# SYLLABUS
# FOR
# BACHELOR OF TECHNOLOGY
# IN
# ELECTRICAL ENGINEERING

## Semester III to Semester VIII


**DEPARTMENT OF ELECTRICAL ENGINEERING**
**UNIVERSITY OF KASHMIR**
**SRINAGAR**


**JULY – 2025**

**(Applicable to Batch 2025 & Onwards)**

# B.Tech. in Electrical Engineering

## Programme Learning Outcomes (PLOs)

**1. Engineering Knowledge:** Apply knowledge of mathematics, science, and electrical engineering fundamentals to solve complex problems in power, control, and energy systems.

**2. Problem Analysis:** Identify and analyze electrical engineering problems using principles of circuit theory, electronics, power systems, and electromagnetic fields.

**3. Design/Development of Solutions:** Design electrical systems and components such as control circuits, machines, and energy systems considering safety, environment, and economic constraints.

**4. Investigation of Complex Problems:** Conduct experiments and investigations to analyze performance characteristics of electrical systems and interpret results using modern methods.

**5. Modern Tool Usage:** Use modern engineering tools such as Python, MATLAB, PSpice, PLCs, SCADA, and simulation software to model and analyze electrical systems.

**6. The Engineer and Society:** Apply contextual knowledge to assess social, health, legal, and cultural issues relevant to electrical system deployment and use.

**7. Environment and Sustainability:** Understand the impact of electrical engineering solutions in environmental and societal contexts and promote sustainable practices.

**8. Ethics:** Apply ethical principles and commit to professional responsibilities in electrical engineering practice.

**9. Individual and Team Work:** Function effectively as an individual and as a team member or leader in multidisciplinary environments.

**10. Communication:** Communicate effectively through technical reports, documentation, presentations, and drawings.

**11. Project Management and Finance:** Apply engineering and management principles for planning and executing electrical engineering projects within budget and time constraints.

**12. Innovation, Entrepreneurship and Life-long Learning:** Exhibit an innovative mindset and entrepreneurial skills for technology development or engage in lifelong learning to adapt to technological changes in electrical engineering and energy systems.

## Accreditation Alignment

- The program is designed in accordance with NEP, AICTE, and NBA guidelines.
- Programme Learning Outcomes (POs) align with Washington Accord Competencies for Engineering Graduates.
- Courses incorporate UPSC and GATE syllabus alignment for research and higher education opportunities.

## Course Code Formula

| Position | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Indicator | B | E | L | E | – | – | – | – | 2 | 5 |

*Example — BELECNA325 = Network Analysis, Semester III, Batch 2025*

### Digit Description

| Digit | Description |
|---|---|
| 1 | Bachelor's Programme |
| 2-4 | Programme Code: Electrical Engineering = ELE |
| 5 | Indicator Alphabet in Course Code |
| 6-7 | Course Title |
| 8 | Semester (1 to 8) |
| 9-10 | Year of Launch |

### Indicator Alphabet

| Indicator Alphabet | Description |
|---|---|
| H | Humanities & Social Science Course |
| B | Basic Science Course |
| E | Engineering Science Course |
| C | Programme Core Course |
| D | Programme Elective Course |
| O | Open Elective Course |
| L | Laboratory Course |
| P | Project/Internship |
| Y | Seminar |
| A | Audit Course |

### Examination Code

| Examination Code | Description |
|---|---|
| MSE | Mid Semester Evaluation |
| IA | Internal Assessment |
| CIE | Continuous Internal Evaluation = MSE + IA |
| SEE | Semester End Evaluation |

## Examination Pattern

### Semester-end Examination (SEE)

| Section | No of questions | Marks | Sectional Marks |
|---|---|---|---|
| A | 10 | 1 | 10 |
| B | 5 | 4 | 20 |
| C | 2 out of 5 (1 from each unit) | 10 | 20 |
| **Total** | | | **50** |

### Mid-term (MSE)

| Section | No of questions | Marks | Sectional Marks |
|---|---|---|---|
| A | 10 | 1 | 10 |
| B | 3 | 5 | 15 |
| C | 1 out of 2 (from unit 1 & 2) | 10 | 10 |
| **Total** | | | **35** |

