** **Marks: Internal:100 External:0 Total:100**

**PRE-REQUISITE:** Nil

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Impart a holistic understanding about Indian Culture and Thoughts from a Historical perspective.
- Encourage critical appreciation of the Indian thoughts and cultural manifestations.
- Introduce the students to important concepts from the diverse intellectual traditions of India.
- Make use of Indian cultural heritage and various epistemological inquiries.
- Gain knowledge of Indian heritage.

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Understand the cultural diversity
- Infer the need of cultural unity
- Know the Dravidian culture
- Realize the power of the Indian educational system called gurukul
- Come to know the concepts of Vedic thought

**UNIT I INTRODUCTION TO INDIAN THOUGHT AND CULTURE**

Plurality of Indian Culture - Cultural Diversity and Cultural Unity -Different Manifestations of Indian Culture: Indus Valley culture -Vedic Culture and Dravidian culture.-The Medieval Bhakti Culture

**UNIT II TRADITIONAL KNOWLEDGE SYSTEMS OF INDIA**

Introduction to the Traditional Indian Education System of Gurukul - Parampara -Understanding Indian Philosophy: Vedic Thought and the nine schools of Philosophy - Indigenous Knowledge and Women in India

**UNIT III PROTECTION OF TRADITIONAL KNOWLEDGE**

Protection of traditional knowledge: The need for protecting traditional knowledge Significance of TK Protection, the value of TK in the global economy, Role of Government to harness TK.

**TEXT BOOKS:**

1. Chatterjee, Satishchandra, and Dhirendramohan Datta. (2007) Introduction to Indian Philosophy. Rupa Publications, New Delhi.
2. Husain, S. Abid. (2003). The National Culture of India. National Book Trust, New Delhi.

**REFERENCE BOOK:**

1. OmPrakash Mishra, Essence of Indian Traditions, by Dr. , Khanna Publishers, Jan 2021.

**SEMESTER-V**

**24BEEE501 RENEWABLE ENERGY SYSTEMS 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electrical Power Generation

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Gain the knowledge about environmental aspects of energy utilization.
- Understand the basic principles of wind energy conversion, Biomass, fuel cell, Geo-thermal power plants and MHD.
- Gain the knowledge about ocean energy, solar cells, photovoltaic conversion

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Outline the environmental issues associated with fossil fuels and other energy resources K2
- Build the Solar PV systems for practical applications K2
- Choose the Wind Turbine systems for applications based on their configuration K3
- Construct bioenergy systems, fuel cells, and other renewable energy technologies. K3
- Identify practical renewable energy systems for various applications. K3

**UNIT I INTRODUCTION 9**

Energy scenario – Different types of Renewable Energy Sources – Environmental aspects of energy utilization – Energy Conservation and Energy Efficiency – Needs and Advantages – Energy Conservation Act 2003.

**UNIT II SOLAR PHOTO-VOLTAIC SYSTEM 9**

Solar radiation and its measurement – Angle of sun rays on solar collector – Optimal angle for fixed collector – Sun tracking – Introduction to solar cell – Solar PV system – Design and applications – Stand-alone and grid connected systems – Environmental impacts.

**UNIT III WIND POWER GENERATION 9**

Wind energy – Classification of wind turbines – Components of wind energy conversion system – Extraction of wind turbine power – Wind turbine power curve – Horizontal axis wind turbine generator – Modes of wind power generation – Stand-alone and grid connected system – Site selection consideration – Environmental impacts

**UNIT IV OCEAN ENERGY 9**

Ocean energy resources – Ocean energy routes – Principles of ocean thermal energy conversion systems – Ocean power plants – OTEC power stations in India and World – Principles of ocean wave energy conversion and tidal energy conversion.

**UNIT V OTHER SOURCES** **9**

Bioenergy and types – Fuel cell – Geo-thermal power plants – Magneto-hydro-dynamic (MHD) energy conversion – $H_2$: Operating Principles – Zero energy concepts – Benefits of Hydrogen Energy – Hydrogen production technologies – Hydrogen energy storage – Application of hydrogen energy – Environmental impacts.

**TOTAL: 45**

**TEXT BOOKS**

1. Rai.G.D, "Non-conventional Energy Sources", 6th Edition, Khanna publishers, 2017.
2. Khan.B.H, "Non-Conventional Energy Resources", 3rd Edition, Mc Graw Hill, 2017.

**REFERENCE BOOKS**

1. D P Kothari, K C Singal and Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", 2nd Edition, PHI Pvt. Ltd,2012.
2. C S Solanki, "Solar Photo-voltaics – Fundamentals, Technologies and Applications", 3rd Edition PHI Pvt. Ltd, 2015.
3. S N Bhadra, D Kastha and S Banerjee, "Wind Electrical Systems", 2nd Edition, Oxford Publications, 2005.
4. Tony Weir and John Twidell, "Renewable Energy Sources", 2nd Edition, Taylor and Francis, 2005.

**WEB URLs:**

1. https://nptel.ac.in/courses/103103206
2. https://onlinecourses.nptel.ac.in/noc22_ch27/preview
3. https://onlinecourses.nptel.ac.in/noc23_ge47/preview

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO2** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **1** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **1** | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-V**

**24BEEE502 ELECTRIC VEHICLE TECHNOLOGY 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE: Nil**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the basics of vehicle dynamics and drive train control
- Understand the fundamental concepts of vehicle design
- Gain the knowledge on energy storing devices, propulsion system

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the concepts of electric vehicle and their impact on environment K2
- Choose the basic architecture and topologies of electric vehicle drive for various Applications K3
- Select various energy storage technologies in electric vehicles K3
- Apply control techniques for various electric propulsion drive systems K3
- Design the power electronics components for electric Vehicles K3

**UNIT I INTRODUCTION 9**

Fundamentals of vehicle propulsion and brake – Vehicle Resistance – Dynamic equation of vehicle motion – Tire-Ground Adhesion – Maximum tractive effort – Power train tractive effort – Vehicle power plant characteristics – Transmission characteristics – Vehicle Performance – Gradeability – Acceleration performance – Brake performance.

**UNIT II BASIC COMPONENTS OF ELECTRIC VEHICLES 9**

Fundamentals of electric traction – Basic architecture of electric drive trains – Electric vehicle drive train topologies – Configuration and power flow control of series – parallel and hybrid drive trains – Power converters for electric vehicles.

**UNIT III ELECTRIC VEHICLE STORAGE TECHNOLOGY 9**

Different types of batteries for electric vehicles – Basic battery parameters – Battery modeling and equivalent circuit – Methods of electric vehicle battery charging – Alternative energy sources – Hydrogen storage systems – Reformers – Super capacitors/Ultra capacitors – Fuel cell powered vehicles – Flywheel technology.

**UNIT IV ELECTRIC PROPULSION DRIVE SYSTEMS 9**

DC motor drives and control – Induction motor drives and control – Permanent magnet brushless DC motor drives and control – AC and Switch reluctance motor drives and control – Drive system efficiency.

**UNIT V DESIGN SPECIFICATIONS** **9**

Selection of motor and sizing – Selection of power electronics components and sizing – Inverter technology – Design of battery pack and auxiliary energy storage system – Design of ancillary systems – EV recharging and refueling system design.

**TOTAL: 45**

**TEXT BOOKS**

1. K. T. Chau, "Electric Vehicle Machines and Drives: Design, Analysis and Application", 1st Edition, John Willey and Sons Singapore Pvt. Ltd., 2015.
2. M. Ehsani, Y. Gao and A. Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", 2nd Edition, CRC press, 2011.

**REFERENCE BOOKS**

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 2nd Edition, Wiley, 2012.
2. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals", 2nd Edition, CRC Press, 2010.
3. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", 1st Edition, Springer, 2013.

**WEB URLs:**

1. https://nptel.ac.in/courses/108/106/108106170/
2. https://nptel.ac.in/courses/108/102/108102121/
3. https://vtumechnotes.com/content/files/2022/09/Electric-Vehicle-4th-Module.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 2 |
| **CO2** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 2 |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 2 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 2 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 2 |
| **Average** | 2.8 | 1.8 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 2 |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER - V**

| | | |
|---|---|---|
| **24BEEE541** | **POWER ELECTRONICS (THEORY and LABORATORY)** | **5H-4C** |

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Electronic Devices and Circuits

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- To describe the construction and working of power semiconductor devices
- To illustrate the working of controlled rectifiers, choppers and inverters
- To illustrate the working of AC voltage controller and cycloconverters

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Outline the architecture and functional flow of Embedded Systems K2
- Explain the concepts of Cortex M3 Microcontroller K2
- Interpret the various protocols used for serial data communication applications K2
- Develop an RTOS based application for embedded systems K3
- Apply the knowledge gained for Programming ARM Cortex M3 for different applications K3

**UNIT I POWER SEMICONDUCTOR DEVICES 9**

Introduction – Structure and switching characteristics – Power Diodes – Power Transistors – SCR – TRIAC – Power MOSFET – IGBT – IGCT – GTO — Driver and snubber circuits for SCR and MOSFET – Thyristor turn ON/OFF methods – Commutation circuits for SCR.

**UNIT II PHASE-CONTROLLED CONVERTERS 10**

Controlled Rectifiers: Single Phase and Three Phase controlled Rectifier with R, RL, and RL with freewheeling diode and RLE load – Performance parameters – Effect of source inductance – Dual converters.

**UNIT III DC-DC CONVERTERS 9**

Introduction – Principles of step-down and step-up chopper – Control strategies – Chopper classifications – Buck – Boost – Buck-Boost – Cuk converters – Introduction to forward and fly back converters.

**UNIT IV DC-AC CONVERTERS 9**

Introduction – Single phase bridge inverters – Three phase bridge inverters – 120 and 180 degrees mode of conduction – Voltage control of inverters – Harmonic control of inverters – PWM inverters – Current source inverters.

**UNIT V AC-AC CONVERTERS** **8**

Introduction – AC voltage controller – Single phase AC voltage controllers with R, RL loads – Three phase AC voltage controller – Single phase and three phase cycloconverters.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS**

1. Demonstrate the characteristics of SCR.
2. Demonstrate the characteristics of MOSFET.
3. Demonstrate the characteristics of IGBT.
4. Demonstrate the characteristics of TRIAC
5. Simulation of single-phase half and fully-controlled converter using SCR.
6. Simulation of DC-DC Boost and Buck convertor using MOSFET.

**TOTAL=45+30=75**

**TEXT BOOKS**


1. P.S. Bimbra, "Power Electronics", Khanna Publishers, 7th Edition, 2022.
2. Ned Mohan Tore. M. Undeland, William. P. Robbins, "Power Electronics: Converters, Applications and Design", 3rd Edition, Wiley, 2011.


**REFERENCE BOOKS**


1. Singh M.D and Khanchandani K .V. "Power Electronics" 2nd Edition, McGraw Hill, 2017.
2. Andrzej M. Trzynadlowski, "Introduction to Modern Power Electronics", 2nd Edition, Wiley India Pvt. Ltd., 2010.
3. M.H. Rashid, "Power Electronics: Circuits, Devices and Applications", 4th Edition, Pearson Education, 2017.


**WEB URLs:**

1. https://nptel.ac.in/courses/108105066/
2. https://nptel.ac.in/content/storage2/courses/108105066/PDF/L34(DP) (PE)%20((EE)NPTEL).pdf
3. https://nptel.ac.in/content/storage2/courses/108103009/download/M4.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO2** | 2 | 1 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **1** | **-** | **-** | **-** | **1** | **1** | **1** | **-** | **1** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-V**

**24BEEE542 EMBEDDED SYSTEMS AND IOT (THEORY & LABORATORY) 5H-4C**

**Instruction Hours/week:L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electric Circuits

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Study and familiarize the fundamental concepts of real time operating system
- Learn the architecture of embedded microcontrollers embedded design processes and embedded applications
- Apply the knowledge of serial communication protocols and internet of things.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Outline the architecture & functional flow of Embedded Systems K2
- Explain the concepts of Cortex M3 Microcontroller K2
- Utilize the various protocols used for serial data communication applications K2
- Develop an RTOS based (framework) application for embedded systems K3
- Apply the knowledge gained for Programming ARM Cortex M3 for different applications K3

**UNIT I INTRODUCTION TO EMBEDDED SYSTEMS AND INTERNET OF THINGS 9**

Introduction to Embedded systems: Definition – Classifications – Real Time Systems – Classifications – General Purpose computing systems vs Embedded systems – Design Metrics – Components of Embedded systems: Reset Circuit – Brown-out Protection Circuit – Oscillator Unit – Real Time Clock – Watchdog Timer, Introduction to IoT: Overview of IoT – architecture – Facilitating Technologies – Communication.

**UNIT II STUDY OF CORTEX M3 MICROCONTROLLER 9**

Overview of Cortex – M3 – Cortex-M3 Basics: Registers – Operation Modes – Exceptions and Interrupts – Vector Tables – Stack Memory Operations – Reset Sequence – Pipeline – Block Diagram – Bus Interfaces on Cortex-M3: I-Code Bus – D-Code Bus – System Bus – External PPB – DAP Bus.

**UNIT III COMMUNICATION STANDARDS AND PROTOCOLS 9**

Serial wired communication standards and protocols: SCI – I2C – SPI – RS485 – USB and CAN Bus – PC Parallel port programming – Wireless Protocols: Wi-Fi – Bluetooth – BLE – NFC.

**UNIT IV REAL TIME OPERATING SYSTEM 9**

Overview of RTOS: scheduler – dispatcher – Objects – Services – Characteristics of an RTOS – Hard real time and soft real time – Difference between general purpose OS and RTOS – Task – Threads – Multi tasks and multi processes – Context Switching – Linux Operating Systems and Scheduling policies – Inter Process Communication – Synchronization mechanisms.

**UNIT V DESIGN METHODOLOGIES AND CASE STUDIES 9**

Overview of Design Methodologies – Testing and debugging Methodologies – Applications and Case study of embedded systems (Vending Machine, Digital camera, Fitness Bands, Elevator Control system, Biometric authentication system, RFID), Industrial IoT protocols, Application of IIoT in industry 4.0.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Interfacing of LED and Switch with ARM Cortex M-microcontroller
2. Interfacing Relay and Buzzer with ARM Cortex M-microcontroller
3. Interfacing a 4x4 matrix keypad with ARM Cortex M-microcontroller
4. Interfacing of Temperature Sensor and LDR with ARM Cortex M-microcontroller
5. Generate PWM and vary its duty cycle using the internal PWM module of ARM Cortex-M controller
6. Demonstrate the use of an external interrupt to toggle an LED ON/OFF
7. Interfacing of RFID using ARM Cortex M-microcontroller

**TOTAL=45+30=75**

**TEXT BOOKS:**


1. Rajkamal,"Embedded Systems –Architecture, Programming and Design", 3rd Edition, Tata McGraw Hill, 2017.
2. Alexander G Dean, "Embedded Systems Fundamentals with Arm Cortex-M based Microcontrollers: A Practical Approach", 2nd Edition, Arm Education Media, 2021.


**REFERENCE BOOKS:**


1. Daniel W. Lewis, "Fundamentals Of Embedded Software With The Arm Cortex - M3", 2nd Edition, Pearson,2015.
2. Peckol, James K., "Embedded Systems-A Contemporary Design Tool", 2nd Edition, Wiley & Sons Ltd, 2019.
3. Sriram V Iyer, Pankaj Gupta, "Embedded Real time Systems Programming", 1st Edition, Tata McGraw Hill, 2017.


**WEB URLs:**

1. https://archive.nptel.ac.in/courses/106/105/106105193/
2. https://documentation-service.arm.com/static/62053c120ca305732a3a5c14?token=
3. www.arm.com/products/silicon-ip-cpu?families=cortex-m&showall=true

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | - | - | - |
| **CO2** | 2 | 1 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | - | - | 1 |
| **CO3** | 2 | 1 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | - | - | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | - | - | 1 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | 1 | 1 | - | - | - | 1 |
| **Average** | **2.8** | **1.8** | **1** | **1** | - | - | - | **1** | **1** | **1** | - | - | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-V**

**24BEEE543 CONTROL SYSTEMS 5H-4C**

**(THEORY & LABORATORY)**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE- REQUISITES**: Matrices and Calculus, Electric Circuit Analysis

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the concept of control systems, transfer function of various systems
- Analyze the time and frequency response of the system analytically and graphically
- Design of compensators for various systems using state space representation

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the basic concept of control systems, transfer function and mathematical modelling K2
- Infer the transient and steady-state behavior of dynamic systems K2
- Develop simple systems in transfer function model and their state variables K3
- Analyze the absolute and relative stability of dynamic systems using time and frequency domains. K4
- Design Lag, Lead and Lag-Lead Compensators for analyzing the stability of the system K4

**UNIT I SYSTEMS AND MODELING 9**

Open loop and Closed loop – Feedback control system characteristics – Mathematical modeling: Mechanical – Electrical and Electromechanical systems – Transfer function representations: Block diagram and Signal flow graph.

**UNIT II TIME DOMAIN ANALYSIS 9**

Standard test inputs –Type and order of system – Time response – First order and second order system response for step input – Time domain specifications – Steady state error – Stability analysis: Concept of stability – Routh Hurwitz stability criterion – Root locus – Effect of adding poles and zeros

**UNIT III FREQUENCY DOMAIN ANALYSIS 9**

Frequency domain specifications – Bode plot, Polar plot and Nyquist plot – Introduction to closed loop Frequency Response – Effect of adding lag and lead compensators.

**UNIT IV DESIGN OF FEED BACK CONTROL SYSTEM 9**

Design specifications – Lag, Lead and Lag-lead compensators using Root locus and Bode plot techniques – P,PI,PID controller – Design using reaction curve and Ziegler-Nichols technique.

**UNIT V STATE VARIABLE ANALYSIS** **9**

State variable formulation – State Variable representation of Electrical Systems – Non uniqueness of state space model – State transition matrix – Eigen values – Eigen vectors – Controllability – Observability.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Determination of transfer functions of AC servo motor
2. Simulation of Time-response of first and second order systems
3. Simulation of stability analysis of the system using Routh Hurwitz criterion
4. Simulation of lag, lead compensators using root locus and bode plot
5. Simulation of mathematical translational systems
6. Digital simulation of linear and non-linear systems.

**TOTAL: 45+30=75**

**TEXT BOOKS:**

1. I. J. Nagrath and M. Gopal, "Control Systems Engineering", 7th Edition, New Age Pub. Co, 2022.
2. Katsuhiko Ogata, "Modern Control Engineering", 5th Edition, Pearson Education, 2015.

**REFERENCES:**

1. Norman S. Nise, "Control Systems Engineering", 7th Edition, Wiley Publications, 2019.
2. Richard C. Dorf and Robert H. Bishop. "Modern Control Systems", 13th Edition, Pearson Education, 2016.
3. Benjamin C. Kuo and Farid Golnaraghi, "Automatic Control Systems", 9th Edition, Wiley Publications, 2014.
4. Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, "Feedback Control of Dynamic Systems", 8th Edition, Pearson Education, 2018.

**WEB URLs:**

1. https://www.controleng.com
2. https://www.mathworks.com
3. https://www.iitmanagement.com/images/Gallery/B.TECH-EE-8TH%20SEM-ACS.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO4** | 3 | 3 | 2 | 1 | 1 | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **CO5** | 3 | 3 | 2 | 1 | 1 | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |
| **Average** | 2.6 | 2 | 1.6 | 1 | 1 | - | - | 1 | 1 | 1 | - | 1 | 2 | 1 |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-V**

**24BEEE511 INTERNSHIP-II/MINI PROJECT-II 2H-1C**

**Instruction Hours/week: L:0 T:0 P:2** **Marks: Internal:100 External:0 Total:100**

**COURSE OBJECTIVES:**

The goal of this course for students is to

- Bridge the gap between academia and industry in providing an industry exposure for satisfying local industrial needs.
- Enable the students to get connected with Industry / Laboratory / Research Institute.
- Get practical knowledge on production process in the industry and develop skills to solve related problems.
- Develop skills to carry out research in the research Institutes / Laboratories.
- Learn the design methodologies and documentation process.

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Gain knowledge on various tools used in industry.
- Know recent technological advancement happening in industry.
- Gain the knowledge in System-level design processes, verification and validation techniques, manufacturing and production processes in the firm or research facilities in the Laboratory/Research Institute.
- Analysis of industrial / research problems and their solutions.
- Documentation of system specifications, design methodologies, process parameters, testing parameters and results and preparing of technical report and presentation. The students individually undergo training in reputed Firms/ Research Institutes / Laboratories for the specified duration. After the completion of training, a detailed report should be submitted within ten days from the commencement of next semester.

**TOTAL HOURS :30**

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 1 | 3 | - | - | 1 | 3 | 3 | 3 | 3 | - | - |
| CO2 | - | 3 | 3 | 3 | 3 | - | 2 | 1 | 3 | 3 | 3 | 3 | 2 | - |
| CO3 | - | - | 3 | 3 | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | - | 3 |
| CO4 | - | - | - | - | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | 2 | 3 |
| CO5 | - | - | - | - | 3 | 3 | - | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| **Average** | **3** | **3** | **2.7** | **2.3** | **3** | **3** | **2** | **1** | **3** | **3** | **3** | **3** | **2** | **3** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-V**

**24BESD512 SKILL DEVELOPMENT - I**
**(DESIGN AND SIMULATION OF RENEWABLE ENERGY SYSTEMS) 2H-1C**

**Instruction Hours/week: L:0 T:0 P:2** **Marks: Internal:100 External:0 Total:100**

**COURSE OBJECTIVES:**

The goal of this course is to:

- Illustrate the renewable energy systems
- Design and simulate the renewable energy system for particular application

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Explain the operation of renewable energy systems K2
- Apply design concept in installing wind energy system, solar PV system and hybrid system for residential and commercial purposes K3
- Make use of simulation tools for understanding the operation of renewable energy systems and optimizing their ratings K3

**UNIT I WIND ENERGY SYSTEMS 10**

Introduction-State of the art- Challenges and future trends- Working principle of wind energy system -Types - Design of stand- alone wind energy system based on available wind speed and location- Sizing of inverters and batteries – Residential and industrial applications.

**UNIT II PHOTOVOLTAIC SYSTEMS 10**

Introduction – Research and development in photovoltaic cells – Working principle of photovoltaic system and solar thermal system – MPPT- Design of stand-alone photo voltaic system for residential and commercial applications – Sizing of converters, inverters and batteries.

**UNIT III SIMULATION OF RENEWABLE ENERGY SYSTEMS 10**

Hybrid energy systems- Simulation tools for design and operation of renewable energy systems – Optimum design of hybrid renewable energy systems

**TEXT BOOKS:**

1. B.H.Khan, Non-conventional Energy Resources, 3rd edition. McGraw Hill, 2017.
2. Erdinc, O., Optimization in renewable energy systems: recent perspectives, Butterworth- Heinemann publishers,2017

**REFERENCE BOOKS:**


1. Ziyad Salameh, Renewable Energy System Design, 1st edition, Academic Press, 2014
2. Ahmad Taher Azar, Nashwa Ahmad Kamal, Design, Analysis and Applications of Renewable Energy Systems, Academic Press, 2021.


**WEB SITES:**

1. https://www.udemy.com/course/renewable-energy-system-design-modeling-and-simulation
2. https://www.mdpi.com/journal/energies/special_issues/Simulation_Modelling_and_Analysis_of_a_Renewable_Energy_System
3. https://nptel.ac.in/courses/103103206

**CO, PO, PSO Mapping:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | 1 | - | - | - | - | 1 | - | - | 1 | 1 | 2 |
| CO2 | 3 | 2 | 1 | 1 | - | - | - | - | 1 | - | - | 1 | 1 | 2 |
| CO3 | 2 | 2 | 1 | 1 | - | - | - | - | 1 | - | - | 1 | 1 | 2 |
| **Average** | **2.3** | **1.7** | **1** | **1** | - | **-** | **-** | **-** | **1** | - | - | **1** | 1 | **2** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-V**

**24BEMC551 CRYPTOGRAPHY AND CYBER SECURITY 1H-0C**

**Instruction Hours/week: L:1 T:0 P:0** **Marks: Internal:100 External:0 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Nil

**COURSE OBJECTIVES:**

The goal of this course for the students is to

- Learn basic knowledge about number theory and classical encryption techniques.
- Use symmetric key encryption and public key encryption for encryption and decryption.
- Infer in-depth knowledge on authentication mechanism and application security.

**COURSE OUTCOMES:**

Upon Completion of this course the students will be able to

- Interpret OSI security services, security attacks and security mechanism.
- Apply symmetric key cryptography algorithms for encryption and decryption process.
- Build public key cryptography algorithms for encryption and decryption process.
- Make use of digital signature and authentication protocols for message authentication and integrity.
- Analyze security solutions for Electronic Mail Security, IP security, and web security.

**UNIT I OSI SECURITY ARCHITECTURE 9**

Overview – OSI security architecture – Attacks and services – Security mechanism – Classical encryption techniques – Basic concepts in number theory and finite fields – Prime numbers – Fermat and Euler's theorem – Primality testing.

**UNIT II SYMMETRIC KEY CRYPTOGRAPHY 9**

Data Encryption Standard – Block cipher design principles – DES example – The Strength of DES – Triple DES – AES – Modes of operation.

**UNIT III PUBLIC KEY CRYPTOGRAPHY 9**

RSA – Attacks – Diffie-hellman key exchange – Elliptic curve arithmetic – Elliptic curve cryptography – ElGamal Public key cryptosystems.

**UNIT IV MESSAGE AUTHENTICATION AND INTEGRITY 9**

Authentication requirement – Authentication function – MAC – Hash function – Security of hash function and MAC – SHA –Digital signature and authentication protocols – DSS- Entity Authentication: Biometrics, Passwords - Authentication applications – Kerberos.

**UNIT V SECURITY PRACTICE AND SYSTEM SECURITY 9**

Electronic Mail security – PGP, S/MIME – IP security – Web Security – System Security: Intruders – Malicious software – viruses – Firewalls.

**TEXT BOOKS:**


1. William Stallings, “Cryptography and Network Security Principles and Practices”, Pearson/PHI, Ninth Edition ,2020
2. Wade Trappe, Lawrence C Washington, “Introduction to Cryptography with coding theory”, Pearson,2021.


**REFERENCE BOOKS:**


1. W. Mao, “Modern Cryptography – Theory and Practice”, Pearson Education, Third Editon,2018.
2. Charles P. Pfleeger, Shari Lawrence Pfleeger – Security in computing – Prentice Hall of India, Fifth Edition,2018.


**WEB URLs:**

1. https://www.onlinecourses.nptel.ac.in/noc22_cs03.
2. https://www.onlinecourses.nptel.ac.in/noc22_cs90.
3. https://www.scaler.com/topics/computer-network/cryptography-and-network-security

**SEMESTER-VI**

| 24BEEE601 | SMART GRID | 3H-3C |
|---|---|---|

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Power System Analysis and stability

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Gain insight into emerging trends in energy systems, including renewable energy integration, demand response, and energy storage.
- Explore advanced grid control and optimization algorithms to enhance the resilience of grid infrastructure.
- Learn about next-generation metering infrastructure and utilize advanced data analytics for optimizing grid performance

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the emerging trends in energy systems to enhance grid performance and reliability. K2
- Utilize advanced grid control algorithms to optimize grid resilience and efficiency. K3
- Identify advanced data analytics for predictive maintenance and fault detection in smart grid. K3
- Implement advanced transmission and distribution technologies for grid modernization and resilience enhancements. K3
- Apply secure communication protocols, blockchain technology, and advanced cybersecurity measures to protect the smart grid against cyber threats. K3

**UNIT I ADVANCED SMART GRID CONCEPTS 9**

Emerging Trends in Energy Systems: Integration of Renewable Energy Sources, Demand Response, and Energy Storage; Advanced Grid Control and Optimization Algorithms; Resilient Grid Infrastructure.

**UNIT II ADVANCED METERING AND DATA ANALYTICS 9**

Next-Generation Metering Infrastructure: Advanced Data Analytics for Grid Optimization; Machine Learning and AI in Meter Data Analysis; Predictive Maintenance and Fault Detection in Smart Metering.

**UNIT III ADVANCED TRANSMISSION AND DISTRIBUTION TECHNOLOGIES 9**

Grid Modernization: HVDC Transmission Technologies; Advanced Distribution Management Systems (DMS); Grid Resilience Enhancements: Self-Healing Networks, Distributed Energy Resource Integration, and Grid Edge Intelligence.

**UNIT IV ADVANCED GRID COMMUNICATIONS AND CYBERSECURITY 9**

Secure Communication Protocols for Smart Grids; Blockchain Technology for Grid Transactions; Advanced Cybersecurity Measures for Grid Protection against Cyber Threats.

**UNIT V ADVANCED APPLICATIONS OF AI AND MACHINE LEARNING IN SMART GRIDS 9**

AI-Driven Predictive Maintenance for Grid Assets; Autonomous Grid Operation with Reinforcement Learning; Advanced Machine Learning Models for Grid Optimization and Control.

**TOTAL: 45**

**TEXT BOOKS:**

1. Samir M. El-Gammal and Hossam A. Gabbar, "Advanced Smart Grids: Opportunities, Challenges, and Applications", Springer, 2012.
2. Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy", Academic Press, 2016.

**REFERENCES:**

1. Chen-Ching Liu and Stephen McArthur, "Smart Grid Handbook", Wiley, 2016.
2. K. Vaisakh and K. Manickavasagam, "Power System Operation in a Smart Grid Environment", Springer, 2017.
3. James Momoh, "Smart Grid: Fundamentals of Design and Analysis," 1st Edition, Wiley-IEEE Press, 2012.
4. Stephen F. Bush, "Smart Grid: Communication-Enabled Intelligence for the Electric Power Grid," 1st Edition, Wiley-IEEE Press, 2014.

**WEB URLs:**

1. https://www.coursera.org/learn/smart-grids
2. https://www.edx.org/professional-certificate/electric-power-systems
3. https://eta-publications.lbl.gov/sites/default/files/advanced-transmission-technologies.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO2** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 2 |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 2 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 2 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 2 |
| **Average** | **3** | **2** | **1** | **1** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **1** | **1** | **1.8** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-VI**

**24BEEE602 DIGITAL POWER SYSTEM PROTECTION 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Transmission and Distribution, Power system analysis and stability

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Gain a thorough understanding of power system protection fundamentals and their significance in ensuring electrical network reliability.
- Master the design, implementation, and analysis of digital protection algorithms for various power system components.
- Develop practical skills through hands-on exercises and simulations using industry-standard software tools for digital protection relay programming and testing

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Describe the need and operation of protective systems and CT/PT K2
- Illustrate the operation of a numerical relay K2
- Identify the different signal conditioning systems K3
- Explain signal processing methods and algorithms in digital protection K2
- Outline the emerging protection schemes in power systems K2

**UNIT I INTRODUCTION 9**

Introduction of digital relays – Elements of digital relays – Need for protective systems – Zones of protection – Current transformers and voltage transformers – Principle of operation of magneto optic CT/ PT – effect on relaying philosophy.

**UNIT II INTRODUCTION TO DIGITAL RELAYS 9**

Basic Components of numerical Relays with block diagram – Processing Unit – Human machine Interface – Principle of operation – Comparison of numerical relays with electromechanical and static relays – Advantages of numerical relays – Communication in protective relays (IEC 61850) – Information handling with substation automation system.

**UNIT III DIGITAL PROTECTION OF TRANSFORMERS 9**

Travelling Wave Protection scheme – Bergeron's –equation based scheme, – Digital differential Protection of Transformers-principles of transformer protection – least-squares curve fitting based algorithms – Fourier- based algorithms – basic hardware of microprocessor based transformer protection.

**UNIT IV DIGITAL FILTERS AND INSTRUMENT TRANSFORMERS** **9**

Digital filters – Fundamentals of Infinite Impulse Response Filters – Finite Impulse Response filters – Filters with sine and cosine windows – Correction of errors introduced by Instrument Transformers – PTs and CTs – Detection of unsaturated fragment of wave shape – CT saturation correction procedure.

**UNIT V WIDE AREA PROTECTION AND MEASUREMENT** **9**

Synchronized sampling – Definition of wide-area protection – Architectures of wide-area protection – Concept of Adaptive relaying – Advantages of adaptive relaying and its application – Adaptive Differential protective scheme.

**TOTAL: 45**

**TEXT BOOKS**


1. A.G.Phadke, James S.Thorp, "Computer Relaying for Power Systems", 2nd Edition, John-Wiley and sons, 2009.
2. Waldemar Rebizant,Janusz Szafran, Andrzej Wiszniewski, "Digital Signal Processing in Power System Protection and Control", 1st Edition, Springer Publication, 2011.


**REFERENCE BOOKS**


1. A.T.Johns and S.K.Salman,, "Digital Protection for Power Systems", IEEE Power Series 15, 1997.
2. Singh, "Digital Power System Protection", 1st Edition, Prentice-Hall of India Pvt. Ltd., 2007.
3. Orhan Gazi, "Understanding Digital Signal Processing", 2nd Edition, Springer, 2017.
4. Paithankar Y.G, "Fundamentals of Power System Protection", 2nd Edition, Prentice-Hall of India Pvt. Ltd., 2010.


**WEB URLs:**

1. https://onlinecourses.nptel.ac.in/noc22_ee46/preview
2. https://onlinecourses.nptel.ac.in/noc20_ee73/preview
3. https://coursecontent.indusuni.ac.in/wp-content/uploads/sites/8/2020/03/Numerical-Relay-PPT-1.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO2** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO4** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.2** | **1.2** | **1** | **1** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **1.4** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-VI**

**24BEEE641 INDUSTRIAL AUTOMATION (THEORY & LABORATORY) 5H-4C**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE- REQUISITES**: Electronic devices and circuits

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Provide knowledge on the basics, building blocks of virtual instrumentation.
- Learn the programming concepts of LabVIEW and perform the simulations of programs.
- Design a real time virtual instrumentation based industrial application.

**COURSE OUTCOMES:**

Upon completion of the course, the students will be able to:

- Understand the necessity and concept of industrial automation K2
- Design virtual instruments using various programming functions. K3
- Categorize the various sensor data and image in various applications K4
- Perform simulation of virtual instruments using different functions. K3
- Analyze case studies of virtual instrumentation based industrial automation K4

**UNIT I INTRODUCTION TO INDUSTRIAL AUTOMATION 9**

Introduction to Industrial Automation -Evolution of Virtual Instrumentation-Architecture of Virtual Instrumentation – Virtual instruments versus traditional Instruments – Role of hardware and software – Conventional and graphical Programming- advantages of LabVIEW–Data types – Data flow programming.

**UNIT II VIRTUAL INSTRUMENTATION SOFTWARE 9**

Components of LabVIEW-Creating and saving a VI - Front panel and block diagram Tool bar – Palettes — Creating and saving a Sub VI – Creating and saving an Express VI – Structures – Case structure – Sequence structures – Timed structures – Loops –Shift registers – Formula nodes – Local and global variables – Control timings- Waveform chart Arrays and array operations – Clusters and cluster functions – String and file I/O

**UNIT III DATA ACQUISTION SYSTEM 9**

Concepts of data acquisition and signals types- Signal conditioning and grounding – Hardware and software configuration – Analog and digital I/O – Timers and counters – DAQ assistant and DAQmx – Selecting and configuring a data acquisition device - Components of computer based measurement system-GPIB – Hardware and software – Instrument I/O assistant – VISA – Instrument drivers –Driver VI s – Serial Port Communication

**UNIT IV IMAQ MACHINE VISION 9**

IMAQ Vision-Image Processing And Analysis-Particle Analysis – Machine Vision – Hardware and Software-Building a Complete Machine Vision System - Acquiring and Displaying Images With NO-IMAQ Driver Software – Image Processing tools and functions in IMAQ Vision – Motion control applications.

**UNIT V CASE STUDIES** **9**

PID Controller – Connect LabVIEW with PLC through OPC –Electrical Power Toolkit –Analysis Function-Power frequency-Magnitude of the supply voltage-Flicker-harmonic Measurement of under-deviation and over-deviation parameters.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Simple program using different data types: Numeric, Boolean and strings
2. Programming using loops and structures.
3. Programming on Arrays and clusters.
4. Programming using charts and graphs.
5. Programming with SubVI and Express VI.
6. Real time voltage, current and Power Measurement.

**TOTAL: 45+30=75**

**TEXT BOOKS:**


1. Jovitha Jerome, 'Virtual Instrumentation Using LabVIEW", Prentice Hall of India,2018.
2. Behzad Ehsani," Data Acquisition using LabVIEW", PACKT Publishing Ltd, 2016


**REFERENCES:**


1. Yik Yang, LabVIEW Graphical Programming Cook book, PACKT Publishing Ltd, 2014
2. Surekha P, Sumathi S,, "Virtual Instrumentation Using LabVIEW", AcmeLearning,2016
3. Sanjay Gupta, "Virtual Instrumentation Using LabVIEW "B S Publications, Hyderabad., 2010


**WEB URLs:**

1. https://www.test-and-measurement-world.com/Terminology/Difference-between-Traditional-Instrument-and-Virtual-Instrument
2. https://www.ni.com/en/support/documentation/supplemental/08/labview-for-loops-and-while-loops
3. https://www.ni.com/en/shop/compactrio/what-are-compactrio-controllers/machine-vision-and-image-processing-with-compactrio

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | 1 | 1 | - | - | 1 | 1 | 1 | - | 1 | - | 1 |
| **CO2** | 3 | 2 | 1 | 1 | 1 | - | - | 1 | 1 | 1 | - | 1 | - | 1 |
| **CO3** | 3 | 3 | 2 | 1 | 1 | - | - | 1 | 1 | 1 | - | 1 | - | 1 |
| **CO4** | 3 | 2 | 1 | 1 | 1 | - | - | 1 | 1 | 1 | - | 1 | - | 1 |
| **CO5** | 3 | 3 | 2 | 1 | 1 | - | - | 1 | 1 | 1 | - | 1 | - | 1 |
| **Average** | **2.8** | **2.2** | **1.4** | **1** | **1** | **-** | **-** | **1** | **1** | **1** | **-** | **1** | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-VI**

**24BEEE642 ELECTRIC DRIVES AND CONTROL (THEORY & LABORATORY) 5H-4C**

**Instruction Hours/week: L:3 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Electrical Machines and Power Electronics

**(i) THEORY**

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand steady state operation and transient dynamics of a motor load system.
- Study and analyze the operation of the converter / chopper fed dc drive, both qualitatively and quantitatively.
- Study and understand the operation and performance of AC Induction motor drives and Synchronous motor drives

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Describe the history, development, and classification of electric drives, including their characteristics and advantages K2
- Evaluate performance of power converters for synchronous motors and special machines K3
- Apply power electronic converters to control the speed of DC motors and induction motors. K3
- Analyse the performance of DC motor drives for various operating condition and its control. K4
- Implement digital speed control techniques using microprocessors and PLCs, and select drives for various industrial applications. K4

**UNIT I INTRODUCTION TO ELECTRIC DRIVES 8**

Drive – Electrical drives – Drive classifications – Block diagram of electrical drives – Choice of electrical drives – Fundamental torque equations – Speed torque conventions and multi-quadrant operation – Components of load torque –Thermal model of motor for heating and cooling – Determination of motor rating – Load equalization.

**UNIT II DC MOTOR DRIVES 10**

Modes of operation – Typical torque and speed characteristics of various types of load – Mathematical steady state stability – Classes of motor duty –braking – Controlled rectifier fed dc drives – Single and three phase half controlled and fully controlled rectifier fed dc separately excited motor – Chopper controlled separately excited dc motors and dc series motor.

**UNIT III CLOSED LOOP CONTROL OF DC MOTOR DRIVES 9**

Source current harmonics – Closed loop current limit control and torque control – Closed loop speed control, Closed loop speed control of multi motor drivers – Phase locked loop (PLL) control – Closed loop position control – Ripple factor effect on motor control– Design of speed controller– Design of current controller.

**UNIT IV AC MOTOR DRIVES** **9**

Speed control of three phase induction motors – Stator voltage control – Variable frequency control from voltage sources – Rotor resistance chopper based speed control – Vector Control – Speed control of synchronous motor drives – Open loop V/f control and self-control of synchronous motor – Marginal angle control and power factor control for synchronous motor.

**UNIT V DIGITAL CONTROL OF DRIVES** **9**

Digital techniques in speed control – Advantages and limitations – Microprocessor/Microcontroller and PLC based control of drives – SRM drive – BLDC drive – Speed detection – Current sensing circuits.

**(ii) LABORATORY**

**LIST OF EXPERIMENTS:**

1. Microcontroller based open loop speed control of 3 phase Induction motor (v/f control)
2. Microcontroller based open loop speed control of BLDC motor
3. Speed control of Switched Reluctance motor
4. Simulation of CUK converter fed DC motor
5. IGBT based 3 phase PWM inverter
6. Step up and Step down Chopper control of drives.

**TOTAL: 45+30=75**

**TEXT BOOKS**

1. Gopal K.Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosa Publishing House, 2010.
2. Bimal K.Bose. "Modern Power Electronics and AC Drives", 1st Edition, Pearson Education, 2002.

**REFERENCE BOOKS**

1. Krishnan R, "Electric Motor Drives: Modeling, Analysis and Control", 1st Edition, Prentice Hall of India, New Delhi, 2010.
2. Vedam Subramanyam, "Electric Drives: Concepts and Applications", Tata McGraw-Hill, New Delhi, 2011.
3. Nisit K. De and Swapan K. Dutta, "Electric Machines and Electric Drives", PHI learning Pvt. Ltd, 2011.

**WEB URLs:**

1. https://nptel.ac.in/courses/108/104/108104140/
2. http://nptel.ac.in/courses/108108077/
3. http://nptel.ac.in/courses/108104011/

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | 1 | 1 | - | - | 2 | - |
| **CO2** | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | - | 2 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | - | 2 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | - | 2 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | 1 | 1 | - | - | 2 | 1 |
| **Average** | **2.8** | **1.8** | **1** | **-** | **-** | **-** | **-** | **1** | **1** | **1** | **-** | **-** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-VI**

**24BEEE691 MINI PROJECT III 2H-1C**

**Instruction Hours/week: L:0 T:0 P:2** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**COURSE OBJECTIVES:**

The goal of this course for students is to:

- Bridge the gap between academia and industry in providing an industry exposure for satisfying local industrial needs.
- Enable the students to get connected with Industry / Laboratory / Research Institute.
- Get practical knowledge on production process in the industry and develop skills to solve related problems.
- Develop skills to carry out research in the research Institutes / Laboratories.
- Learn the design methodologies and documentation process.

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Gain knowledge on various tools used in industry.
- Know recent technological advancement happening in industry.
- Gain the knowledge in System-level design processes, verification and validation techniques, manufacturing and production processes in the firm or research facilities in the Laboratory/Research Institute.
- Analysis of industrial / research problems and their solutions.
- Documentation of system specifications, design methodologies, process parameters, testing parameters and results and preparing of technical report and presentation. The students individually undergo training in reputed Firms/ Research Institutes / Laboratories for the specified duration. After the completion of training, a detailed report should be submitted within ten days from the commencement of next semester.