## SCHOOL OF ENGINEERING, UNIVERSITY OF KASHMIR

## Course Structure of B.Tech. Programme in Electrical Engineering (Semester III – VIII)

| S.No | Course Code | Category | Course Title | L | T | P | Total | Credits |
|---|---|---|---|---|---|---|---|---|
| **Semester III** | | | | | | | | |
| 1 | BELEBMT325 | Basic Science Course | Engineering Mathematics–III | 2 | 1 | 0 | 3 | 3 |
| 2 | BELECNA325 | Professional Core Course | Network Analysis | 2 | 1 | 2 | 5 | 4 |
| 3 | BELECAC325 | Professional Core Course | Analog Electronic Circuits | 2 | 1 | 2 | 5 | 4 |
| 4 | BELECSS325 | Professional Core Course | Signals and Systems | 2 | 1 | 0 | 3 | 3 |
| 5 | BELECEM325 | Professional Core Course | Electrical Machines–I | 2 | 1 | 2 | 5 | 4 |
| 6 | BELELMX325 | Laboratory Course | Introduction to Matrix Programming | 1 | 0 | 2 | 3 | 2 |
| **TOTAL** | | | | **11** | **5** | **8** | **24** | **20** |
| **Semester IV** | | | | | | | | |
| 1 | BELECDE425 | Professional Core Course | Digital Electronics | 2 | 1 | 2 | 5 | 4 |
| 2 | BELECCS425 | Professional Core Course | Control Systems | 2 | 1 | 2 | 5 | 4 |
| 3 | BELECME425 | Professional Core Course | Electrical Measurement | 2 | 1 | 2 | 5 | 4 |
| 4 | BELECNC425 | Professional Core Course | Non Conventional Energy Sources | 1 | 1 | 0 | 2 | 2 |
| 5 | BELECEM425 | Professional Core Course | Electrical Machines–II | 2 | 1 | 2 | 5 | 4 |
| 6 | BELELPY425 | Laboratory Course | Introduction to Python | 1 | 0 | 2 | 3 | 2 |
| **TOTAL** | | | | **10** | **5** | **10** | **25** | **20** |
| **Semester V** | | | | | | | | |
| 1 | BELECPS525 | Professional Core Course | Power Systems – I | 2 | 1 | 2 | 5 | 4 |
| 2 | BELECPE525 | Professional Core Course | Power Electronics | 2 | 1 | 2 | 5 | 4 |
| 3 | BELECPP525 | Professional Core Course | Power Station Practices | 2 | 1 | 0 | 3 | 3 |
| 4 | BELECED525 | Professional Core Course | Electric Drives & Control | 2 | 1 | 2 | 5 | 4 |
| 5 | BELEEMC525 | Professional Core Course | Microprocessors | 2 | 1 | 2 | 5 | 4 |
| 6 | BELEPIT525 | Internship | Industrial Training | 0 | 0 | 2 | 2 | 1 |
| **TOTAL** | | | | **10** | **5** | **10** | **25** | **20** |
| **Semester VI** | | | | | | | | |
| 1 | BELECPS625 | Professional Core Course | Power Systems – II | 2 | 1 | 2 | 5 | 4 |
| 2 | BELECPG625 | Professional Core Course | Power System Protection & Switchgear | 2 | 1 | 2 | 5 | 4 |
| 3 | BELECAE625 | Professional Core Course | Advanced Power Electronics | 2 | 1 | 2 | 5 | 4 |
| 4 | BELED**625 | Professional Elective Course | Professional Elective – I | 2 | 1 | 0 | 3 | 3 |
| 5 | BELEO**625 | Open Elective Course | Open Elective - I | 1 | 1 | 0 | 2 | 2 |
| 6 | BELELES625 | Laboratory Course | Embedded Systems | 1 | 1 | 2 | 4 | 3 |
| **TOTAL** | | | | **10** | **6** | **8** | **24** | **20** |
| **Semester VII** | | | | | | | | |
| 1 | BELECPA725 | Professional Core Course | Power System Analysis | 2 | 1 | 2 | 5 | 4 |
| 2 | BELECEV725 | Professional Core Course | Electric Vehicles | 2 | 1 | 2 | 5 | 4 |
| 3 | BELEDSC725 | Professional Core Course | SCADA Systems | 2 | 1 | 0 | 3 | 3 |
| 4 | BELED**725 | Professional Elective Course | Professional Elective – II | 2 | 1 | 0 | 3 | 3 |
| 5 | BELEO**725 | Open Elective Course | Open Elective – II | 2 | 1 | 0 | 3 | 3 |
| 6 | BELEPMP725 | Project | Minor Project | 0 | 0 | 6 | 6 | 3 |
| **TOTAL** | | | | **10** | **5** | **10** | **25** | **20** |
| **Semester VIII** | | | | | | | | |
| 1 | BELED**825 | Professional Elective Course | Professional Elective – III | 2 | 1 | 0 | 3 | 3 |
| 2 | BELED**825 | Professional Elective Course | Professional Elective – IV | 2 | 1 | 0 | 3 | 3 |
| 3 | BELEO**825 | Open Elective Course | Open Elective -III | 1 | 1 | 0 | 2 | 2 |
| 4 | BELEPMP825 | Project | Major Project | 0 | 0 | 24 | 24 | 12 |
| **TOTAL** | | | | **5** | **3** | **24** | **32** | **20** |