**TOTAL HOURS :30**

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 1 | 3 | - | - | 1 | 3 | 3 | 3 | 3 | - | - |
| CO2 | - | 3 | 3 | 3 | 3 | - | 2 | 1 | 3 | 3 | 3 | 3 | 2 | - |
| CO3 | - | - | 3 | 3 | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | - | 3 |
| CO4 | - | - | - | - | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | 2 | 3 |
| CO5 | - | - | - | - | 3 | 3 | - | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| **Average** | **3** | **3** | **2.7** | **2.3** | **3** | **3** | **2** | **1** | **3** | **3** | **3** | **3** | **2** | **3** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-VI**

**24BEMC651 UNIVERSAL HUMAN VALUES 2H-2C**

**Instruction Hours/week: L:2 T:0 P:0** **Marks: Internal:100 External:0 Total:100**

**End Semester Exam: 3Hours**

**PRE-REQUISITE: Nil**

**COURSE OBJECTIVES:**

The goal of this course for students is to

- Help students to understand the need, basic guidelines, content and process of value education.
- Help students distinguish between values and skills
- Help students initiate a process of dialog within themselves to know what they 'really want to be' in their life and profession
- Help students understand the meaning of happiness within their selves.
- Help students understand the meaning of happiness and prosperity for a human being.

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Illustrate the significance of value inputs in a classroom, distinguish between values and skills. K2
- Interpret the need, basic guidelines, content and process of value education, explore the meaning of happiness and prosperity and do a correct appraisal of the current scenario in the society K2
- Distinguish between the Self and the Body; understand the meaning of Harmony in the Self the Co-existence of Self and Body. K4
- Illustrate the value of harmonious relationship based on trust, respect and other naturally acceptable feelings in human-human relationships. K2
- Identify their role in ensuring a harmonious society. K3

**UNIT I COURSE INTRODUCTION - NEED, BASIC GUIDELINES, CONTENT AND PROCESS FOR VALUE EDUCATION**

Understanding the need, basic guidelines, content and process for Value Education, Self-Exploration–what is it? - its content and process; 'Natural Acceptance' and Experiential Validation- as the mechanism for self exploration, Continuous Happiness and Prosperity- A look at basic Human Aspirations, Right understanding, Relationship and Physical Facilities- the basic requirements for fulfillment of aspirations of every human being with their correct priority, Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfill the above human aspirations: understanding and living in harmony at various levels.

**UNIT II UNDERSTANDING HARMONY IN THE HUMAN BEING - HARMONY IN MYSELF**

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - Sukh and Suvidha, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Swasthya; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Swasthya.

**UNIT III UNDERSTANDING HARMONY IN THE FAMILY AND SOCIETY- HARMONY IN HUMAN-HUMAN RELATIONSHIP**

Understanding harmony in the Family- the basic unit of human interaction , Understanding values in human-human relationship; meaning of Nyaya and program for its fulfillment to ensure Ubhay-tripti; Trust (Vishwas) and Respect (Samman) as the foundational values of relationship, Understanding the meaning of Vishwas; Difference between intention and competence, Understanding the meaning of Samman, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Samadhan, Samridhi, Abhay, Sah-astitva as comprehensive Human Goals, Visualizing a universal harmonious order in society Undivided Society (Akhand Samaj), Universal Order (SarvabhaumVyawastha)- from family to world family!

**TEXT BOOKS:**


1. R R Gaur, R Sangal and G P Bagaria (2009).“A Foundation Course in Human Values and Professional Ethics”
2. Ivan Illich, 1974, Energy & Equity, The Trinity Press, Worcester, and Harper Collins, USA


**REFERENCE BOOKS:**


1. E.F. Schumacher, 1973, Small is Beautiful: a study of economics as if people mattered, Blond & Briggs, Britain.
2. Sussan George, 1976, How the Other Half Dies, Penguin Press. Reprinted 1986, 1991
3. Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens III, 1972, Limits to Growth – Club of Rome’s report, Universe Books.
4. A Nagraj, 1998, Jeevan Vidya Ek Parichay, Divya Path Sansthan, Amarkantak.
5. P L Dhar, RR Gaur, 1990, Science and Humanism, Commonwealth Publishers.
6. A N Tripathy, 2003, Human Values, New Age International Publishers.


**TOTAL HOURS :15**

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | - | - | - | - | - | 3 | 2 | - | - | 2 | - | - |
| CO2 | - | - | - | - | - | - | - | 3 | 2 | - | - | 2 | - | - |
| CO3 | - | - | - | - | - | 3 | - | 3 | 2 | - | - | 2 | - | - |
| CO4 | - | - | - | - | - | - | - | 3 | 2 | - | - | 2 | - | - |
| CO5 | - | - | - | - | - | - | - | 3 | 2 | - | - | 2 | - | - |
| **Average** | - | - | - | - | - | **3** | | **3** | **2** | - | - | **2** | - | - |

**1 - Low, 2 - Medium, 3 - High, ‘-' - No Correlation**

**SEMESTER-VI**

**24BESD611 SKILL DEVELOPMENT -II (PCB DESIGN) 2H-1C**

**Instruction Hours/week: L: 0 T: 0 P: 2** **Marks: Internal:100 External:0 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE**: Electronic devices and circuits

**COURSE OBJECTIVES:**

The goal of this course is to:

- Acquire knowledge required to understand PCBs
- Design and fabricate PCB for prototyping as well as in industrial production environment.

**COURSE OUTCOMES:**

At the end of this course, the students will be able to

- Understand the fundamental concepts of PCB design and apply Electronic Design Automation tools for designing PCB K3
- Interpret the steps involved in PCB production techniques K2
- Design an efficient PCB compatible with EMI/EMC and recognize the latest trends in PCB technology used in electronic industry K3

**UNIT I INTRODUCTION TO PCB DESIGN 10**

Introduction- Need- Types- PCB Materials- Fundamentals of electronic components- Basic electronic circuits – Basics of PCB designing-Layout planning, general rules and parameters, ground conductor considerations, thermal issues, check and inspection of artwork-Design rules for PCBs- Introduction to Electronic design automation (EDA) tools for PCB designing- Brief Introduction of various simulators- Selecting the Components Footprints as per design-Making New Footprints- Assigning Footprint to components- Net listing-PCB Layout Designing- Auto routing and manual routing- Assigning specific text to design- Creating report of design, creating manufacturing data for design.

**UNIT II PCB PRODUCTION 10**

Introduction to printed circuit board production techniques- Photo printing, film- master production- reprographic camera- basic process for double sided PCBs photo resists- Screen printing process and chemical etching- Solders alloys, fluxes, soldering techniques- Panelization, cleaning, drilling, plating, screen printing, etching machines, automated optical inspection- Tinning- legend printing- PCB testing- relative performance and quality control.

**UNIT III PCB DESIGN FOR EMI/EMC AND PCB TECHNOLOGY TRENDS 10**

Subsystem/PCB Placement in an enclosure- Filtering circuit placement- decoupling and bypassing- Electronic discharge protection - Introduction to Integrated Circuit Packaging and footprints- NEMA and IPC standards -

Multilayer PCBs- Multi wire PCB- Flexible PCBs- Surface mount PCBs- Reflow soldering -Introduction to High-Density Interconnection (HDI) Technology- Electronic waste- Printed circuit boards Recycling techniques.

**TEXT BOOKS:**


1. R. S. Khandpur, Printed circuit board design, fabrication assembly and testing, Tata McGraw Hill 2006
2. Elaine Rhodes, Developing Printed Circuit Assemblies: From Specifications to Mass Production, 2008


**REFERENCE BOOKS:**


1. C. Robertson. PCB Designer´s Reference. Prentice Hall, 2003
2. S. D Mehta, Electronic Product Design Volume-I, S Chand Publications,2011
3. Clyde F. Coombs, Jr, Happy T. Holden, Printed Circuits Handbook, Sixth Edition,McGraw-Hill Education, 2016


**WEB SITES:**

1. Open source EDA Tool KiCad Tutorial: http://kicad-pcb.org/help/tutorials/
2. PCB Fabrication user guide page: http://www.wikihow.com/Create-Printed-Circuit-Boards , http://www.siongboon.com/projects/2005-09-07_home_pcb_fabrication/ , http://reprap.org/wiki/MakePCBInstructions#Making_PCBs_yourself
3. PCB Fabrication at home: https://www.youtube.com/watch?v=mv7Y0A9YeUc, https://www.youtube.com/watch?v=imQTCW1yWkg

**CO, PO, PSO Mapping**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | - | - | - | - | - | - | 1 | - | - | 1 | 1 | - |
| CO2 | 2 | 1 | - | - | 2 | - | - | - | 1 | - | - | 1 | 1 | - |
| CO3 | 2 | 1 | - | - | - | - | - | - | 1 | - | - | 1 | 1 | - |
| **Average** | **2** | **1** | **-** | **-** | **2** | **-** | **-** | **-** | **1** | - | - | **1** | 1 | - |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-VII**

**24BEEE701 PRINCIPLES OF MANAGEMENT AND ENGINEERING ETHICS 3H-3C**

**Instruction Hours/week: L: 3 T: 0 P: 0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Nil

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Develop a comprehensive understanding of the fundamental aspects of management
- Understand the roles and responsibilities of a manager
- Acquire knowledge in various verticals of management
- Cultivate students' awareness of engineering ethics and human values
- Instil values, foster loyalty, and promote respect for others' rights

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Display an understanding of the fundamental aspects of management K2
- Enhance the skill sets for formulating better business management processes in Organizations K2
- Acquire skills to plan, organize, direct, control and work in teams for efficient outcomes K2
- Reflect on the significance of ethics in the professional realm K2
- Assess situations and make unbiased decisions considering social, environmental, and technological impacts K2

**UNIT I INTRODUCTION TO MANAGEMENT 9**

Management – Science or Art – Manager Vs Entrepreneur – Managerial Roles, skills, and styles – Evolution of Management Thought – Types of Business Organization – Current Trends and Issues in Management.

**UNIT II FUNDAMENTALS OF ORGANIZATIONAL PLANNING 9**

Planning – Nature and Purpose of Planning – Planning Process – Types of Planning – Strategic Management – MBO – Decision Making Process – Organizing – Nature and Purpose of Organizing – Formal and Informal Organization – Organization Chart – Organization Structure – Line and Staff Authority – Centralization and Decentralization – HRM – Career Planning

**UNIT III LEADERSHIP, COMMUNICATION AND CONTROLLING IN MANAGEMENT 9**

Directing – Nature and Purpose of Directing – Motivation – Motivation Theories – Job Satisfaction – Job Enrichment – Leadership – Communication – Process and Barrier of Communication – Controlling – System and Process of Controlling – Budgetary and Non-budgetary Control Techniques – Control Performance – Direct and Preventive Control – Reporting.

**UNIT IV ETHICS AND PROFESSIONALISM** **9**

Scope of Engineering Ethics – Accepting and Sharing Responsibility – Resolving Ethical Dilemmas – Making Moral Choices – Rights Ethics - Duty Ethics – Virtue Ethics – Workplace Responsibilities and Rights – Teamwork – Rights of Engineers – Whistle-Blowing – Truthfulness and Trustworthiness

**UNIT V ENGINEERING AS SOCIAL EXPERIMENTATION** **9**

Engineering as Experimentation – Engineers as Responsible Experimenters – Research Ethics and Integrity - Codes of Ethics – Industrial Standards - A Balanced Outlook on Law – The Challenger Case Study

**TOTAL: 45**

**TEXT BOOKS:**


1. Harold Koontz and Heinz Welhrich, "Essentials of Management - An International, Innovation and Leadership Perspective", McGraw Hill, Tenth Edition, 2015.
2. Mike Martin and Roland Schinzinger, "Ethics in Engineering", McGraw Hill, New York, 2005.


**REFERENCE BOOKS:**


1. Tripathi P C and Reddy P N, "Principles of Management", Tata McGraw Hill, Fifth Edition, 2012.
2. Robbins S.P, Coulter M., and Vohra, N., Management, Pearson (India), Tenth Edition, 2016.
3. Christoper P Neck, Jeffery D Houghton, Emma Murray and Charles L Lattimer, "Management", Wiley, Second Edition, 2016.
4. Charles E Harris, Michael S Pritchard and Michael J Rabins, "Engineering Ethics – Concepts and Cases", Thompson Learning, 2000.
5. R. Subramanian, "Professional Ethics", Oxford University Press, 2017.


**WEB URLs:**

1. www.onlineethics.org
2. www.nspe.org
3. www.globalethics.org
4. www.ethics.org

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | - | - | - | - | - | 1 | - |
| **CO2** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - | 2 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - | 2 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - | 2 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | - | - | - | - | - | 2 | 1 |
| **Average** | 2.8 | 1.8 | 1 | - | - | - | - | - | - | - | - | - | 1.8 | 1 |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-VII**

**24BEEE791 PROJECT WORK PHASE I 8H-4C**

**Instruction Hours/week: L: 0 T:0 P:8** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**COURSE OBJECTIVES:**

The goal of this course is to

- Develop the ability to understand and solve a specific problem right from its identification and literature review till the successful solution of the same.
- Train the students in preparing project reports and to face reviews and viva voce examination.

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 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.

**COURSE OUTCOMES:**

At the end of this course students will be able to

- Conceive a problem statement either from rigorous literature survey or from the requirements raised from industries.
- Analyze and categorize executable project modules after considering risks.
- Design, implement and test the prototype/algorithm in order to solve the conceived problem.
- Combine all the modules through effective team work after efficient testing.
- Elaborate the completed task and compile the project report.

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 1 | 3 | - | - | 1 | 3 | 3 | 3 | 3 | - | - |
| CO2 | - | 3 | 3 | 3 | 3 | - | 2 | 1 | 3 | 3 | 3 | 3 | 2 | - |
| CO3 | - | - | 3 | 3 | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | - | 3 |
| CO4 | - | - | - | - | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | 2 | 3 |
| CO5 | - | - | - | - | 3 | 3 | - | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| **Average** | **3** | **3** | **2.7** | **2.3** | **3** | **3** | **2** | **1** | **3** | **3** | **3** | **3** | **2** | **3** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-VIII**

**24BEEE891 PROJECT WORK PHASE-II 16H-8C**

**Instruction Hours/week: L: 0 T:0 P:16** **Marks: Internal:120 External:180 Total:300**

**End Semester Exam:** 3 Hours

**COURSE OBJECTIVES:**

The goal of this course is to

- Develop the ability to understand and solve a specific problem right from its identification and literature review till the successful solution of the same.
- Train the students in preparing project reports and to face reviews and viva voce examination.

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 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.

**COURSE OUTCOMES:**

At the end of this course students will be able to

- Conceive a problem statement either from rigorous literature survey or from the requirements raised from industries.
- Analyze and categorize executable project modules after considering risks.
- Design, implement and test the prototype/algorithm in order to solve the conceived problem.
- Combine all the modules through effective team work after efficient testing.
- Elaborate the completed task and compile the project report.

**CO, PO, PSO MAPPING:**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 1 | 3 | - | - | 1 | 3 | 3 | 3 | 3 | - | - |
| CO2 | - | 3 | 3 | 3 | 3 | - | 2 | 1 | 3 | 3 | 3 | 3 | 2 | - |
| CO3 | - | - | 3 | 3 | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | - | 3 |
| CO4 | - | - | - | - | 3 | 3 | 2 | 1 | - | 3 | 3 | 3 | 2 | 3 |
| CO5 | - | - | - | - | 3 | 3 | - | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| **Average** | **3** | **3** | **2.7** | **2.3** | **3** | **3** | **2** | **1** | **3** | **3** | **3** | **3** | **2** | **3** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

## PROFESSIONAL ELECTIVE COURSES

### VERTICAL I - POWER AND ENERGY ENGINEERING

**B.E. Electrical and Electronics Engineering** **2024-2025**

**SEMESTER-X**

**24BEEEXXX UTILIZATION AND CONSERVATION OF ELECTRICAL ENERGY 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Electrical Machines

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand fundamentals and selection criteria of electric drives.
- Analyze mechanics, components of electric traction systems and explore methods of electric heating and welding.
- Identify strategies for reducing electrical losses and conserving energy

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Interpret the factors influencing the choice of motors for various applications. K2
- Identify the rating of traction motors and analyze the performance and efficiency of electric traction systems. K3
- Design an illumination system for specific requirements in indoor and outdoor lighting K3
- Understand the construction, operation and applications of electric heating and welding. K2
- Implement the energy conservation strategies in electrical systems. K3

**UNIT I ELECTRIC DRIVES** **9**

Fundamentals of Electric Drives – Characteristics of different motors – Speed control methods – Criteria for motor selection – Specific motor types – Requirements of traction motors – Systems of railway electrification – AC vs DC systems - Overhead systems.

**UNIT II ELECTRIC TRACTION** **9**

Electric Traction – Traction systems; Speed-time curves and mechanics of train movement – Traction motors – Control of motors – Electric braking methods – Regeneration – Electric Vehicles – Types of electric vehicles and hybrid vehicles – Motors and batteries for EV – Drive systems for electric traction.

**UNIT III ILLUMINATION** **9**

Introduction to Illumination Engineering – Types of Light Sources: Incandescent lamps – Fluorescent lamps – LED lamps – Construction and working – Characteristics and applications – Design of Illumination Systems: Indoor Lighting Systems – Outdoor Lighting Systems – Energy efficient Lighting – Lighting Calculations: Lumen method – Point to point method.

**UNIT IV HEATING AND WELDING** **9**

Electric Heating – Resistance Heating – Induction Heating – Dielectric Heating Radiation Heating – Principles and applications – Design considerations – Electric Arc Furnaces – Construction and working – Electric Welding – Resistance Welding – Arc Welding – Welding Automation – Types and characteristics.

**UNIT V ELECTRICAL LOSSES AND ENERGY CONVERSION** **9**

Electrical transmission – Distribution and utilization losses – Classification – Reduction of losses – Benefits of electrical energy conservation – Energy conservation in lighting – Electric furnaces – Electric drive – Traction systems – Use of energy – Efficient equipment.

**TOTAL: 45**

**TEXT BOOKS:**

1. N. K. De and P. K. Sen, "Electric Drives," 1st Edition, Prentice Hall of India, 1999.
2. J. Upadhyay and S. N. Mahendra, "Electric Traction," 1st Edition, Allied Publishers, 2003.

**REFERENCES:**

1. Mehrdad Ehsani, Yimin Gao, and Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles," 3rd Edition, CRC Press, 2018.
2. T. P. Dawson, "Traction Electric Machines", 1st Edition, Springer, 2013.
3. Illuminating Engineering Society, "The Lighting Handbook", 10th Edition, Illuminating Engineering Society, 2011.
4. Charles E. Tudor, "Fundamentals of Electric Heating", 1st Edition, Wiley, 1982.

**WEB URLs:**

1. https://onlinecourses.nptel.ac.in/noc19_ee65/preview
2. https://professional.mit.edu/course-catalog/design-electric-motors-generators-and-drive-systems
3. https://searchworks.stanford.edu/view/13060405

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | - |
| **CO2** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO4** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO5** | 3 | 2 | 2 | 1 | - | - | - | 1 | - | - | - | 1 | 1 | - |
| **Average** | **2.6** | **1.6** | **1.2** | **1** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **1** | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX UNDER GROUND CABLE ENGINEERING 3H-3C**

**Instruction Hours/week:L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Transmission and Distribution

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the development, architecture, and characteristics of underground and transmission cables for electrical power transmission.
- Explore the design, applications, advancements, and installation techniques of various types of cables used in supply distribution and transmission systems.
- Learn cable testing, maintenance procedures, fault locating, and predictive maintenance techniques.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the environmental impact of underground cables and devise mitigation strategies to address them. K2
- Identify the various properties of insulation materials and their influence on cable performance. K3
- Utilize suitable distribution cables particularly in scenarios involving renewable energy integration. K3
- Explain the suitability of transmission cables for high voltage applications and offshore windfarms K2
- Apply advanced techniques, such as digital twin technology and AI to enhance cable installation, testing, fault location, and predictive maintenance processes. K3

**UNIT I INTRODUCTION TO ELECTRICAL POWER CABLES 8**

Underground Cables – Overview of Underground Residential Distribution Systems – Medium Voltage Cable Development – Cable Insulation Materials – Environmental Impact and Mitigation Strategies for Underground Cables – Smart Grid Integration of Underground Cables.

**UNIT II CABLE ARCHITECTURE AND CHARACTERISTICS 9**

Architecture of Underground Cabling Systems – Basic Dielectric Theory of Cables – Importance of Armour and Protective Finishes – Electrical Fundamentals of Insulation Materials – Electrical Properties of Cable Insulating Materials – Cable Standards and Quality Assurance Measures – Design Parameters of Cables: Current Carrying Capacity and Short Circuit Ratings – High Temperature Superconducting Cables – Advanced Materials for Cable Armouring and Sheathing.

**UNIT III SUPPLY DISTRIBUTION SYSTEMS AND CABLES 10**

Overview of Supply Distribution Systems – Design and Applications of Various Distribution Cable Types – Paper Insulated Distribution Cables: Properties and Uses – PVC Insulated Cables: Characteristics and Applications – Techniques for Jointing and Terminating Distribution Cables – Testing Procedures for Distribution Cables – Renewable Energy Integration with Distribution Cables.

**UNIT IV TRANSMISSION SYSTEMS AND CABLES 9**

Types of Basic Cables for A.C. Transmission – Self Contained Fluid Filled Cables: Design and Function – Gas Pressure Cables: Applications and Techniques – High Pressure Fluid Filled Pipe Cables – Polymeric Insulated Cables for Transmission Voltages – HVDC Cables and Their Applications – Submarine Cables for Offshore Wind Farms – Innovative Cooling Techniques for High Voltage Cables.

**UNIT V CABLE INSTALLATION, TESTING AND MAINTENANCE 9**

Procedures for Installation of Transmission Cables – Splicing – Termination and Use of Accessories – Techniques for Sheath Bonding and Grounding – Testing Methods for Transmission Cable Systems – Techniques for Underground System Fault Locating – Digital Twin Technology for Cable Systems – Advanced Fault Location Techniques in Complex Networks.

**TOTAL: 45**

**TEXT BOOKS:**


1. Sushil Kumar Ganguli, "Power Cable Technology", 1st Edition, CRC Press, 2013.
2. Robert J. Manion, "Underground Cable Thermal Backfill", 1st Edition, IEEE Press, 1990.


**REFERENCES:**


1. Martin Heathcote, "The J & P Transformer Book", 14th Edition, Newnes, 2018.
2. Hugh M. Ryan, "High Voltage Engineering and Testing", 2nd Edition, IET, 2001.
3. N. H. Malik, A. A. Al-Arainy, M. I. Qureshi, "Electrical Insulation in Power Systems," 1st Edition, CRC Press, 1997.
4. George J. Anders, "Rating of Electric Power Cables in Unfavorable Thermal Environment," 1st Edition, Wiley-IEEE Press, 2005.


**WEB URLs:**

1. https://ieeexplore.ieee.org/document/43688
2. https://nptel.ac.in/courses/108/108/108108073/
3. https://ncr.indianrailways.gov.in/uploads/files/1683096708023-Cable%20Maintenance%20Practices.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO2** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO4** | 2 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.6** | **2** | **1** | **-** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX SUBSTATION ENGINEERING AND AUTOMATION 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Power System Analysis

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Develop a comprehensive understanding of substation fundamentals, classifications, and factors influencing design, including renewable energy integration and smart grid technology.
- Acquire knowledge and skills in the selection, sizing, and design principles of main substation equipment, auxiliary systems, and power system protection.
- Gain proficiency in substation layout engineering, encompassing equipment layout, cable routing, earthing design, and augmented reality applications

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Implement suitable bus bar switching schemes and design standards in substation projects. K3
- Demonstrate expertise in selecting and sizing main substation equipment, recognizing the benefits of gas insulated substations. K2
- Configure power system protection schemes, numerical relays, and deploy substation automation systems. K2
- Design substation layouts, secure necessary clearances, and employ advanced earthing techniques. K3
- Apply civil, structural, and mechanical engineering principles, including seismic design and advanced HVAC systems in substation development. K3

**UNIT I SUBSTATION DESIGN DEVELOPMENT 9**

Introduction to Substations and Classifications – Different Bus Bar Switching Schemes for Substations – Standards and Practices in Substation Design – Factors Influencing Substation Design – Integration of Renewable Energy Sources into Substation Design – Smart Grid Technology and its Impact on Substation Design.

**UNIT II SUBSTATION EQUIPMENT 9**

Selection and Sizing of Main Substation Equipment – MV/LV Switchgear Construction and Control Scheme Design, Station Auxiliary Equipment: Diesel Generator System – AC/DC Auxiliary Power System – Introduction to Gas Insulated Substations (GIS): Operating Principles – Construction of GIS – Advanced Diagnostics and Monitoring of Substation Equipment.

**UNIT III PROTECTION AND SUBSTATION AUTOMATION** **9**

Substation Protection methods – Familiarization with Numerical Relays – Substation Integration and Automation Functional Architecture – Substation Signal List: DI, DO, AI, AO – Bay Control Unit (BCU) – Remote Terminal Unit (RTU) – Cybersecurity in Substation Automation Systems – Integration of IoT in Substation Automation.

**UNIT IV SUBSTATION DESIGN AND LAYOUT ENGINEERING** **9**

Layout Aspects of Outdoor Air Insulated Substations (AIS) and GIS – Cable Routing Layout and Erection Key Diagram (EKD) – Switchyard Earthing Design as per IEEE 80 – Direct Stroke Lightning Protection for Switchyards (IS/IEC 62305) – LV and MV Cables: Power and Control – Installation Methods – Practical Aspects of Cable Sizing – Cable Accessories – Augmented Reality (AR) for Substation Layout Design.

**UNIT V INTERFACE ENGINEERING** **9**

Structural Engineering in Substation Development: Site Development Plan – Equipment Support Structures – Foundation for Equipment – Mechanical Systems: Fire Detection – Alarm System – Fire Suppression System for Transformers – Seismic Design Considerations for Substation Structures – Advanced HVAC Systems for Substations.

**TOTAL: 45**

**TEXT BOOKS:**


1. John D. McDonald, “Electric Power Substations Engineering”, 3rd Edition, 2012.
2. S. Rao, “Electrical Power Substation Engineering & Practice”, 1st Edition, 2018.


**REFERENCES:**


1. Ravindra P. Singh, "Switchgear and Power System Protection", 2nd Edition, 2014.
2. E. Kuffel and W.S. Zaengl, “High Voltage Engineering Fundamentals",2nd Edition, 2000.
3. Andrew R. Hileman, “Insulation Coordination for Power Systems”, 1st Edition, CRC Press, 1999.
4. A. Haddad, D.F. Warne, “Advances in High Voltage Engineering”, 1st Edition, IET, 2004.


**WEB URLs:**

1. https://www.coursera.org/learn/electric-power-systems
2. https://nptel.ac.in/courses/108/106/108106110/
3. https://pserc.wisc.edu/wp-content/uploads/sites/755/2018/08/T-37_Final-Report_Sept-2010.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | - | - | - | - | 1 | - | - | - | 1 | 2 | 2 |
| **CO2** | 2 | 2 | 2 | - | - | - | - | 1 | - | - | - | 1 | 2 | 2 |
| **CO3** | 2 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 2 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 2 |
| **CO5** | 3 | 2 | 2 | - | - | - | - | 1 | - | - | - | 1 | 2 | 2 |
| **Average** | **2.6** | **2** | **1.6** | **-** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **1** | **2** | **2** |

**1 - Low, 2 - Medium, 3 - High, ‘-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX ENERGY AUDITING AND MANAGEMENT 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Transmission and Distribution

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand energy audits and their methodology, analyze energy consumption patterns and identify efficiency improvement measures.
- Explore energy management for electrical systems, focusing on load analysis, power factor improvement and renewable energy integration.
- Examine thermal systems and energy management, including boilers, heat transfer, waste heat recovery, and co-generation.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Conduct diverse energy audits and apply management principles. Utilize AI for audits. K2
- Proficiently use audit instruments and techniques, integrating AI. Analyze electrical systems, implement corrections, and optimize distributions. K3
- Optimize thermal systems with recovery techniques and efficient heat exchangers. K3
- Apply energy assessment methods, monitor systems, and ensure policy compliance. K3
- Apply energy performance assessment methods. K3

**UNIT I INTRODUCTION TO ENERGY AUDITING 9**

Energy audit – Definition, Concept, Type of audit – Energy index – Cost index – Load profiles – Energy conservation schemes – Energy audit for industries – Energy saving potential – Thermal power station – Building energy audit.

**UNIT II ENERGY MANAGEMENT 9**

Principles of energy management – Organizing energy management program – Initiating – Planning – Controlling – Promoting – Monitoring – Reporting – Energy auditor and energy manager – Eligibility, qualification and functions – Questionnaire and check list for top level energy management

**UNIT III EFFICIENCY ANALYSIS 9**

Factors affecting efficiency – Energy efficient motors – Constructional details – Characteristics – Efficiency determination – IEEE Standard 112-1984 – Voltage variation – Voltage unbalance – Over motoring.

**UNIT IV ENERGY PERFORMANCE ASSESSMENT AND MONITORING** **9**

Power factor – Methods of improvement – Location of capacitors – Power factor with non-linear loads – Effect of harmonics on power factor – Energy efficient lighting system design and practice – Lighting control – Measuring Instruments – Wattmeter – data loggers – thermocouples – pyrometers – lux meters and clamp arm meter

**UNIT V ENERGY MANAGEMENT STRATEGIES** **9**

Economics analysis – Depreciation methods – Time value of money – Rate of return – Present worth method – Replacement analysis – Life cycle costing analysis – Calculation of simple payback method and net present worth method.

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**TOTAL: 45**

**TEXT BOOKS:**


1. Frank Kreith and D. Yogi Goswami, "Energy Management and Conservation Handbook", 2nd Edition, CRC Press, 2015.
2. Wayne C. Turner and Steve Doty, "Energy Management Handbook", 8th Edition, Lulu Press, 2017.


**REFERENCES:**


1. Larry C. Witte, Philip S. Schmidt, and David R. Brown, "Industrial Energy Management and Utilization",1st Edition, CRC Press, 2005.
2. Albert Thumann and Terry Niehus, "Handbook of Energy Audits", 9th Edition, Fairmont Press, 2018.
3. Anthony J. Pansini, Kenneth D. Smalling, "Guide to Electrical Power Distribution Systems," 6th Edition, CRC Press, 2006.
4. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "Guide to Energy Management," 8th Edition, Fairmont Press, 2016.


**WEB URLs:**

1. https://www.coursera.org/learn/energy-management
2. https://www.edx.org/professional-certificate/energy-management-and-decentralised-production
3. https://coursecontent.indusuni.ac.in/wp-content/uploads/sites/8/2020/05/UNIT-4-2.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO2** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 2 |
| **CO3** | 3 | 2 | 1 | - | - | 1 | - | 1 | - | - | - | 1 | 1 | 2 |
| **CO4** | 3 | 2 | 1 | - | - | 1 | - | 1 | - | - | - | 1 | 1 | 2 |
| **CO5** | 3 | 2 | 1 | - | - | 1 | - | 1 | - | - | - | 1 | 1 | 2 |
| **Average** | **2.8** | **1.8** | **1** | **-** | **-** | **1** | **-** | **1** | **-** | **-** | **-** | **1** | **1** | **1.8** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX POWER QUALITY 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Power System Analysis and stability

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Gain an understanding of energy auditing and management fundamentals, encompassing power quality characterization, standards, and mitigation techniques for harmonics.
- Analyze the impact of single-phase and three-phase systems on power quality, including balanced and unbalanced loads, and explores load compensation using DSTATCOM.
- Explore series compensation techniques for power distribution systems, including DVR and UPQC, focusing on dynamic voltage restoration and power quality conditioning.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Classify the electric power quality parameters based on power quality standards in single phase and three phase systems K2
- Identify the impact of renewable energy sources on power quality in smart grid. K3
- Design effective filters for power system harmonics mitigation. K3
- Implement advanced control algorithms for DSTATCOM to compensate for load unbalancing and voltage control. K3
- Assess the impact of series compensation techniques on grid stability. K3

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

Introduction to Energy Auditing and Management – Characterization of Electric Power Quality: Transients – Short Duration and Long Duration Voltage Variations – Voltage Imbalance and Waveform Distortion – Power Quality Standards – Impact of Renewable Energy Sources on Power Quality – Smart Grid Technologies and Their Effect on Power Quality.

**UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEMS** **9**

Single Phase Linear and Non Linear Loads – Analysis of Three Phase Balanced and unbalanced Systems – Three Phase Unbalanced and Distorted Sources Supplying Non Linear Loads – Concept of Power Factor – Analysis of Three Phase – Three Wire and Three Phase – Four Wire Systems – Advanced Power Factor Correction Techniques.

**UNIT III MITIGATION OF POWER SYSTEM HARMONICS** **9**

Introduction to Harmonic Mitigation – Principles of Harmonic Filters: Series Tuned Filters – Double Band Pass Filters – Damped Filters – Detuned Filters – Active Filters – Power Converters and Their Role in Harmonic Mitigation – Design of Harmonic Filters – Impedance Plots for Filter Banks and Three Branch 33 kV Filter – Real Time Harmonic Monitoring and Mitigation.

**UNIT IV LOAD COMPENSATION USING DSTATCOM** **9**

Compensating Single Phase Loads – Ideal Three Phase Shunt Compensator Structure – Generating Reference Currents When the Source is Unbalanced – Realization and Control of DSTATCOM – DSTATCOM in Voltage Control Mode – Advanced Control Algorithms for DSTATCOM and Integration of DSTATCOM with Renewable Energy Systems.

**UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEMS** **9**

Rectifier Supported DVR – DC Capacitor Supported DVR – DVR Structure and Functionality – Voltage Restoration Techniques – Series Active Filters – Unified Power Quality Conditioner (UPQC) – Impact of Series Compensation on Grid Stability.

**TOTAL: 45**

**TEXT BOOKS:**


1. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, and H. Wayne Beaty, "Electrical Power Systems Quality", 3rd Edition, McGraw-Hill Education, 2012.
2. Alexander Kusko and Marc T. Thompson, "Power Quality in Electrical Systems", 1st Edition, McGraw-Hill Education, 2007.


**REFERENCES:**


1. Angelo Baggini, "Handbook of Power Quality", 1st Edition, Wiley, 2008.
2. J. C. Das, "Power System Harmonics and Passive Filter Designs", 1st Edition, Wiley, 2009.
3. Ali Chowdhury, Don Koval, "Power Distribution System Reliability: Practical Methods and Applications," 1st Edition, Wiley-IEEE Press, 2009.
4. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality: Problems and Mitigation Techniques," 1st Edition, Wiley-IEEE Press, 2014.


**WEB URLs:**

1. https://www.coursera.org/learn/power-quality-electrical-systems
2. https://www.edx.org/course/power-electronics
3. https://www.kau.edu.sa/Files/0056868/Subjects/Chapter%2010.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO2** | 3 | 2 | 1 | 1 | - | 1 | - | 1 | - | - | - | 1 | 1 | 2 |
| **CO3** | 3 | 2 | 1 | 1 | - | 1 | - | 1 | - | - | - | 1 | 1 | 2 |
| **CO4** | 3 | 2 | 1 | 1 | - | 1 | - | 1 | - | - | - | 1 | 1 | 2 |
| **CO5** | 3 | 2 | 1 | 1 | - | 1 | - | 1 | - | - | - | 1 | 1 | 2 |
| **Average** | **2.8** | **1.8** | **1** | **1** | **-** | **1** | **-** | **1** | **-** | **-** | **-** | **1** | **1** | **1.8** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX POWER SYSTEM OPERATION AND CONTROL 3H-3C**

**Instruction Hours/week:L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Power System Analysis and Stability

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand real power control and operation
- Know the importance of frequency and reactive power control
- Understand unit commitment problem and importance of economic load dispatch

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the day-to-day operation of power system K2
- Model the control actions that are implemented to meet the minute-to-minute variation of system real power demand K3
- Analyze the compensators for control of reactive power and voltage in power system K3
- Develop strategies for solving load forecasting and unit commitment problems. K3
- Implement computer aided control of power system for efficient energy management. K3

**UNIT I OPERATION OF POWER SYSTEM 9**

Power scenario in Indian grid – National and Regional load dispatching centres – Requirements of good power system – Necessity of voltage and frequency regulation – real power vs frequency and reactive power vs voltage control loops – Load Curve – Load duration curve – Introduction to load forecasting.

**UNIT II REAL POWER CONTROL 9**

Real Power – Frequency Control: Fundamentals of speed governing mechanism and modeling: Speed-load characteristics – Load sharing between two synchronous machines in parallel – Concept of control area – LFC control of a single area system – Static and dynamic analysis of uncontrolled and controlled cases – Tie line control – Two area system.

**UNIT III REACTIVE POWER CONTROL 9**

Generation and absorption of reactive power – Basics of reactive power control – Automatic Voltage Regulator (AVR) – Brushless AC excitation system – Block diagram representation of AVR loop static and dynamic analysis – Stability compensation – Methods of reactive power injection – Regulating transformer – SVC and STATCOM for voltage control

**UNIT IV UNIT COMMITMENT** **9**

Unit commitment: Constraints in unit commitment – Problem Formulation – Solution using Priority List method – Economic dispatch problem – With and without network losses considered – Solution Methods – Lambda - iteration method.

**UNIT V COMPUTER AIDED CONTROL OF POWER SYSTEM** **9**

Need of computer control of power system – Concept of energy control centers and functions – PMU system monitoring – Data acquisition and controls – System hardware configurations – SCADA and EMS functions – State estimation – Weighted least square estimation – Various operating states – State transition diagram.

**TOTAL: 45**

**TEXT BOOKS**


1. Olle. I. Elgerd, "Electric Energy Systems theory – An introduction", 2nd edition, McGraw Hill Education Pvt. Ltd., New Delhi, 2017.
2. Abhijit Chakrabarti and Sunita Halder, "Power System Analysis Operation and Control", 4th Edition, PHI learning Pvt. Ltd., New Delhi, 2018.


**REFERENCE BOOKS**


1. Kothari D.P. and Nagrath I.J., "Power System Engineering", 2nd Edition, Tata McGraw– Hill Education, Reprint 2018.
2. Hadi Saadat, "Power System Analysis", 23rd reprint, McGraw Hill Education Pvt. Ltd., New Delhi, 2015.
3. Kundur P., "Power System Stability and Control", 12th reprint, McGraw Hill Education Pvt. Ltd., New Delhi, 2015.
4. B.M. Weedy, B.J. Cory et al, 5th Edition, "Electric Power systems", Wiley, 2012.


**WEB URLs:**

1. https://archive.nptel.ac.in/courses/108/104/108104052/
2. https://onlinecourses.nptel.ac.in/noc23_ee128/preview
3. https://www.openlearning.com/courses/power-system-analysis/?cl=1

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | - |
| **CO2** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **Average** | 2.8 | 1.8 | 1 | - | - | - | - | **1** | - | - | - | **1** | 1.8 | 1 |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX RESTRUCTURED POWER MARKET 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Power System Analysis and stability

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand economic analysis in restructured power systems, including dynamic pricing mechanisms and behavioral economics.
- Explore innovative approaches to transmission congestion management, such as transmission rights allocation and demand response.
- Learn advanced models for locational marginal pricing (LMP) and financial transmission rights.
- Analyze advanced ancillary service management strategies and transmission pricing methods for optimal grid operation.
- Examine global perspectives on market evolution, including case studies and future trends in market design and governance.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Apply advanced economic analysis techniques in analyzing restructured power systems and making informed decisions. K3
- Implement innovative congestion management strategies to improve grid reliability and efficiency. K2
- Utilize advanced models for locational marginal pricing (LMP) calculation and financial transmission rights to manage congestion and market risks. K3
- Manage ancillary services and optimize transmission pricing for efficient grid operation. K2
- Apply global market perspectives to navigate regulatory reforms and anticipate future trends in power market evolution. K3

**UNIT I ADVANCED POWER SYSTEMS ECONOMICS 9**

Advanced Economic Analysis in Restructured Power Systems: Dynamic Pricing Mechanisms, Behavioral Economics in Consumer and Supplier Decision Making, Market Equilibrium Dynamics, Implications of Technological Innovation on Market Models.

**UNIT II ADVANCED TRANSMISSION CONGESTION MANAGEMENT STRATEGIES 9**

Innovative Approaches to Congestion Management: Transmission Rights Allocation Mechanisms, Dynamic Line Rating Technologies, Demand Response for Congestion Relief, Integration of Energy Storage in Congestion Management.

**UNIT III ADVANCED FINANCIAL TRANSMISSION RIGHTS AND LMP CALCULATION 9**

Advanced Models for Locational Marginal Pricing: Incorporating Network Constraints in LMP Calculation, Probabilistic Approaches for Risk Hedging with Financial Transmission Rights, Market-Based Solutions for Addressing Congestion and Market Power Issues.

**UNIT IV ADVANCED ANCILLARY SERVICE MANAGEMENT AND TRANSMISSION PRICING 9**

Next-Generation Ancillary Service Markets: Market-Based Approaches for Voltage Control and Reactive Power Support, Optimal Scheduling and Pricing of Black Start Services, Co-optimization of Ancillary Services and Energy Markets.

**UNIT V GLOBAL PERSPECTIVES ON MARKET EVOLUTION 9**

International Market Comparison and Lessons Learned: Case Studies from European and Asian Power Markets, Regulatory Reforms and Market Evolution in Emerging Economies, Future Trends in Power Market Design and Governance.

**TOTAL: 45**

**TEXT BOOKS:**

1. Steven Stoft, "Power System Economics: Designing Markets for Electricity," Cambridge University Press, 2002.
2. Alexandra von Meier, "Electric Power Systems: A Conceptual Introduction," Wiley, 2006.

**REFERENCES:**

1. Antonio Gomez-Exposito, Antonio J. Conejo, and Claudio Canizares, “Electric Energy Systems: Analysis and Operation”, CRC Press, 2018.
2. Mohammad Shahidehpour and Mohammad Reza Maragal, “Market Operations in Electric Power Systems: Forecasting, Scheduling, and Risk Management”, Wiley, 2002.

**WEB URLs:**

1. https://www.coursera.org/learn/electric-power-systems
2. https://www.edx.org/course/energy-markets

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | - | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| CO2 | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| CO3 | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| CO4 | 2 | 1 | - | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| CO5 | 2 | 1 | - | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **Average** | **2.2** | **1.4** | **1.0** | **-** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **1** | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, ‘-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX ELECTRICAL SAFETY 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electric Circuit Analysis

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand basic electricity concepts, hazards, and safety standards to prevent accidents.
- Learn safety procedures, including PPE selection, to ensure a safe working environment and legal compliance.
- Gain knowledge of electrical safety equipment and grounding systems to prevent accidents and ensure workplace safety.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand electrical hazards and risks including shock, arc flash and fire hazards to ensure workplace safety. K2
- Implement hazard identification techniques and risk assessment methods to mitigate electrical risks effectively. K3
- Utilize safety procedures such as lockout/tagout (LOTO) and permit-to-work systems for safe electrical maintenance. K3
- Choose safe working practices and procedures while working near energized parts adhering to safe approach distances and clearance requirements. K2
- Apply advanced electrical safety measures, including arc flash analysis and safety management systems, to enhance safety practices and technologies. K3

**UNIT I FUNDAMENTALS OF ELECTRICAL SAFETY 9**

Basic Concepts of Electricity and Electrical Hazards – Electrical Safety Standards and Regulations – Safety Procedures and Practices in Electrical Work – Importance of Personal Protective Equipment (PPE) in Electrical Safety.

**UNIT II ELECTRICAL SAFETY EQUIPMENT AND TOOLS 9**

Insulation Materials and Techniques – Grounding and Bonding Systems – Electrical Safety Devices: Circuit Breakers – Fuses and Ground Fault Circuit Interrupters (GFCIs) – Safe Use of Electrical Tools and Equipment.