## List of Professional Electives

| S.No | Elective / Semester | Course Title | Course Code |
|---|---|---|---|
| 1 | **Professional Elective – I** *Semester VI* | Advanced Control Systems | BELEDAC625 |
| 2 | **Professional Elective – I** *Semester VI* | Power Quality | BELEDPQ625 |
| 3 | **Professional Elective – I** *Semester VI* | Design of Photovoltaic Systems | BELEDPV625 |
| 4 | **Professional Elective – I** *Semester VI* | Electrical Machine Design | BELEDMD625 |
| 5 | **Professional Elective – I** *Semester VI* | Electrical Materials | BELEDMA625 |
| 6 | **Professional Elective – II** *Semester VII* | Power Plant Engineering | BELEDPP725 |
| 7 | **Professional Elective – II** *Semester VII* | Optimization for Engineering Design | BELEDOE725 |
| 8 | **Professional Elective – II** *Semester VII* | Energy Storage Systems | BELEDES725 |
| 9 | **Professional Elective – II** *Semester VII* | Special Electrical Machines | BELEDSM725 |
| 10 | **Professional Elective – II** *Semester VII* | High Voltage Engineering | BELEDHV725 |
| 11 | **Professional Elective – III** *Semester VIII* | Smart Grid | BELEDSG825 |
| 12 | **Professional Elective – III** *Semester VIII* | Distribution System Modelling & Analysis | BELEDDM825 |
| 13 | **Professional Elective – III** *Semester VIII* | Microgrids and Distributed Generation | BELEDMG825 |
| 14 | **Professional Elective – III** *Semester VIII* | FACTS | BELEDFS825 |
| 15 | **Professional Elective – III** *Semester VIII* | Optimal Control | BELEDOC825 |
| 16 | **Professional Elective – IV** *Semester VIII* | HVDC Transmission | BELEDHV825 |
| 17 | **Professional Elective – IV** *Semester VIII* | Fuzzy Logic and Neural Networks | BELEDFL825 |
| 18 | **Professional Elective – IV** *Semester VIII* | Restructuring of Power Systems | BELEDRP825 |
| 19 | **Professional Elective – IV** *Semester VIII* | Utilization and Traction | BELEDUT825 |
| 20 | **Professional Elective – IV** *Semester VIII* | Insulation Engineering and Diagnostics | BELEDIE825 |