**UNIT III HAZARD IDENTIFICATION AND RISK ASSESSMENT 9**

Identification of Electrical Hazards: Shock – Arc Flash and Fire Hazards – Risk Assessment Techniques for Electrical Work – Hazard Mitigation Strategies: Engineering Controls – Administrative Controls and Personal Protective Measures.

**UNIT IV SAFE WORKING PRACTICES AND PROCEDURES 9**

Lockout/Tagout (LOTO) Procedures – Permit to Work Systems for Electrical Maintenance – Working near Energized Parts: Safe Approach Distances and Clearance Requirements – Emergency Response and First Aid for Electrical Accidents.

**UNIT V SAFE WORKING PRACTICES AND PROCEDURES 9**

Advanced Arc Flash Analysis and Hazard Assessment – Electrical Safety Management Systems (ESMS) – Electrical Safety Training and Awareness Programs – Continuous Improvement in Electrical Safety Practices and Technologies.

**TOTAL: 45**

**TEXT BOOKS:**

1. John Cadick, Mary Capelli-Schellpfeffer, and Dennis K. Neitzel, "Electrical Safety Handbook", 2005.
2. Mark McGuire Moran, "Construction Safety Handbook," 2nd Edition, CRC Press, 2003.

**REFERENCES:**

1. N John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, and Al Winfield, "Electrical Safety Handbook," 3rd Edition, McGraw-Hill Education, 2006.
2. J. Maxwell Adams, "Electrical Safety: A Guide to the Causes and Prevention of Electrical Hazards," 1st Edition, Institution of Engineering and Technology, 1994.
3. Dennis K. Neitzel, Al Winfield, and Charles H. Sfetko, "Electrical Safety Handbook," 4th Edition, McGraw-Hill Education, 2012.
4. Ray A. Jones and Jane G. Jones, "Electrical Safety in the Workplace," 2nd Edition, Jones & Bartlett Learning, 2011.

**WEB URLs:**

1. https://www.coursera.org/learn/electrical-safety
2. https://www.udemy.com/course/electrical-safety-awareness/
3. https://www.uab.edu/ehs/images/docs/2021/General_Safe_Work_Practices_2021.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | 1 | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO2** | 3 | 2 | 1 | - | - | 1 | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | 1 | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | 1 | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | 1 | - | 1 | - | - | - | 1 | 1 | 1 |
| **Average** | 2.8 | 1.8 | 1 | - | - | **1** | - | **1** | - | - | - | **1** | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

## VERTICAL – II - CONVERTERS AND DRIVES

**B.E. Electrical and Electronics Engineering** **2024-2025**

**SEMESTER - X**

**24BEEEXXX ANALYSIS OF ELECTRICAL MACHINES 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 T otal:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electrical machines I and II

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Explain the principles behind DC machine modeling and analyze their steady-state and transient behaviors.
- Apply reference frame theory to transform machine variables and analyze electrical systems.
- Evaluate and compare different modeling techniques for induction and synchronous machines to determine their suitability for specific applications.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Interpret the basic principles of electrical machine and their modeling. K2
- Analyze the steady-state and transient behaviors of DC machines K4
- Apply reference frame theory to transform machine variables and analyze electrical systems K3
- Examine transformer models and its connections to predict system behavior K3
- Select appropriate modeling techniques for induction and synchronous machines based on specific application requirements K3

**UNIT I CONCEPTS OF MODELING** **9**

Basic two pole machine representation of commutator machines – 3- phase synchronous machine with and without damper bar and 3-phase induction machine – Kron's primitive machine – DC Machine modeling: Mathematical model of separately excited D.C motor – Steady State analysis – Transient State analysis – Sudden application of Inertia Load – Transfer function of Separately excited D.C Motor.

**UNIT II REFERENCE FRAME THEORY** **9**

Reference frame theory Real time model of a two phase induction machine – Transformation to obtain constant matrices – Three phase to two phase transformation – Power equivalence.

**UNIT III MODELING OF TRANSFORMER** **9**

Introduction – Single phase transformer model – Three phase transformer connections – Per phase analysis – Normal systems – Per unit normalization – Per unit three phase quantities – Change of base – Per unit analysis of normal system – Regulating transformers for voltage and phase angle control – Auto transformers – Transmission line and transformers.

**UNIT IV INDUCTION MACHINE** **9**

Dynamic modeling of three phase Induction Machine: Generalized model in arbitrary reference frame – Electromagnetic torque – Derivation of commonly used Induction machine models – Stator reference frame model – Rotor reference frame model synchronously rotating reference frame model – Equations in flux linkages.

**UNIT V SYNCHRONOUS MACHINE** **9**

Introduction – Voltage equations and torque equation in machine variables – Stator voltage equations in arbitrary and rotor reference frame variables – Park's transformation – Torque equations in substitute variables – Rotor angle – Analysis of steady state operation.

**TOTAL: 45**

**TEXT BOOKS:**

1. Stephen J. Chapman, "Electric Machinery Fundamentals", McGraw-Hill Education, 2017.
2. Bhag S. Guru and Hüseyin R. Hiziroglu, "Electric Machinery and Transformers", Oxford University Press, 2000.

**REFERENCES:**

1. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, "Analysis of Electrical Machinery and Drive Systems", 2nd Edition, Wiley (India), 2010.
2. P.S.Bimbra, "Generalized Theory of Electrical Machines", 5th Edition, Khanna Publications, 1995.
3. Stephen D. Umans, "Fitzgerald & Kingsley's Electric Machinery", 7th Edition, Tata McGraw Hill, 2020.
4. Chee Mun Ong, "Dynamic Simulation of Electric Machinery using MATLAB", 1st Edition, Prentice Hall of India, 1997.

**WEB URLs:**

1. https://archive.nptel.ac.in/courses/108/106/108106023/
2. https://onlinecourses.nptel.ac.in/noc21_ee24/preview
3. https://www.udemy.com/course/fundamentals-of-transformer-for-electrical-power-engineering/

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **1** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX MULTILEVEL POWER CONVERTERS 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Power Electronics, Electrical Machines and Drives

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Comprehend the structure and functionality of diode-clamped multilevel inverters and operational principles of flying capacitor multilevel converters.
- Apply control strategies and assess various PWM techniques for cascaded H-bridge (CHB) inverters.
- Evaluate the performance and advantages of reduced switch count multilevel converters.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the significance and various types of multilevel converters K2
- Infer the structure and operation of diode-clamped multilevel inverters K2
- Develop the different PWM techniques for CHB inverters K3
- Apply the topology and operation of flying capacitor multilevel converters in various Application K3
- Analyze the performance and benefits of reduced switch count multilevel converters. K4

**UNIT I MULTILEVEL TOPOLOGIES 10**

Introduction – Generalized Topology with Common DC bus – Converters derived from the generalized topology – symmetric topology without common DC link – Asymmetric topology- Applications in solar system – Electric vehicles and power grids.

**UNIT II DIODE CLAMPED MULTILEVEL INVERTERS 10**

Introduction – Structure – Working principle and operation – Voltage Balancing – Methods of voltage balancing – Control Strategies – Voltage source methods – Current regulated methods – Performance Analysis.

**UNIT III CASCADED H-BRIDGE MULTILEVEL INVERTERS 10**

Introduction – Structure – Working principle and operation – Topology Variations – Symmetric vs. Asymmetric Cascaded H-Bridge Inverters – Control Strategies for CHB Inverters – Pulse Width Modulation (PWM) techniques – Performance Analysis of PWM – Comparison of different PWM techniques.

**UNIT IV FLYING CAPACITOR MULTILEVEL CONVERTER 9**

Introduction – Flying Capacitor topology – Modulation scheme for the FCMC – Control Strategies for Flying Capacitor Converters – Dynamic voltage balance of FCMC.

**UNIT V MULTILEVEL CONVERTER WITH REDUCED SWITCHES 6**

Introduction – Structures – working principles and pulse generation methods.

**TOTAL: 45**

**TEXT BOOKS:**

1. Rashid M.H, "Power Electronics Circuits, Devices and Applications", 4th Edition, Prentice Hall India, 2014.
2. Sergio Alberto Gonzalez, Santiago Andres Verne, Maria Ines Valla, "Multilevel Converters for Industrial Applications", 1st Edition, CRC Press, 2017.

**REFERENCES:**

1. Juan Dixon, Mario Marchesoni, Patricio Cortés, and Marco Rivera, "Multilevel Converters for Industrial Applications", John Wiley & Sons, 2014.
2. Marcelo Godoy Simões, Francisco A. S. Neves, and Davi Antônio dos Santos, "Multilevel Converters: Analysis, Control, and Applications", CRC Press, 2018.
3. Bin Wu, Mehdi Narimani, "High Power Converters and AC drives", 2nd Edition, IEEE press 2017.
4. D.Grahame Holmes, Thomas A. Lipo, "Pulse Width Modulation for Power Converters: Principles and Practice", 1st Edition, Wiley-IEEE Press, 2003.

**WEB URLs:**

1. https://archive.nptel.ac.in/courses/108/102/108102157/
2. https://www.edx.org/learn/electrical-engineering/the-georgia-institute-of-technology-multilevel-converters-for-medium-high-power-applications
3. https://trace.tennessee.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=2967&context=utk_gradthes

**CO, PO, PSO MAPPING:**

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO3** | 3 | 2 | 1 | - | 1 | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO4** | 3 | 2 | 1 | - | 1 | - | - | 1 | - | - | - | - | 2 | - |
| **CO5** | 3 | 2 | 1 | - | 1 | - | - | 1 | - | - | - | - | 2 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **-** | **1** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX ADVANCED ELECTRICAL DRIVE SYSTEMS 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electric Drives and Control

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Determination of motor power ratings, including thermal models and duty cycles.
- Modeling and control of DC and AC motor drives.
- Examine the application of electric drives in industrial application.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Explain the concept, classification, and components of electric drives. K2
- Demonstrate the steady-state and transient stability of electric drives K2
- Model DC and AC motors using state space, block diagrams, and transfer functions. K3
- Identify the different braking techniques to the drives depending on applications. K3
- Implement the control schemes for PMSM, BLDC and Switched Reluctance Motor drives K3

**UNIT I MOTOR POWER RATING 9**

Thermal model of motor for heating and cooling – Classes of motor duty – Determination of motor rating for continuous – Short time and intermittent duty – Equivalent current – Torque and power methods of determination of rating for fluctuating and intermittent loads – Effect of load inertia and environmental factors.

**UNIT II STARTING OF ELECTRIC DRIVES 9**

Effect of starting on Power supply – Motor and load – Methods of stating of electric motors – Acceleration time Energy relation during stating – Methods to reduce the Energy loss during starting – Braking of Electric Drives: Types of braking – braking of DC motor – Induction motor and Synchronous motor – Energy loss during braking.

**UNIT III DC MOTOR DRIVES 9**

DC motor drives: Modeling of DC motors – State space modeling – block diagram and Transfer function – Single phase – three phases fully controlled and half controlled DC drives – Dual converter control of DC drives – Power factor – supply harmonics and ripple in motor current chopper controlled DC motor drives – Phase locked loop and microcomputer control of DC drives.

**UNIT IV AC MOTOR DRIVES 9**

Induction motor drives: Stator voltage variation by three phase controllers – Speed control using chopper resistance in the rotor circuit – Pulse width modulated inverter fed and current source inverter fed induction motor drive – Vector control – SVM control for drives – DSP and Microcontroller control for drives.

**UNIT V APPLICATIONS** **9**

Introduction to Solar and Battery Powered Drive – Stepper motor – Switched Reluctance motor drive – Industrial application: Machine tools – Cranes and hoist drives – Variable frequency drive applications – Drives for electrical vehicles – Drives for robotics and drones control.

**TOTAL: 45**

**TEXT BOOKS:**


1. Stephen J. Chapman, "Electric Machinery Fundamentals", 1st Edition, McGraw-Hill Education, 2017.
2. Bhag S. Guru and Hüseyin R. Hiziroglu, "Electric Machinery and Transformers", 1st Edition, Oxford University Press, 2000.


**REFERENCES:**


1. P.C.Krause, Oleg Wasynczuk, Scott D. Sudhoff, "Analysis of Electrical Machinery and Drive Systems", 2nd Edition, Wiley (India), 2010.
2. P.S.Bimbra, "Generalized Theory of Electrical Machines", 5th Edition, Khanna Publications, 1995.
3. Stephen D. Umans, "Fitzgerald & Kingsley's Electric Machinery", 7th Edition, Tata McGraw Hill, 2020.
4. Chee Mun Ong, "Dynamic Simulation of Electric Machinery using MATLAB", 1st Edition, Prentice Hall, 1997.


**WEB URLs:**

1. https://nptel.ac.in/courses/108104011
2. https://onlinecourses.nptel.ac.in/noc21_ee24/preview
3. https://www.udemy.com/course/fundamentals-of-transformer-for-electrical-power-engineering/

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO2** | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **-** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **2** | **1.3** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX SWITCH MODE CONVERTERS 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Power Electronics

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Analyze non-isolated and isolated DC-DC converters, focusing on stress analysis, component selection, and thermal management.
- Develop skills in converter modeling, control techniques, and advanced strategies.
- Investigate advanced topics including resonant converters, multi-phase converters, power factor correction, and their applications in renewable energy and electric vehicle chargers.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the fundamental principles of power electronics and its key components K2
- Infer voltage and current stress in converters and select appropriate components K2
- Identify different types of transformer-based isolated DC-DC converters and their Applications K3
- Examine the control loops using Bode plots and advanced strategies K3
- Select power electronics control strategies to renewable energy systems and electric vehicle chargers. K3

**UNIT I INTRODUCTION TO POWER CONVERTERS 9**

Overview of Power converters – Power Semiconductor Devices – Basic Converter Topologies – Introduction to Control Strategies – Operating Principles – Waveform Analysis – Switching Losses – Efficiency Calculations-Applications of DC-DC Converters.

**UNIT II NON-ISOLATED DC-DC CONVERTERS 9**

Detailed Analysis of Buck Converter – Boost Converter – Buck-Boost Converter – Cuk Converter – SEPIC Converter – Zeta Converter – Continuous vs. Discontinuous Conduction Modes – Voltage and Current Stress in Converters.

**UNIT III ISOLATED DC-DC CONVERTERS 9**

Flyback Converter – Forward Converter – Push-Pull Converter-Half Bridge Converter – Full Bridge Converter – Magnetic Component Design – High Frequency Operation – Soft Switching Techniques – Comparison of Isolated Converters.

**UNIT IV CONVERTER MODELING AND CONTROL 9**

Advanced Switch Modeling – State Space Averaging – Small Signal Modeling – Voltage Mode Control – Current Mode Control – Digital Control of Power Converters – Loop Compensation – Bode Plot Analysis – Advanced Control Strategies – Practical Implementation Issues.

**UNIT V ADVANCED CONVERTERS** **9**

Resonant Converters – LLC Resonant Converter – Multi-Phase Converters – ZVS – ZCS – Interleaved boost converters – AC-DC Converters – Multi level boost converter.

**TOTAL: 45**

**TEXT BOOKS:**

1. Ned Mohan, Tore M. Undeland, and William P. Robbins, "Power Electronics: Converters, Applications, and Design", 3rd Edition, Wiley, 2003.
2. Robert W. Erickson and Dragan Maksimovic, "Fundamentals of Power Electronics", 2nd Edition, Springer, 2007.

**REFERENCES:**

1. Muhammad H. Rashid, "Power Electronics: Circuits, Devices & Applications", 4th Edition, Pearson Education, 2013.
2. Keith Billings and Taylor Morey, "Switchmode Power Supply Handbook", 3rd Edition, McGraw-Hill, 2010.
3. Issa Batarseh and Ahmad Harb, "Power Electronics: Circuit Analysis and Design", 2nd Edition, Springer, 2017.

**WEB URLs:**

1. https://archive.nptel.ac.in/courses/108/108/108108036/
2. https://onlinecourses.nptel.ac.in/noc22_ee124/preview
3. https://ee.iisc.ac.in/wp-content/uploads/2023/01/SMPC_VRamnarayanan.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | - |
| CO2 | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | - |
| CO3 | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | 1 |
| CO4 | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | 1 |
| CO5 | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **-** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Power Electronics

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the principles, technologies, and applications of solar energy conversion systems.
- Analyze AC-DC-AC converters for distributed power generation and address power quality issues.
- Develop knowledge of grid-connected wind and solar energy conversion systems, including performance optimization and hybrid configurations.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the modern power converters for renewable energy power harnessing K2
- Explain the interfacing of power electronic converters with grid K2
- Design the power converters for renewable energy applications K3
- Identify the various power electronic converters and the associated power quality issues K3
- Examine the performance of grid connected wind and solar energy conversion systems K3

**UNIT I INTRODUCTION 9**

Environmental aspects of electric energy conversion: Features of Renewable Generation impacts of renewable energy generation – Qualitative study of different renewable energy resources: ocean – Biomass – Hydrogen energy systems – Solar PV – Fuel cells – wind energy conversion system – control strategy – operating area – operating principles and characteristics

**UNIT II SOLAR ENERGY 9**

Solar radiation – Estimation – Solar thermal conversion devices and storage – Solar cells – Solar cell interconnection – Solar cell characteristics and photovoltaic conversion – PV systems – Analysis of PV systems – Solar Tracking – MPPT – Solar energy collectors and storages – Selection of power converters for solar energy conversion system.

**UNIT III WIND ENERGY 9**

Wind energy conversion system – Basic components of wind energy conversion system – Schemes for electric generations – Generator control – Load control – Energy storage – Power converters in Wind Energy conversion.

**UNIT IV DISTRIBUTED POWER GENERATION SYSTEMS 9**

Introduction to distributed generation – Topologies – Microgrid – Interface with grid – Microgrid drivers – Structure and Configuration of microgrid – AC and DC microgrids – Power electronics interface with AC and DC microgrids – Energy storage systems: Batteries – Ultra capacitor – SMES.

**UNIT V GRID CONNECTED WIND AND SOLAR ENERGY CONVERSION SYSTEMS 9**

Connection issues – Wind farm and its accessories – Grid related problems – Performance improvements – Different schemes – Power converters for Grid connected Wind Energy Conversion System and Grid connected Solar Energy Converter systems – Hybrid Systems.

**TOTAL: 45**

**TEXT BOOKS:**

1. Mario Garcia-Sanz and Constantine H. Houpis, "Wind Energy Systems: Control Engineering Design", 1st Edition, CRC Press, 2022.
2. Chetan Singh Solanki, "Solar Photovoltaic Power Systems: Principles, Design and Applications", 3rd Edition, Prentice Hall of India, 2020.

**REFERENCES:**

1. Henrik Lund, "Renewable Energy Systems: A Smart Energy Systems Approach to the Choice and Modeling of 100% Renewable Solutions", 1st Edition, Elsevier Science, 2014.
2. Ewald F. Fuchs and Mohammad A. S. Masoum, "Power Quality in Power Systems and Electrical Machines", 1st Edition, Academic Press Inc, 2008.
3. Godfrey Boyle, Bob Everett, and Janet Ramage, "Renewable Energy: Power for a Sustainable Future", 2nd Edition, Oxford University Press, 2012.
4. James F. Manwell, Jon G. McGowan, and Anthony L. Rogers, "Wind Energy Explained: Theory, Design and Application", 2nd Edition, John Wiley & Sons, 2010.

**WEB URLs:**

1. https://onlinecourses.nptel.ac.in/noc23_ee127/preview
2. https://www.magnelab.com/wp-content/uploads/2015/01/Role-of-power-electronics-in-renewable-energy-systems.pdf
3. https://dlib.hust.edu.vn/bitstream/HUST/19207/1/OER000000486.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | 1 | 1 | - | - | - | 1 | 2 | - |
| **CO2** | 2 | 1 | - | - | 1 | - | - | 1 | - | - | - | 1 | 2 | - |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **CO4** | 3 | 2 | 1 | - | 1 | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **CO5** | 3 | 2 | 1 | - | 1 | - | 1 | 1 | - | - | - | 1 | 2 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **1** | **1** | **-** | **1** | **1** | **-** | **-** | **-** | **1** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX CONTROL OF POWER ELECTRONICS CIRCUITS 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Power Electronics

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Learn the basics of control system simulation and do symbolic calculation.
- Study the principles of sliding mode control and the way of apply smc for buck
- Design simulate smc for buck converter and power factor correction circuit with controller.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Calculate transfer function for constant, differential, integral, First order and Second order factors. K2
- Illustrate the effect of poles and zero's in the 's' plane. K3
- Select Symbolic equations for solving problems related with Matrices, Polynomial and vectors. K3
- Compute the control expression for DC – DC buck converter using sliding mode control theory. K3
- Determine the controller expression for power factor correction circuits. K3

**UNIT I SIMULATION BASICS IN CONTROL SYSTEMS 9**

Transfer Function – How to build transfer function – Identify Poles – Zeros – Draw time response plots – Bode plot (Bode Plots for Multiplication Factors, Constant, Single and Double Integration Functions, Single and Double Differentiation Functions, Single Pole and Single Zero Functions, RHP Pole and RHP Zero Functions) – State space modelling – Transfer function from state space Model.

**UNIT II SYMBOLIC CALCULATIONS 9**

Symbolic Variables – Symbolic Vector Variables – Commands for Handling Polynomial Expressions – Extracting Parts of a Polynomial – Factorization and Roots of Polynomials – Symbolic Matrix Algebra – Operations with Symbolic Matrices – Other Symbolic Matrix Operations.

**UNIT III SLIDING MODE CONTROL BASICS 9**

Introduction – Introduction to Sliding – Mode Control – Basics of Sliding – Mode Theory – Application of Sliding – Mode Control to DC-DC Converters – Principle – Sliding mode control of buck converter.

**UNIT IV POWER FACTOR CORRECTION CIRCUITS 9**

Introduction – Operating Principle of Single Phase PFCs – Control of boost converter based PFCs – Designing the Inner Average – Current Control Loop – Designing the Outer Voltage-Control Loop – Example of Single Phase PFC Systems.

**UNIT V CONTROLLER DESIGN FOR PFC CIRCUITS 9**

Power factor correction circuit using other SMPS topologies: C'uk and SEPIC converter – PFC circuits employing bridgeless topologies.

**TOTAL: 45**

**TEXT BOOKS:**

1. Dean Frederick and Joe Chow, "Feedback Control problems using MATLAB and the Control system tool box", 1st Edition, Cengage Learning, 2000.
2. Ned Mohan, "Power Electronics: A First Course", 1st Edition, Johnwiley, 2013.

**REFERENCES:**

1. Lucian Nicolae Tutelea and Marcel Oproescu, "Advances in Power Electronics and Control System Technologies for Renewable Energy Systems", 1st Edition, IGI Global, 2019.
2. Marian K. Kazimierczuk and Agasthya Ayachit, "Laboratory Manual for Pulse-Width Modulated DC-DC Power Converters", 1st Edition Wiley, 2016.
3. S.K.Varenina, "Power Electronics handbook, Industrial Electronics series", 1st Edition, CRC press, 2002.
4. Marian K. Kazimierczuk, "Pulse-Width Modulated DC-DC Power Converters", 2nd Edition, Wiley, 2015.

**WEB URLs:**

1. https://archive.nptel.ac.in/courses/108/102/108102145/
2. https://www.coursera.org/specializations/modeling-and-control-of-power-electronics
3. https://dlib.hust.edu.vn/bitstream/HUST/19207/1/OER000000486.pdf

**CO, PO, PSO MAPPING:**

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | - |
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| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **-** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **2** | **1** |

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**SEMESTER-X**

| 24BEEEXXX | HVDC and FACTS | 3H-3C |
|---|---|---|

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Power Electronics

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Analyze the operation and control characteristics of Line Commutated Converters (LCC) and Voltage Source Converters (VSC) in HVDC systems.
- Investigate the principles of operation and control strategies for series compensation FACTS controllers such as TCSC and SSSC, and assess their impact on power system stability.
- Explore advanced topics including HVDC Light, HVDC Plus, multi-terminal HVDC systems, and grid integration of renewable energy sources using HVDC and FACTS technologies, and evaluate recent advances and future trends in HVDC and FACTS applications.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the fundamental concepts and components of HVDC and FACTS systems K2
- Demonstrate the working of different types of HVDC converters K2
- Develop the control strategies of SVC and STATCOM K3
- Apply series compensation in power systems to improve stability K3
- Examine the operation and benefits of advanced FACTS controllers K3

**UNIT I INTRODUCTION TO HVDC AND FACTS 9**

Overview of HVDC Systems – Comparison of HVAC and HVDC Transmission – Components of HVDC Systems – Types of HVDC Links: Monopolar – Bipolar and Homopolar – Converter Stations and their Components – Control of HVDC Systems – Advantages and Applications of HVDC – Overview of FACTS (Flexible AC Transmission Systems) – Types and Benefits of FACTS Controllers – Comparison between HVDC and FACTS

**UNIT II HVDC CONVERTERS AND CONTROL 9**

Introduction to Line Commutated Converters (LCC) – Current Source Converters (CSC) – Voltage Source Converters (VSC) – HVDC Converter Configurations – Control Characteristics of LCC HVDC Systems – Control Characteristics of VSC HVDC Systems – Reactive Power Requirements of HVDC Converters – Harmonics and Filters in HVDC Systems – Protection Schemes for HVDC Converter.

**UNIT III FACTS CONTROLLERS - SHUNT COMPENSATION 9**

Introduction to Shunt Compensation – Static Var Compensators (SVC) – Thyristor Controlled Reactor (TCR) – Thyristor Switched Capacitor (TSC) – Static Synchronous Compensator (STATCOM) – Principles of Operation of SVC and STATCOM – Control Strategies for SVC – Control Strategies for STATCOM – Applications of Shunt Compensation – Comparison of SVC and STATCOM

**UNIT IV FACTS CONTROLLERS - SERIES COMPENSATION 9**

Introduction to Series Compensation – Thyristor Controlled Series Capacitor (TCSC) – Thyristor Switched Series Capacitor (TSSC) – Static Synchronous Series Compensator (SSSC) – Principles of Operation of TCSC and SSSC – Control Strategies for TCSC – Control Strategies for SSSC – Comparison of TCSC and SSSC.

**UNIT V ADVANCEMENT IN HVDC AND FACTS** **9**

HVDC Light and HVDC Plus Technologies – Hybrid HVDC Systems – Multi-Terminal HVDC Systems – Grid Integration of Renewable Energy Sources using HVDC and FACTS – Advanced FACTS Controllers: UPFC – IPFC – Control of Power Flow using FACTS Controllers.

**TOTAL: 45**

**TEXT BOOKS:**

1. K. R. Padiyar, "HVDC Power Transmission Systems: Technology and System Interactions", 2nd Edition, New Age International Publishers, 2008.
2. Narain G. Hingorani and Laszlo Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", 1st Edition, Wiley-IEEE Press, 2000.

**REFERENCES:**

1. J. Arrillaga, "High Voltage Direct Current Transmission", 2nd Edition, The Institution of Engineering and Technology, 1998.
2. Y. H. Song and A. T. Johns, "Flexible AC Transmission Systems (FACTS)", 1st Edition, The Institution of Engineering and Technology, 1999.
3. K. R. Padiyar, "High Voltage Direct Current Transmission: Converters, Systems and DC Grids", 1st Edition, New Academic Science, 2013.
4. Vijay K. Sood, "HVDC and FACTS Controllers: Applications of Static Converters in Power Systems", 1st Edition, Springer, 2004.

**WEB URLs:**

1. https://nptel.ac.in/courses/108104013
2. https://tite.ac.in/assets/frontend/pdf/lecture-notes/btech/6thsem/FACTS-6th-sem-EEE.pdf
3. https://gvpfaciitb.wordpress.com/wp-content/uploads/2018/02/3-hvdc-converter-control.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **Average** | **2.6** | **1.6** | **1** | **1** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX DIGITAL CONTROL IN POWER ELECTRONICS 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Control Systems, Power Electronics

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Explore various digital control algorithms such as PID, PWM, sliding mode control, MPC, adaptive control, fuzzy logic, neural network, and robust control techniques.
- Learn digital control strategies for different types of DC-DC converters including buck, boost, buck-boost, Cuk, SEPIC, full-bridge, half-bridge, and dual active bridge converters.
- Gain insight into digital control applications in energy storage systems, renewable energy, battery management, DC-AC inverters, micro grids, virtual synchronous generator control, and considerations for cyber security and reliability in digital control systems.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Describe the basic principle of digital control systems and digital signal processing K2
- Illustrate the design and implementation of various digital control algorithms K2
- Apply appropriate digital control strategies to various types of DC-DC converters K3
- Implement digital control techniques for AC-DC converters K3
- Develop digital control strategies for microgrid K3

**UNIT I INTRODUCTION TO DIGITAL CONTROL IN POWER ELECTRONICS 9**

Introduction to Digital Control Systems – Advantages of Digital Control Digital Signal Processing Fundamentals – Analog-to-Digital Conversion Techniques – Digital Control Hardware Overview – Software Tools for Digital Control Design – Implementation Challenges and Considerations.

**UNIT II DIGITAL CONTROL ALGORITHMS 9**

PID Control in Digital Systems – Digital Pulse – Width Modulation (PWM) – Sliding Mode Control in Digital Systems – Model Predictive Control (MPC) – Adaptive Control Algorithms – Fuzzy Logic Control – Neural Network Control – Robust Control Techniques.

**UNIT III DIGITAL CONTROL OF DC-DC CONVERTERS 9**

Buck Converter Control Strategies – Boost Converter Control Techniques – Buck-Boost Converter Control – Cuk Converter Control – SEPIC Converter Control – Full Bridge Converter Control – Half Bridge Converter Control – Dual Active Bridge (DAB) Converter Control.

**UNIT IV DIGITAL CONTROL OF AC-DC CONVERTERS 9**

Single Phase Rectifiers and Digital Control – Three Phase Rectifiers and Control Techniques – Voltage Source Rectifiers (VSC) Control – Current Source Rectifiers (CSR) Control – Power Factor Correction (PFC) Techniques – Direct Power Control (DPC) – Space Vector Modulation (SVM) – Digital Control of Matrix Converters.

**UNIT V DIGITAL CONTROL IN ENERGY STORAGE SYSTEMS AND RENEWABLE ENERGY 9**

Battery Management Systems (BMS) with Digital Control – Digital Control of DC-DC Converters in Energy Storage Systems – Digital Control of DC-AC Inverters in Energy Storage Systems – Energy Management Strategies – Control of Hybrid Renewable Energy Systems – Microgrid.

**TOTAL: 45**

**TEXT BOOKS:**


1. M. Sami Fadali and Antonio Visioli, "Digital Control Engineering: Analysis and Design", 3rd Edition, Academic Press (Elsevier), 2020.
2. Bimal K. Bose, "Power Electronics and Motor Drives: Advances and Trends", Taylor and Francis, 4th Edition, First Edition", Academic Press (Elsevier), 2020.


**REFERENCES:**


1. Fang Lin Luo and Hong Ye, "Digital Control in Power Electronics", 1st Edition, Academic Press, 2017.
2. Luca Corradini, Dragan Maksimovic, and Paolo Mattavelli, "Digital Control of High-Frequency Switched-Mode Power Converters", 1st Edition, CRC Press, 2017.
3. M. Sami Fadali and Antonio Visioli, "Digital Control Engineering: Analysis and Design", 2nd Edition, Academic Press, 2012.
4. Seddik Bacha, Iulian Munteanu, and Antoneta Iuliana Bratcu, "Advanced Control Methods for Power Converters", 1st Edition, Springer, 2021.


**WEB URLs:**

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2. https://ee.eng.usm.my/eeacad/syafrudin/nota/Lecture%20Note%20Macine%20&%20Drives%20(Power%20Electronic%20Converter).pdf
3. http://www.eiti.uottawa.ca/~rhabash/ELG4157DigitalControlSystems.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | - |
| **CO2** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 2 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **1** | **-** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **2** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER - X**

**24BEEEXXX ELECTRIC AND HYBRID VEHICLE ARCHITECTURE 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3Hours

**PRE-REQUISITE:** Electric Vehicle Technology

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Gain comprehensive understanding of vehicle fundamentals, electric and hybrid vehicle technologies, energy storage systems, and converters for hybrid energy storage.
- Analyze vehicle dynamics, power train characteristics, and energy storage requirements. Evaluate electric drive-trains, propulsion units, and charger fundamentals.
- Apply knowledge to optimize vehicle performance, efficiency, and charging infrastructure

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Illustrate the fundamentals of electric vehicle K2
- Classify the concepts of electric vehicles with drive-train topologies and advanced propulsion techniques K2
- Interpret the concepts of hybrid electric vehicles and their impact on environment K2
- Identify the various energy storage technologies in hybrid electric vehicles K3
- Select suitable power converter topologies for motor control and hybrid energy storage K3

**UNIT I VEHICLE FUNDAMENTALS 9**

Vehicle movement – Vehicle resistance – Dynamic equation – Power train tractive effort and vehicle speed – Vehicle power plant and transmission characteristics – Vehicle performance – Operating fuel economy – Braking performance.

**UNIT II ELECTRIC DRIVE-TRAINS 9**

Electric drive-trains: Basic concept of electric traction – Introduction to various electric drive – Train topologies – Power flow control in electric drive – Train topologies – Fuel efficiency analysis.

**UNIT III ELECTRIC PROPULSION UNIT 9**

Electric Propulsion unit: Electric components used in electric vehicles – Configuration and control of DC Motor drives – Induction Motor drives – Permanent Magnet Motor drives – Switch Reluctance Motor drives – Drive system efficiency.

**UNIT IV HYBRID ELECTRIC DRIVE-TRAINS 9**

Basic concept of hybrid traction – Introduction to various hybrid drive – Train topologies – Power flow control in hybrid drive – Train topologies – Fuel efficiency analysis.

**UNIT V SIZING THE DRIVE SYSTEM 9**

Matching the electric machine and the internal combustion engine (ICE) – Sizing the propulsion motor – Sizing the power electronics – Selecting the energy storage technology – Communications – Supporting subsystems

**TOTAL: 45**

**TEXT BOOKS:**

1. Ali Emadi, "Advanced Electric Drive Vehicles", 1st Edition, CRC Press, Taylor & Francis Group, 2015.
2. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", 2nd Edition, CRC Press, 2003.

**REFERENCES:**

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", 1st Edition, CRC Press, 2005.
2. James Larminie and John Lowry, "Electric Vehicle Technology Explained", 1st Edition, Wiley, 2003.
3. Chris Mi, M. Abul Masrur, and David Wenzhong Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2nd Edition, Wiley, 2017.
4. Luca Corradini, Dragan Maksimovic, and Paolo Mattavelli, "Digital Control of High-Frequency Switched-Mode Power Converters", 1st Edition, CRC Press, 2017.

**WEB URLs:**

1. https://nptel.ac.in/courses/108/106/108106170/
2. https://nptel.ac.in/courses/108/102/108102121/
3. https://coursecontent.indusuni.ac.in/wp-content/uploads/sites/8/2020/05/UNIT-1-2.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO3** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.4** | **1.4** | **1** | - | - | - | - | **1** | - | - | - | - | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX DESIGN OF POWER TRAIN FOR ELECTRIC VEHICLES 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:** 3 Hours

**PRE-REQUISITE:** Electric Vehicle Technology, Power Electronics, Electric Drives and Control

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Familiarize students with the concept of electric vehicles
- Understand power train for electric vehicles
- Apply the knowledge of electric drives used in electric vehicles and their control.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the EV history, tractive effort, and vehicular dynamics K2
- Develop the on-board charger and control of bi-directional DC-DC converters K3
- Illustrate induction motor basics and control techniques K2
- Examine the high-power induction motor applications, converter design, and PWM Techniques K3
- Evaluate efficiency and performance in EV power trains and chargers K3

**UNIT I INTRODUCTION 9**

Components of conventional vehicle and propulsion load – Power train of HEV and EV – Efficiency considerations for conventional vehicle – HEV and EV – Multi-motor in-wheel EVs – Impact and benefits of EV on utility grid.

**UNIT II ON-BOARD CHARGERS 9**

basics of non-isolated/isolated DC-DC and grid connected converters – Classification of EV chargers – Modeling and control of bi-directional DC-DC converters.

**UNIT III INDUCTION MOTOR DRIVES 9**

Basics of induction motor – Open-loop v/f control – Basics of DC-AC power converters – Basic pulse width modulation techniques – Vector control of IM drives – Advanced control techniques

**UINIT IV SRM AND PMSM DRIVES 9**

Basics of magnetic circuits and principle of reluctance – Basics of switched reluctance motor – Modeling and control of switched reluctance motor – Modeling and control of PMSM drive – Advanced control techniques for PMSM drive.

**UNIT V HIGH-POWER AND HIGH-SPEED EVs 9**

Applications of High power induction motor drives – Power converter design – Special PWM techniques for high power applications – Field oriented control of high power IM drives – Applications of high speed PMSM drives – Power converter design and PWM techniques – Field oriented control of high speed PMSM drives.

**TOTAL: 45**

**TEXT BOOKS:**

1. Ali Emadi, "Advanced Electric Drive Vehicles", 1st Edition, CRC Press, 2015.
2. Iqbal Husain, "Electric and Hybrid Vehicles – Design Fundamentals", 2nd Edition, CRC Press, 2011.

**REFERENCES:**

1. Berker B., James W. J., and A. Emadi, "Switched Reluctance Motor Drives", 1st Edition, CRC Press, 2019.
2. Bin Wu, "High-Power Converters and AC Drives", 1st Edition, IEEE Wiley Press, 2017.
3. Bimal K. Bose, "Modern Power Electronics and AC Drives", 1st Edition, Prentice Hall PTR, 2001.
4. W. Leonard, "Control of Electric Drives", 1st Edition, Springer, 2007.

**WEB URLs:**

1. https://www.energy.gov/eere/electricvehicles/history-electric-car
2. https://www.electronics-tutorials.ws/power/switch-mode-power-supply.html
3. https://www.electronics-notes.com/articles/electronic_components/motor-control/brushless-dc-motor-control/foc-field-oriented-control.php

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO2** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO3** | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **1** | - | - | - | **1** | - | - | - | - | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL 3H-3C**

**Instruction Hours/week:L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electric Vehicle Technology

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Study the modelling of electric vehicle range, including driving cycles and range modelling for battery electric, fuel cell, and hybrid electric vehicles.
- Understand the principles of regenerative braking and its application in electric and hybrid electric vehicles.
- Gain insights into the fundamentals of Vehicle Dynamic Control (VDC) systems.

**COURSE OBJECTIVES:**

Upon completion of this course, the student will be able to:

- Demonstrate the acceleration modeling for electric scooters and small cars. K2
- Illustrate the tractive effort, range modeling, and driving cycles for battery electric vehicles, including hybrid and fuel cell vehicles K2
- Interpret the characteristics of EV/HEV power trains and components, including performance and braking modeling K2
- Show the energy management strategies, including power allocation and control techniques for electric and hybrid vehicles K2
- Outline the vehicle dynamic control fundamentals and implement control systems for electric and hybrid vehicles, utilizing case studies for analysis K2

**UNIT I MODELLING OF PERFORMANCE PARAMETER 9**

Modelling Vehicle Acceleration – Acceleration performance parameters – modelling the acceleration of an electric scooter – modelling the acceleration of a small car.

**UNIT II VEHICLE DYNAMIC CONTROL 9**

Vehicle Mechanics – Law of motion – Dynamics of vehicle motion – Fundamentals of Vehicle Dynamic Control (VDC) Systems – VDC Implementation on Electric and Hybrid vehicles – Case Studies: Rechargeable battery vehicles – Hybrid vehicles – Fuel cell powered bus.

**UNIT III MODELLING OF ELECTRIC VEHICLES 9**

Electric Vehicle Modelling – Tractive effort – Grip and Rolling resistance – Tyre mechanics – Aerodynamic drag – Hill climbing force – Modelling of electric vehicle range – Driving cycles – Range modelling: Battery electric vehicles – fuel cell vehicles – Hybrid electric vehicles.

**UNIT IV DRIVE TRAIN CHARACTERISTICS 9**

Modelling and Characteristics of EV/HEV Powertrains Components – Battery Performance Characteristics – Transmission and Drivetrain Characteristics – Regenerative Braking Characteristics – Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking – Vehicle Braking Modelling and Analysis.

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

Handling Analysis of Electric and Hybrid Electric Vehicles – Simplified Handling Models Energy/Power Allocation and Management – Power/Energy Management Controllers – Rule Based Control Strategies – Optimization Based Control Strategies.

**.TOTAL: 45**

**TEXT BOOKS:**

1. C. C. Chan, "The Principles and Applications of Electric and Hybrid Electric Vehicles", 1st Edition, World Scientific Publishing, 2019.
2. John M. Miller, "Propulsion Systems for Hybrid Vehicles", 1st Edition, Institution of Engineering and Technology, 2004.

**REFERENCES:**

1. David Greenwood, "Advanced Electric Vehicle Propulsion Systems", 1st Edition, Butterworth-Heinemann, 2019.
2. Simona Onori, Lorenzo Serrao, and Giorgio Rizzoni, "Energy Management of Hybrid Electric Vehicles: 15 (IEEE Press Series on Power Engineering)", 1st Edition, Wiley-IEEE Press, 2016.
3. Antoni Szumanowski "Hybrid Electric Power Train Engineering and Technology Modeling, Control, and Simulation", 1st Edition, Engineering Science Reference/IGI Global, 2013.
4. J. Christian Gerdes and Michael Masin, "Model Predictive Control for Advanced Driver Assistance Systems", 1st Edition, Springer, 2016.

**WEB URLs:**

1. https://www.sciencedirect.com/science/article/abs/pii/S1474667018414924
2. https://www.sciencedirect.com/science/article/abs/pii/S2212827114001853
3. https://ieeexplore.ieee.org/document/7995625

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO2** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO3** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.4** | **1.4** | **1** | - | - | - | - | **1** | - | - | - | - | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER-X**

**24BEEEXXX DESIGN OF CHARGING STATIONS 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40 External:60 Total:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Electric Vehicle Technology

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Recognize the levels of onboard and off-board chargers and their charging speeds
- Explore various converter topologies used in charging stations.
- Learn about the control of single-phase and three-phase AC-DC converters.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Explain the configurations of chargers for electric vehicle K2
- Select a converter topology for electric vehicle charging station K3
- Make use of an appropriate control scheme for charging converter K3
- Identify the various wireless power transfers for EV charging station K3
- Interpret the latest developments in electric vehicle charging technologies K2

**UNIT I CHARGING ARCHITECTURES FOR ELECTRIC VEHICLES 9**

Classification of EV charging architectures – Onboard Chargers – Level 1: Dedicated Converter (Slow Charging) – Level 2: Integrated Converter (Semi-fast Charging) – Off Board Chargers – Level 3: Dedicated Off Board DC Chargers (Fast Charging) – Common AC Bus Architecture – Common DC Bus Architecture.

**UNIT II CONVERTER TOPOLOGIES FOR CHARGING STATION 9**

Vienna Rectifier – Multipulse Rectifier with DC Active Power Filter – Non-isolated Multichannel Interleaved Buck Converter – Phase Shifted ZVS Full Bridge Converter – Grid connected cascaded H-bridge converter – Grid connected Modular Multilevel Converter based integrated charger for split integrated battery pack.

**UNIT III CONTROL SCHEMES AND CHARGING STANDARDS 9**

Control Schemes for Charging Converters – Single Phase AC-DC Converter Control – Three Phase AC-DC Converter Control – Voltage oriented control (VOC) and direct power control (DPC) – Electric Vehicle / Plug in Hybrid Electric Vehicle charging Standards

**UNIT IV EV CHARING TECHNIQUES 9**

Introduction – Inductive – Magnetic Resonance – Capacitive types – Wireless Chargers for Electric Vehicles – Battery Technology in EVs – Charging Modes in EVs – Benefits of WPT – WPT Operation Modes – Standards for EV Chargers – SAE J2954 – IEC 61980 – ISO 19363 – SAE J1772.

**UNIT V LATEST DEVELOPMENTS IN EV CHARGING 9**

Inductive Charging, Vehicle to Grid (V2G) and Vehicle to Home (V2H) – EV charging safety configuration and considerations – Grid Tied Residential charging Systems – Grid Tied Public charging Systems – EV cable communication protocols – Charging cable standards.

**TOTAL: 45**

**TEXT BOOKS:**

1. David Greenwood, "Advanced Electric Vehicle Propulsion Systems", 1st Edition, Butterworth-Heinemann, 2019.
2. Ali Emadi, "Energy-Efficient Electric Motors and their Applications", 1st Edition, CRC Press, 2004.

**REFERENCES:**

1. Xiao-Ping Zhang and Frede Blaabjerg, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", 1st Edition, Wiley-IEEE Press, 2014.
2. Mahmoud Abdel-Hakim and Ahmed F. Zobaa, "Electric and Plug-In Hybrid Vehicle Networks: Optimization and Control", 1st Edition, CRC Press, 2017.
3. Thomas M. Jahns and Ronald G. Harley, "Modeling and Control of Electric Machines", 1st Edition, John Wiley & Sons, 2006.
4. John M. Miller, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", 1st Edition, Wiley-IEEE Press, 2014.

**WEB URLs:**

1. https://uta.pressbooks.pub/sustainablemobility/chapter/chapter-7-design-of-charging-infrastructure/
2. https://www.statedevelopment.qld.gov.au/__data/assets/pdf_file/0016/18142/practice-note-electric-vehicle-charging.pdf
3. https://www.transportationandclimate.org/sites/default/files/EV_Siting_and_Design_Guidelines.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO2** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO3** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.4** | **1.4** | **1** | - | - | - | - | **1** | - | - | - | - | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

## SEMESTER – X

**24BEEEXXX TESTING OF ELECTRIC VEHICLES 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks: Internal:40** External**:60** Total**:100**

**End Semester Exam:** 3Hours

**PRE-REQUISITE:** Electric Vehicle Technology

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Gain knowledge in the field of E-vehicle certification
- Understand the concept of dynamic testing of E-vehicle
- Understand the fundamentals of charging station & hybrid electric vehicle

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the regulations and approval schemes in the field of E-vehicle certification K2
- Explain the concept of static testing of E-Vehicle K2
- Apply the concept of dynamic testing of E-Vehicle K3
- Identify the testing of various E-Vehicle components K3
- Select the testing method for various charging station and hybrid electric vehicles. K3

**UNIT I INTRODUCTION 9**

Specification & Classification of Vehicles (including M, N and O layout) – Homologation and its types – Regulations overview (EEC, ECE, FMVSS, AIS, CMVR) – Homologation for export – Conformity of Production – Various Parameters – Instruments and Types of test tracks – Hardware in The Loop (HIL) concepts for EV/HEVs.

**UNIT II STATIC TESTING OF VEHICLE 9**

Photographs, CMVR physical verification – Tyre Tread Depth Test – Vehicle Weightment – Horn installation – Rear view mirror installation – Tell Tales – External Projection – Wheel Guard – Arrangement of Foot Controls for M1 Vehicle – Angle and Dimensions Measurement of Vehicle – The requirement of temporary cabin for drive away – Chassis – Electric vehicle – Safety norms

**UNIT III DYNAMICS TESTING OF VEHICLE 9**

Hood Latch – Grade ability – Pass-by Noise – Interior Noise – Turning Circle Diameter and Turning Clearance Circle Diameter – Steering Effort – Constant Speed Fuel Consumption – Cooling Performance – Speedometer Calibration – Range Test – Maximum Speed – Acceleration Test – Coast down test – Brakes Performance ABS Test – Electric vehicle: Range Test.

**UNIT IV VEHICLE COMPONENT TESTING 9**

Safety Glasses Test: Windscreen laminated and toughened safety glass – Tire and Wheel Rim Test – Bumper Impact Test – Side Door Intrusion – Crash test with dummies – Demist test – Defrost Test – Airbag Test – Accelerator Control System – Motor power – Safety Requirements of Traction Batteries.

**UNIT V TESTS FOR HYBRID ELECTRIC VEHICLES, RETRO-FITMENT AND CHARGING STATION 9**

Hybrid Electric Vehicles Tests (M and N category) – Tests for Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category (GVW < 3500 kg) – Test for Electric Propulsion kit intended for Conversion – Test for Electric Vehicle Conductive AC Charging System – Test for Electric vehicle conductive DC charging system.

**TOTAL: 45**

**TEXT BOOKS:**


1. Ali Emadi, "Handbook of Automotive Power Electronics and Motor Drives", 1st Edition, Taylor & Francis, 2005.
2. Li Zhai , "Electromagnetic Compatibility of Electric Vehicle", 1st Edition , Springer, 2021.


**REFERENCES:**


1. Kai Borgeest, "EMC and Functional Safety of Automotive Electronics", 1st Edition, IET, 2018.
2. Druce Archam beault, colin branch, Omar M.Ramachi, "EMI/EMC Computational Modeling Handbook", 2nd Edition, Springer, 2012.
3. Mark Steffika, "Automotive EMC", 1st Edition, Springer, 2013.
4. Beate Müller, Gereon Meyer, "Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiative", 1st Edition, Springer, 2015.


**WEB URLs:**

1. tuvsud-eu-ece-type-approval.pdf
2. Vehicle Dynamics Testing - ARAI - Search (bing.com)
3. Hybrid Electric Vehicles Testing - TÜV SÜD - Search (bing.com)

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.6** | **1.6** | **1** | - | - | - | - | **1** | - | - | - | - | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER – X**

**24BEEEXXX GRID INTEGRATION OF ELECTRIC VEHICLES 3H-3C**

**Instruction Hours/week:L:3 T:0 P:0** **Marks:** Internal**: 40** External**:60** Total**:100**
**End Semester Exam:** 3Hours

**PRE-REQUISITE:** Electric Vehicle Technology

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Develop a comprehensive understanding of electric vehicle (EV) fundamentals, including types, advantages, challenges, and key technologies.
- Explore electric vehicle batteries, charging techniques, and grid applications, emphasizing efficiency, performance, and integration with smart grid systems.
- Examine advanced topics such as EV drivetrains, chargers, and infrastructure impact on grid management.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the Electric Vehicle concepts and its importance in power system K2
- Classify the various batteries used in electric vehicle K2
- Assess the role of Electric Vehicle in modern distribution system and smart grids K3
- Choose various charging methods and control strategies for electric vehicles K3
- Develop the charger and control for hybrid electric vehicle and plug-in electric vehicle K3

**UNIT I FUNDAMENTALS OF ELECTRIC VEHICLES (EV) 9**

Introduction to Electric Vehicle technology – Types – Fundamental issues related to electric vehicles (EVs) and hybrid electric vehicles (HEVs) – Interdisciplinary Nature of EVs – State of the Art of EVs – Advantages and Disadvantages – Challenges and Key Technologies of EVs – Challenges for EV Industry in India

**UNIT II ELECTRIC VEHICLE BATTERIES 9**

Electric vehicle battery efficiency – Type – Capacity –Charging/discharging –Technical characteristics – Performance – Testing – EV battery for stationary applications (B2U).

**UNIT III CHARGING TECHNIQUES 9**

Architecture/Components of EV charging station – EVSE (Electric Vehicle Supply Equipment) – Type of EV Chargers – Charging Methods – Automotive networking and communication – EV and EV charging standards.

**UNIT IV GRID APPLICATIONS 9**

Concept of Vehicle to Grid (V2G/G2V) – Ancillary Services – peak saving – load generation balance – Demand Response – Energy time shift – Energy Management strategies and its general architecture – integration of EVs in smart grid – social dimensions of EVs.

**UNIT V ADVANCED TOPICS** **9**

Different design and control aspects of electric drives and chargers for EVs and HEVs – Infrastructure for Plug-In-Electric and Hybrid Vehicles – Impact of Plug-in Hybrid Electric Vehicles on smart Grid/Distribution Networks – Sizing Ultra capacitors for Hybrid Electric Vehicles – Effect of charging infrastructure on grid protection and control – Role of AMI/Smart Meters in EV Management.

**TOTAL: 45**

**TEXT BOOKS:**

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 2nd Edition, Wiley-Blackwell, 2012.
2. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", 1st Edition, Springer, 2016.

**REFERENCES:**

1. Sandeep Dhameja, "Electric Vehicle Battery Systems", 1st Edition, Elsevier, 2012.
2. Ali Emadi, "Advanced Electric Drive Vehicles", 1st Edition, CRC Press, 2017.
3. Iqbal Hussain, "Electric & Hybrid Vehicles Design Fundamentals", 2nd Edition, CRC Press, 2011.
4. Chris Mi, M. Abul Masrur, D. Wenzhong Gao, A. Dearborn, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2nd Edition, John Wiley & Sons Ltd., 2017.

**WEB URLs:**

1. https://ocw.tudelft.nl/course-readings/3-1-2-lecture-notes-grid-integration-of-electrics-vehicles/
2. https://ee.eng.chula.ac.th/wp-content/uploads/2023/01/Electric-Vehicle-Grid-Integration.pdf

https://www.niti.gov.in/sites/default/files/202108/HandbookforEVChargingInfrastructureImplementation081221.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | 1 | 1 | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **Average** | **2.6** | **1.6** | **1** | - | - | - | - | **1** | - | - | - | **1** | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER- X**

**24BEEEXXX INTELLIGENT CONTROL OF ELECTRIC VEHICLES 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks:** Internal**: 40 External:60 Total:100**

**End Semester Exam:**3Hours

**PRE-REQUISITE:** Electric Vehicle Technology

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Design and drive the mathematical model of a BLDC motor and its characteristics
- Learn the different control schemes for BLDC motor
- Implement fuzzy logic control of BLDC motor in real time

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Design the mathematical model of a BLDC motor and discuss about its characteristics K3
- Demonstrate the role of PID controller, ant windup controller, Intelligent Controller and Vector Controller on BLDC motor K2
- Apply the basics of fuzzy logic system in electric vehicle K3
- Implement the basics of VHDL and FPGA applied to the control of electric vehicles K3
- Design the fuzzy logic control scheme for BLDC motor using FPGA in real time K3

**UNIT I MATHEMATICAL MODEL AND CHARACTERISTICS ANALYSIS OF THE BLDC MOTOR 9**

Structure and Drive Modes – Basic Structure – General Design Method – Drive Modes – Mathematical Model – Differential Equations – Transfer Functions – State-Space Equations – Characteristics Analysis – Starting Characteristics – Steady State Operation – Dynamic Characteristics – Load Matching Commutation Transients.

**UNIT II SPEED CONTROL FOR ELECTRIC DRIVES 9**

Introduction – PID Control Principle – Anti windup Controller – Intelligent Controller – Vector Control – Control applied to BLDC motor

**UNIT III FUZZY LOGIC 9**

Fuzzy arithmetic and fuzzy measures: fuzzy arithmetic – Extension principle – Fuzzy measures – Measures of fuzziness – Fuzzy integrals – Fuzzy rule base and approximate reasoning: truth values and tables – Fuzzy propositions – Formation of rules decomposition of rules – Aggregation of fuzzy rules – Fuzzy reasoning – Fuzzy inference systems – Overview of fuzzy expert system – Fuzzy decision making.

**UNIT IV FPGA AND VHDL BASICS 9**

Introduction – FPGA Architecture – Advantages – Review of FPGA family processors – Spartan 3, Spartan 6 and Spartan 7 – VHDL Basics – Fundamentals – Instruction set – Data type – Conditional statements – Programs like arithmetic, sorting, PWM generation, Speed detection.

**UNIT V REAL TIME IMPLEMENTATION 9**

Inverter design – Identifying rotor position via hall effect sensors – Open loop and fuzzy logic control of 48 V BLDC motor using FPGA.

**TOTAL: 45**

**TEXT BOOKS:**

1. Austin Hughes, Bill Drury, "Electric Motors and Drives: Fundamentals, Types and Applications", 5th Edition, Newnes, 2019.
2. Ramu Krishnan, "Permanent Magnet Synchronous and Brushless DC Motor Drives", 1st Edition, CRC Press, 2009.

**REFERENCES:**

1. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", 1st Edition, Springer, 2016.
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", 3rd Edition, Wiley, 2010.
3. William J. Dally, R. Curtis Harting, "Digital Design using VHDL: A Systems Approach", 1st Edition, Cambridge University Press, 2012.
4. Pong P. Chu, "FPGA Prototyping by VHDL Examples: Xilinx Spartan-3 Version", 1st Edition, Wiley, 2008.

**WEB URLs:**

1. http://eprints.utar.edu.my/137/1/3E-2011-0705823-1.pdf
2. https://www.eecs.umich.edu/courses/doing_dsp/handout/vhdl-tutorial.pdf
3. http://esd.cs.ucr.edu/labs/tutorial/

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO2** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO3** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.6** | **1.6** | **1** | **1** | - | - | - | **1** | - | - | - | - | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER – X**

**24BEEEXXX BATTERY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLES 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks:** Internal**: 40 External:60 Total:100**

**End Semester Exam:**3Hours

**PRE-REQUISITE**: Electric Vehicle Technology

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the requirements and functionalities of a BMS, such as voltage, temperature, and current sensing, high-voltage contactor control, isolation sensing, thermal control, protection, and communication interfaces.
- Acquire knowledge on estimating battery state of charge (SOC) and state of health (SOH), understand the aging process of lithium-ion batteries, and study methods for cell balancing.
- Gain proficiency in creating and using equivalent-circuit models (ECMs) and physics-based models (PBMs) for simulating electric vehicles and battery packs under various conditions.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Interpret the role of battery management system K2
- Identify the requirements of Battery Management System K2
- Make use of different methods to know about SOC, SOH and cell balancing of batteries K3
- Develop the model of battery packs and electric vehicles K3
- Design an efficient battery management system K3

**UNIT INTRODUCTION 9**

Introduction to Battery Management System – Cells and Batteries – Nominal voltage and capacity – C rate – Energy and power – Cells connected in series – Cells connected in parallel – Electrochemical and lithium-ion cells – Rechargeable cell – Charging and Discharging Process – Overcharge and Undercharge – Modes of Charging.

**UNIT II BATTERY MANAGEMENT SYSTEM REQUIREMENT 9**

Introduction and BMS functionality – Battery pack topology – BMS Functionality – Voltage Sensing – Temperature Sensing – Current Sensing – BMS Functionality – High-voltage contactor control – Isolation sensing – Thermal control – Protection – Communication Interface – Range estimation – State-of charge estimation – Cell total energy and cell total power.

**UNIT III BATTERY STATE OF CHARGE AND STATE OF HEALTH ESTIMATION, CELL BALANCING 9**

Battery state of charge estimation (SOC) – voltage-based methods to estimate SOC – Model based state estimation – Battery Health Estimation – Lithium-ion aging – Negative electrode – Lithium ion aging – Positive electrode – Cell Balancing – Causes of imbalance – Circuits for balancing.

**UNIT IV MODELLING AND SIMULATION 9**

Equivalent circuit models (ECMs) – Physics based models (PBMs) – Empirical modelling approach – Simulating an electric vehicle – Vehicle range calculations – Simulating constant power and voltage – Simulating battery packs.

**UNIT V DESIGN OF BATTERY BMS** **9**

Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system

. **TOTAL: 45**

**TEXT BOOKS:**


1. Henk Jan Bergveld, Willy M.C. Sansen, Hugo J. Bakker, "Battery Management Systems: Design by Modelling", Springer, 2017.
2. H.J. Bergveld, W.M.C. Sansen, H.J. Bakker, "Battery Management Systems: Accurate State-of-Charge Indication for Battery-Powered Applications", Springer, 2008.


**REFERENCES:**


1. D. A. Howey, "Battery Management Systems for Large Lithium-Ion Battery Packs", Artech House, 2010.
2. D.A. Corrigan, J. Gu, X. Zhang, "Lithium-Ion Batteries: Fundamentals and Applications", CRC Press, 2014.
3. Henk Jan Bergveld, Willy M.C. Sansen, Hugo J. Bakker, "Battery Management Systems: Design by Modelling", Springer, 2017.
4. D.A. Corrigan, J. Gu, X. Zhang, "Lithium-Ion Batteries: Fundamentals and Applications", CRC Press, 2014.


**WEB URLs:**

1. https://www.renesas.com/us/en/document/whp/battery-management-system-tutorial
2. https://in.mathworks.com/discovery/battery-state-of-charge.html
3. https://pureadmin.qub.ac.uk/ws/files/288308512/ALL_21_TIE_1545.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | 1 | 1 | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | 1 | 1 | - |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 1 | 1 |
| **Average** | **2.6** | **1.6** | **1** | - | - | - | - | **1** | - | - | - | **1** | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

## VERTICAL IV - AUTOMATION AND CONTROL

**B.E. Electrical and Electronics Engineering** **2024-2025**

**SEMESTER – X**

**24BEEEXXX PROCESS MODELLING AND SIMULATION 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks:** Internal**: 40 External:60 Total:100**

**End Semester Exam:**3Hours

**PRE-REQUISITE:** Control Systems

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- understand the important of mathematical models for industrial processes.
- Students with different forms of mathematical models.
- Develop and simulate mathematical models for different industrial processes.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the different types of models for industrial processes. K2
- Build the mathematical models of distributed processes. K3
- Implement the mathematical models of industrial processes using relevant software. K3
- Perform analysis and subsequent conclusion for the developed models of processes K3
- Examine the graphical response of developed mathematical models. K3

**UNIT I GENERAL PRINCIPLES OF MODELLING 9**

Introduction to mathematical modeling – Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes – Classification of models – Linear vs Nonlinear – Lumped parameter vs. Distributed parameter – Static vs. Dynamic – Continuous vs. Discrete – Numerical Methods: Iterative convergence methods – Numerical integration of ODE – IVP and ODEBVP.

**UNIT II MODELLING OF DISTRIBUTED PROCESSES 9**

Steady state models giving rise to differential algebraic equation (DAE) systems – Rate based Approaches for staged processes – Modeling of differential contactors – distributed parameter models of packed beds – Packed bed reactors – Modeling of reactive separation processes – Review of solution strategies for Differential Algebraic Equations (DAEs) – Partial Differential Equations (PDEs) and available numerical software libraries.

**UNIT III INTRODUCTION TO PROCESS MODELLING 9**

Concept of degree of freedom analysis – System and its subsystem – System interaction – Degree of freedom in a system e.g. Heat exchanger – Equilibrium still – Reversal of information flow – Design variable selection algorithm – Information flow through subsystems – Structural effects of design variable selection – Persistent Recycle.

**UNIT IV MODELLING OF INDUSTRIAL PROCESSES 9**

Simple process models – Models giving rise to nonlinear algebraic equation (NAE) systems – steady state models of flash vessels – equilibrium staged processes distillation columns – absorbers – strippers – CSTR – heat exchangers – Review of solution procedures and available numerical software libraries.

**UNIT V SIMULATION OF MATHEMATICAL MODELLING 9**

Simulation and their approaches – Modular – Sequential – Simultaneous and Equation solving approach – Simulation softwares and their applications – Review of solution techniques and available numerical software libraries – Case Studies.

**TOTAL: 45**

**TEXT BOOKS:**

1. Bequette. B W, "Process Control Modeling, Design and Simulation", 2nd Edition, Prentice Hall of India, 2004.
2. Stephanopoulos G, "Chemical Process Control – An Introduction to Theory and Practice", 2nd Edition, Prentice Hall of India, 2004.

**REFERENCES:**

1. Eckman D P, "Automatic Process control", 3rd Edition, John Wiley, 2008.
2. Curtis D Johnson, "Process Control Instrumentation Technology", 3rd Edition, Pearson, 2010.
3. A. K. Jana, "Chemical Process Modelling and Computer Simulation", 1st Edition, Prentice Hall of India, 2011.

**WEB URLs:**

1. https://archive.nptel.ac.in/courses/103/107/103107096/
2. https://nptel.ac.in/courses/103101111https://nptel.ac.in/courses/111107105
3. https://www.academia.edu/37228967/Process_Modeling_Simulation_and_Control_for_Chemical_Engineers

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO2** | 2 | 1 | - | - | 1 | - | - | 1 | - | - | - | - | 1 | - |
| **CO3** | 3 | 2 | 1 | - | 1 | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO4** | 3 | 2 | 1 | - | 1 | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 3 | 2 | - | - | 1 | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.6** | **1.6** | **1** | - | **1** | - | - | **1** | - | - | - | - | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER -X**

**24BEEEXXX COMPUTER CONTROL OF PROCESSES 3H-3C**

**Instruction Hours /week:L:3 T:0 P:0** **Marks: Internal:40** External**:60** Total**:100**
**End Semester Exam:**3Hours

**PRE-REQUISITE:** Control Systems

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Introduce about the computer controlled systems in process industries and direct discrete design techniques.
- Have an adequate knowledge about the design of various digital controller and discrete time systems in state variable form.
- Design controllers for multi-loop and multivariable systems

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the mathematical models of discrete time systems using state variable techniques and study the stability of the systems. K2
- Build multi-loop controller and multivariable controller for multi-variable systems. K3
- Examine the different digital controllers to satisfy the required criterion. K3
- Construct models from input-output data by least square and recursive least square method. K3
- Evaluate multivariable dynamic matrix controller for industrial processes. K4

**UNIT I DISCRETE STATE-VARIABLE TECHNIQUE 9**

State equation of discrete data system with sample and hold – State transition equation – Methods of computing the state transition matrix – Decomposition of discrete data transfer functions – State diagrams of discrete data systems – System with zero-order hold – Controllability and observability of linear time invariant discrete data system –Stability tests of discrete data system.

**UNIT II SYSTEM IDENTIFICATION 9**

Identification of Non Parametric Input Output Models: Transient analysis – Frequency analysis – Correlation analysis – Spectral analysis – Identification of Parametric Input Output Models: Least Squares Method – Recursive Least Square Method.

**UNIT III DIGITAL CONTROLLER DESIGN 9**

Review of z transform – Modified of z transform – Pulse transfer function – Digital PID controller – Dead-beat controller and Dahlin's controller – Kalman's algorithm – Pole Placement Controller

**UNIT IV MULTI-LOOP REGULATORY CONTROL 9**

Introduction – Process Interaction – Pairing of Inputs and Outputs – The Relative Gain Array (RGA) – Properties and Application of RGA – Multi loop PID Controller – Biggest Log Modulus Tuning Method – De-coupler.

**UNIT V MULTIVARIABLE REGULATORY CONTROL 9**

Introduction to Multivariable control – Multivariable PID Controller – Multivariable Dynamic Matrix Controller – Case Studies: Distillation Column – CSTR and Four-tank system.

**TOTAL: 45**

**TEXT BOOKS:**

1. Stephanopoulos, G., "Chemical Process Control -An Introduction to Theory and Practice", 1st Edition, Prentice Hall of India, 2015.
2. Sigurd Skogestad, Ian Postlethwaite, "Multivariable Feedback Control: Analysis and Design", 2nd Edition, John Wiley and Sons, 2005.

**REFERENCES:**

1. Thomas E. Marlin, "Process Control – Designing Processes and Control systems for Dynamic" Performance, 2nd Edition , McGraw Hill, 2000.
2. Gopal, M., "Digital Control and State Variable Methods", 4th Edition, Tata McGraw Hill, 2017.
3. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, "Process Dynamics and Control", 4th Edition, Wiley John and Sons, 2016.

**Web URL's:**

1. https://nptel.ac.in/courses/103104050
2. https://www.mathworks.com/matlabcentral/mlcdownloads/downloads/submissions/10816/versions/1/previews/Mimotools/rga.m/index.html
3. https://in.mathworks.com/help/ident/

**CO, PO, PSO MAPPING:**

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - |
| **CO2** | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **Average** | **2.6** | **1.6** | **1** | - | - | - | - | **1** | - | - | - | - | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER – X**

**24BEEEXXX NON - LINEAR CONTROL 3H-3C**

**Instruction Hours /week: L:3 T:0 P:0** **Marks: Internal:40** External**:60** Total**:100**
**End Semester Exam:**3Hours

**PRE-REQUISITE:** Control Systems

**COURSE OBJECTIVES:**
The goal of this course is for students to:

- Provide knowledge on design in state variable form and phase plane analysis
- Give basic knowledge in describing function analysis.
- Study the design of optimal controller and optimal estimator including Kalman Filter

**COURSE OUTCOMES:**
Upon completion of this course, the student will be able to:

- Understand the basics and Importance of Kalman filter K2
- Apply the knowledge gained on state feedback control and nonlinear control K3
- Infer advanced control theory to practical engineering problems K3
- Develop the analysis for common nonlinearities in a system K3
- Design and analyze optimal controller for non-linear systems. K4

**UNIT I STATE VARIABLE DESIGN 9**
Introduction to state Model – effect of state Feedback – Necessary and Sufficient Condition for Arbitrary Pole placement – Pole placement Design – Design of state Observers – Separation principle – Servo design – State Feedback with integral control.

**UNIT II PHASE PLANE ANALYSIS 9**
Features of linear and non-linear systems – Common physical non-linearities – Methods of linearization – Concept of phase portraits – Singular points – Limit cycles – Construction of phase portraits – Phase plane analysis of linear and non-linear systems – Isocline method.

**UNIT III DESCRIBING FUNCTION ANALYSIS 9**
Basic concepts – Derivation of describing functions for common non-linearities – Describing function analysis of non-linear systems – Limit cycles – Stability of oscillations.

**UNIT IV OPTIMAL CONTROL 9**
Introduction – Time varying optimal control – LQR steady state optimal control – Solution of Ricatti's equation – Application examples.

**UNIT V OPTIMAL ESTIMATION 9**
Optimal estimation – Kalman Bucy Filter – Solution by duality principle – Discrete systems Kalman Filter – Application examples.

**TOTAL: 45**

**TEXT BOOKS:**

1. M.Gopal, "Modern Control System Theory", 4th Edition, New Age International Publishers, 2022.
2. K. P. Mohandas, "Modern Control Engineering", 1st Edition, Sanguine Technical Publishers, 2008.

**REFERENCES:**

1. Ashish Tewari, "Modern Control Design with Matlab and Simulink", 1st Edition John Wiley, New Delhi, 2002.
2. K. Ogata, "Modern Control Engineering", 5th Edition, PHI, New Delhi, 2009.
3. D.S.Naidu, "Optimal Control Systems" 1st Edition, CRC Press, 2009.

**WEB URL'S:**

1. https://in.mathworks.com/discovery/kalman-filter.html
2. https://onlinecourses.nptel.ac.in/noc22_ee24/preview
3. http://www.nitttrc.edu.in/nptel/courses/video/101108047/lec22.pdf

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - |
| **CO2** | 2 | 1 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | 1 | 1 |
| **Average** | **2.6** | **1.6** | **1** | - | - | - | - | **1** | - | - | - | - | **1** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER – X**

**24BEEEXXX MACHINE MONITORING SYSTEM 3H-3C**

**Instruction Hours/week: L:3 T:0 P:0** **Marks:** Internal**:40** External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Control Systems

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Make the students familiarize with the concept of condition-based maintenance for effective utilization of machines.
- Impart the knowledge of artificial intelligence for machinery fault diagnosis.
- Give basic knowledge on vibration monitoring and machinery vibrations using signal processing techniques.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Classify the faults in machinery. K2
- Choose the proper maintenance strategies and condition monitoring techniques for identification of failure in a machine. K3
- Construct a classifier model for machine learning based fault diagnosis. K3
- Predict the faulty component in a machine by analyzing the acquired vibration signals. K3
- Build a model using machine learning. K3

**UNIT I INTRODUCTION TO MACHINE CONDITION MONITORING 9**

Machinery condition monitoring - Present status - Fault prognosis - Future needs.

**UNIT II MACHINERY MAINTENANCE 9**

Maintenance strategies – Reactive, Preventive, and Predictive – Benefits of planned maintenance – Bath tub curve – Failure Modes Effects and Criticality Analysis (FMECA).

**UNIT III INTRODUCTION TO MACHINERY VIBRATION AND MONITORING 9**

Characteristics of Vibration systems – Mode shapes & operational deflection shapes – Experimental modal analysis – Principles of vibration monitoring – Machinery faults diagnosed by vibration analysis.

**UNIT IV SIGNAL PROCESSING IN MACHINERY MONITORING 9**

FFT analysis – Time domain analysis – Time-frequency analysis – Signal filtering – Cepstrum analysis – Health condition of compressor & engine.

**UNIT V MACHINE LEARNING FOR CONDITION MONITORING 9**

Machine Learning: Feature extraction and feature selection methods – Feature reduction – Classification techniques – Case studies of condition monitoring in nuclear plant components – Distillation column.

**TOTAL: 45**

**TEXT BOOKS:**

1. Cornelius Scheffer and Paresh Girdhar, "Practical Machinery Vibration Analysis and Predictive Maintenance", 1st Edition, Elsevier, 2004.
2. R. Mohanty, "Machinery Condition Monitoring: Principles and Practices", 1st Edition, CRC Press, Taylor & Francis, 2017.

**REFERENCES:**

1. Stephen Marsland, "Machine Learning: An Algorithmic Perspective", 2nd Edition, CRC Press, 2014.
2. Davies, "Handbook of Condition Monitoring – Techniques and Methodology", 1st Edition, Springer, 2011.
3. Ferdinand van der Heijden, Robert Duin, Dick de Ridder, David M. J. Tax, "Classification, Parameter Estimation and State Estimation: An Engineering Approach Using MATLAB", 2nd Edition, John Wiley & Sons, 2017.

**WEB URLs:**

1. https://onlinecourses.nptel.ac.in/noc22_cs29/preview 2
2. https://www.udemy.com/topic/maintenance-management/ 3
3. https://www.vi-institute.org/analyst-categories/ 4

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **Average** | **2.6** | **1.6** | **1** | - | - | - | - | **1** | - | - | - | - | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER - X**

**24BEEEXXX** **ROBOTICS AND AUTOMATION** **3H- 3C**

**Instruction Hours/week: L: 3 T: 0 P: 0** **Marks:** Internal**:40**External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Control Systems

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand robotics, encompassing components, applications, and system integration.
- Explore sensor, energy, and vision technologies in robot enhancement.
- Study the concepts of kinematics principles and gripper selection in robotic design.

**COURSE OUTCOME:**

Upon completion of this course, the student will be able to:

- Understand the parts and working of robots and functions of various sensors in robots. K2
- Identify the kinematic equations for a given robot configuration K3
- Apply the concepts of machine vision for various processes K3
- Design and develop manipulators for simple tasks K3
- Select actuators and sensors for specified tasks K3

**UNIT I INTRODUCTION 9**

Definition and origin of robotics – Rules and laws of robotics – Basic elements of robot system – Basic movements and Joints of a robot – Robot anatomy – Degree of freedom – Work volume – Classification of robots by configuration and control – Industrial automation – Types.

**UNIT II ROBOTIC VISION 9**

Power sources – Hydraulic, pneumatic and electric drives – Position, velocity, touch, and force sensors – Fiber optic and tactile sensors – Machine vision – Components of vision system – Function of machine vision system – Lighting techniques – Image processing and analysis – Segmentation – Object recognition.

**UNIT III FORWARD AND INVERSE KINEMATICS 9**

Introduction to manipulator kinematics – Forward and inverse kinematics – Forward and reverse kinematics transformation of two degrees of freedom robot – Robot dynamics – Properties of robot dynamic equations.

**UNIT IV END EFFECTORS 9**

Construction of manipulators – Electronic and pneumatic manipulator control circuits – End effectors – Design considerations – Grippers – Types – Selection of grippers.

**UNIT V ROBOTIC PROGRAMMING 9**

Methods of programming – Lead through programming – Motion interpolation – WAIT, SIGNAL and Delay commands – Pick and place application of a robot using VAL programming – Industrial applications of robots in material handling, assembly and inspection.

**TOTAL: 45**

**TEXT BOOKS:**

1. Mikell P, Weiss G M, Nagel R N "Industrial Robotics", 2nd Edition, McGraw Hill Education; 2017.
2. Mikell P Groover, "Industrial Robotics: Technology Programming and Applications", 1st Edition, Tata McGraw Hill, 2012.

**REFERENCES:**

1. Mark W Spong and Seth Hutchinson, "Robot Modeling and Control", 1st Edition, Wiley, 2014.
2. Bhaskar Kumar Ghosh, Ning Xi, Tzyh-Jong Tarn, "Control in Robotics and Automation: Sensor Based Integration", 1st Edition, Academic Press, 1999.
3. Deb S R and Deb S, "Robotics technology and flexible Automation", 2nd Edition, Tata McGraw Hill Education Pvt. Ltd. 2010.

**WEB URLs:**

1. https://kaska-robotics.com/
2. https://www.science.org/journal/scirobotics
3. https://nptel.ac.in/courses/112101099

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **Average** | **2.6** | **1.6** | **1** | - | - | - | - | **1** | - | - | - | - | - | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER -X**

**24BEEEXXX** **INDUSTRIAL INTERNET OF THINGS** **3H- 3C**

**Instruction Hours/week: L: 3 T: 0 P: 0** **Marks:** Internal**:40**External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Embedded systems and IoT

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Introduce various design aspects of IoT, its communication models and its general architecture
- Study the various wireless communication technologies used in IoT.
- Know the need of Data analytics and Cloud computing for IoT.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the basic concepts and architectures of Internet of Things. K2
- Comprehend various IoT Layers and their relative importance. K2
- Identify the importance of Data Analytics in IoT. K3
- Build next-gen cloud infrastructure for IoT and security. K3
- Implement the concepts of design thinking in real cased studies. K3

**UNIT I INTRODUCTION AND ARCHITECTURE OF IoT** **9**

Introduction – Definition and characteristics of IoT – Physical and Logical Design of IoT – Communication models and APIs – Challenges in IoT – Evolution of IoT– Components of IoT – A Simplified IoT Architecture – Core IoT Functional Stack.

**UNIT II INDUSTRIAL IoT** **9**

Introduction to IIoT – Industrial IoT: Business Model and Reference Architecture: IIoT – Business Models, Industrial IoT – Layers: IIoT Sensing – IIoT Processing – IIoT Communication – IIoT Networking.

**UNIT III IIOT ANALYTICS** **9**

Big Data Analytics and Software Defined Networks – Machine Learning and Data Science – Julia Programming – Data Management with Hadoop

**UNIT IV IOT SECURITY** **9**

Industrial IoT: Security and Fog Computing – Cloud Computing in IIoT – Fog Computing in IIoT– Security in IIoT

**UNIT V CASE STUDY** **9**

Industrial IOT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies: Milk Processing and Packaging Industries, Manufacturing Industries.

**TOTAL: 45**

**TEXT BOOKS:**

1. S. Misra, A. Mukherjee, and A. Roy, “Introduction to IoT”. Cambridge University Press. 2020.
2. S. Misra, C. Roy, and A. Mukherjee, “Introduction to Industrial Internet of Things and Industry 4.0”. CRC Press.2020.

**REFERENCES:**

1. Oliver Hersent, David Boswarthichk and Omar Elloumi, “The Internet of Things – Key Applications and Protocols”, 1st Edition, John Wiley, 2012.
2. Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat “Industrial Internet of Things: Cyber Manufacturing Systems”, Springer International Publishing AG, 2017.
3. Pethuru Raj and Anupama C Raman, “The Internet of Things: Enabling Technologies, Platforms, and Use Cases”, 1st Edition, CRC Press, 2017.

**WEB URLs:**

1. https://www.csc2.ncsu.edu/faculty/mpsingh/tutorials/IoT/
2. https://www.codeproject.com/Learn/IoT/
3. https://onlinecourses.nptel.ac.in/noc20_cs69/preview

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - |
| **CO2** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | - | - |
| **CO3** | 3 | 2 | - | - | - | - | - | 1 | - | - | - | - | - | - |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 2 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 2 |
| **Average** | 2.6 | 1.6 | 1 | - | - | - | - | 1 | - | - | - | - | - | 2 |

**1 - Low, 2 - Medium, 3 - High, ‘-' - No Correlation**

**SEMESTER -X**

| **24BEEEXXX** | **PLC AND SCADA** | **3H- 3C** |
|---|---|---|
| **Instruction Hours/week: L: 3 T: 0 P: 0** | | **Marks:** Internal**:40**External**:60** Total**:100** |
| | | **End Semester Exam:**3 Hours |

**PRE-REQUISITE:** Control Systems

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Explain the components of Programmable Logic Controllers (PLC).
- Explain the various programming instructions for PLC.
- Impart knowledge on architecture of SCADA and project components.

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the concepts of Programmable Logic Controllers and SCADA. K2
- Develop PLC using various programming languages and instructions. K3
- Make use of industrial automation using PLC and SCADA. K3
- Identify the history, components, architecture, and protocols of SCADA systems and their importance in industrial applications. K3
- Implement SCADA in power systems and process control, utilizing closed loop, cascade, and feed forward control to manage process dead time. K3

**UNIT I INTRODUCTION TO PROGRAMMABLE LOGIC CONTROLLER 9**

Evolution of PLCs – Basic Operation – Components of PLC Architecture – Advantages of PLC panel – Concepts of inputs and outputs – Scan time of PLC - Selection criteria for PLC – Maintenance and trouble shooting of PLC.

**UNIT II PLC PROGRAMMING – I 9**

PLC Programming languages – Relay logic – Ladder programming – Functional block diagram – Instruction list, structured text – Timer and Counters – Functions – Types and programming – Advanced instructions in PLC – Applications of PLCs

**UNIT III PLC PROGRAMMING – II 9**

Program control instructions – Math instructions – Sequencer instructions and shift registers – NO NC Concept – Data file handling – Requirement of communication networks for PLC, PLC to PC Communication to computer – FBD equivalent to LL – FBD Programming - IL- SFC-ST

**UNIT IV SCADA 9**

History of SCADA – Elements of SCADA system – Need for SCADA system – General definition and SCADA components – Hardware and software architecture –SCADA protocols.

**UNIT V APPLICATIONS OF SCADA** **9**

SCADA in power system – Modeling of SCADA in power generation, power distribution and power grid – SCADA in process control – Control modes in closed loop control – Cascade control – Feed forward control – Automatic feed forward control – Overcoming process dead time.

**TOTAL: 45**

**TEXT BOOKS:**

1. William Bolton, "Programmable Logic Controllers", 6th Edition, Elsevier, 2015.
2. Robert Radvanovsky and Jacob Brodsky, "Handbook of SCADA/Control Systems Security", 2nd Edition, CRC Press 2016.

**REFERENCES:**

1. F.D. Petruzella, "Programmable Logic Controllers", 3rd Edition, Tata Mc-Graw Hill, 2010.
2. Nancy Fichtman Dana and Diane Yendol–Hoppey, "The PLC Book", 1st Edition, Corwin Press 2015.
3. Stuart G McCrady, "Designing SCADA application software: A practical approach", 1st Edition, Elsevier 2013

**WEB URLs:**

1. https://learn.automationcommunity.com/
2. https://electricalsphere.com/scada-automation-system-in-electrical-substation-and-power-system/amp/
3. https://inductiveautomation.com/resources/article/what-is-scada

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | - | - | - | - | - | 1 | - | - | - | 1 | 2 | - |
| **CO2** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **CO4** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **CO5** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 1 |
| **Average** | 2.6 | 1.6 | 1 | - | - | - | - | 1 | - | - | - | 1 | 2 | 1 |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**

**SEMESTER -X**

**24BEEEXXX** **MODEL BASED CONTROL** **3H- 3C**

**Instruction Hours/week: L: 3 T: 0 P: 0** **Marks:** Internal**:40**External**:60** Total**:100**

**End Semester Exam:**3 Hours

**PRE-REQUISITE:** Control systems

**COURSE OBJECTIVES:**

The goal of this course is for students to:

- Understand the Model predictive control schemes and its elements.
- Make the student understand the principles of STR, MRAC and Gain scheduling.
- Make the student design simple adaptive controllers for linear systems

**COURSE OUTCOMES:**

Upon completion of this course, the student will be able to:

- Understand the control schemes on MIMO systems. K2
- Design controller for MIMO system. K3
- Illustrate the control schemes in industries K2
- Design adaptive controllers for practical engineering problems K3
- Choose suitable controllers for the given problems K3

**UNIT I INTRODUCTION TO MIMO CONTROL 9**

Introduction to MIMO Systems – Multivariable control – Multiloop Control – Multivariable IMC – IMCPID – Case studies

**UNIT II MODEL PREDICTIVE CONTROL SCHEMES 9**

Introduction to Model Predictive Control – Model Predictive Control Elements – Generalized Predictive Control Scheme – Multivariable Generalized Predictive Control Scheme – Multiple Model based Model Predictive Control Scheme Case Studies.

**UNIT III STATE SPACE BASED MODEL PREDICTIVE CONTROL SCHEMES 9**

Introduction – Review of Kalman Update based filters – State Observer Based Model Predictive Control Schemes – Case Studies

**UNIT IV CONSTRAINED MODEL PREDICTIVE CONTROL SCHEMES 9**

Constraints Handling: Amplitude Constraints and Rate Constraints – Constraints and Optimization – Constrained Model Predictive Control Scheme – Case Studies.

**UNIT V ADAPTIVE CONTROL SCHEMES 9**

Introduction – Gain Scheduling – Self tuning regulators – MARS – Adaptive Model Predictive Control Scheme –Case Studies

**TOTAL: 45**

**TEXT BOOKS:**

1. Coleman Brosilow, Babu Joseph, "Techniques of Model-Based Control", 1st Edition, Prentice Hall PTR Pub 2002.
2. E. F. Camacho, C. Bordons,"Model Predictive Control" , 2nd Edition, Springer-Verlag London Limited 2007.
3. K.J. Astrom and B. J. Wittenmark, "Adaptive Control", Second Edition, 2nd Edition, Pearson Education, 2013.

**REFERENCES:**

1. Paul Serban Agachi, Zoltan K. Nagy, Mircea Vasile Cristea, and Arpad Imre-Lucaci, "Model Based Control Case Studies in Process Engineering", 1st Edition, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2007.
2. Ridong Zhang, Anke Xue Furong Gao,"Model Predictive Control Approaches Based on the Extended State Space Model and Extended Non-minimal State Space Model", 1st Edition, Springer Nature, Singapore, 2019.
3. J.A. Rossiter "Model-Based Predictive Control A Practical Approach", 1st Edition, Taylor & Francis eLibrary, 2005.

**WEB URLs:**

1. https://nptel.ac.in/courses/103103037
2. https://onlinecourses.nptel.ac.in/noc21_ge01/preview
3. https://nptel.ac.in/courses/127106225

**CO, PO, PSO MAPPING:**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | - | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO2** | 2 | 1 | 1 | 1 | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO3** | 3 | 2 | 1 | - | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO4** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | - | 1 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | 1 | - | - | - | - | - | 1 |
| **Average** | **2.6** | **1.6** | **1** | 1 | **-** | **-** | **-** | 1 | **-** | **-** | **-** | **-** | **-** | **1** |

**1 - Low, 2 - Medium, 3 - High, '-' - No Correlation**