## List of Open Electives

| S.No | Elective / Semester | Course Title | Course Code |
|---|---|---|---|
| 1 | **Open Elective – I** *Semester VI* | Communication Systems | BELEOCS625 |
| 2 | **Open Elective – I** *Semester VI* | Thermal Engineering | BELEOTE625 |
| 3 | **Open Elective – I** *Semester VI* | Energy Audit and Management | BELEOEA625 |
| 4 | **Open Elective – II** *Semester VII* | Digital Signal Processing | BELEODS725 |
| 5 | **Open Elective – II** *Semester VII* | Energy Management in Buildings | BELEOEB725 |
| 6 | **Open Elective – II** *Semester VII* | Internet of Things for Engineers | BELEOIT725 |
| 7 | **Open Elective – III** *Semester VIII* | Artificial Intelligence Applications in Engineering | BELEOAI825 |
| 8 | **Open Elective – III** *Semester VIII* | Electrical Safety and Energy Conservation | BELEOSC825 |
| 9 | **Open Elective – III** *Semester VIII* | Organisation of Engineering Systems and Human Resource Management | BELEOHR825 |

# Average Course-wise Mapping of Programme Learning Outcomes

## Semester III — Average Course-wise Mapping of Programme Learning Outcomes

| S.No | Course Code | Course Title | Average Programme Learning Outcome (PLO) Score | | | | | | | | | | | | Cum. Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| 1 | BELEBMT325 | Engineering Mathematics–III | 3.0 | 2.8 | 1.6 | 1.2 | 1.2 | 0.2 | 0.4 | 0.0 | 0.4 | 0.8 | 0.2 | 1.4 | **1.10** |
| 2 | BELECNA325 | Network Analysis | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 3 | BELECAC325 | Analog Electronic Circuits | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 4 | BELECSS325 | Signals and Systems | 3.0 | 2.8 | 1.6 | 1.2 | 1.2 | 0.2 | 0.4 | 0.0 | 0.4 | 0.8 | 0.2 | 1.4 | **1.10** |
| 5 | BELECEM325 | Electrical Machines–I | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 6 | BELELMX325 | Introduction to Matrix Programming | 2.2 | 2.0 | 2.2 | 1.8 | 2.6 | 0.2 | 0.4 | 0.0 | 1.2 | 1.0 | 0.4 | 2.0 | **1.33** |
| **Avg PLO** | | | **2.9** | **2.7** | **2.0** | **1.7** | **1.8** | **0.2** | **0.5** | **0.0** | **0.7** | **0.9** | **0.2** | **1.7** | **1.27** |

## Semester IV — Average Course-wise Mapping of Programme Learning Outcomes

| S.No | Course Code | Course Title | Average Programme Learning Outcome (PLO) Score | | | | | | | | | | | | Cum. Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| 1 | BELECDE425 | Digital Electronics | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 2 | BELECCS425 | Control Systems | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 3 | BELECME425 | Electrical Measurement | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 4 | BELECNC425 | Non Conventional Energy Sources | 2.6 | 2.4 | 2.2 | 1.8 | 1.8 | 2.0 | 2.4 | 0.4 | 0.8 | 1.0 | 0.6 | 2.2 | **1.68** |
| 5 | BELECEM425 | Electrical Machines–II | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 6 | BELELPY425 | Introduction to Python | 2.2 | 2.0 | 2.2 | 1.8 | 2.6 | 0.2 | 0.4 | 0.0 | 1.2 | 1.0 | 0.4 | 2.0 | **1.33** |
| **Avg PLO** | | | **2.8** | **2.6** | **2.2** | **1.9** | **2.1** | **0.5** | **0.9** | **0.1** | **0.9** | **1.0** | **0.3** | **1.9** | **1.43** |

## Semester V — Average Course-wise Mapping of Programme Learning Outcomes

| S.No | Course Code | Course Title | Average Programme Learning Outcome (PLO) Score | | | | | | | | | | | | Cum. Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| 1 | BELECPS525 | Power Systems – I | 2.8 | 2.6 | 2.0 | 1.8 | 1.8 | 1.4 | 1.6 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.50** |
| 2 | BELECPE525 | Power Electronics | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 3 | BELECPP525 | Power Station Practices | 2.8 | 2.6 | 2.0 | 1.8 | 1.8 | 1.4 | 1.6 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.50** |
| 4 | BELECED525 | Electric Drives & Control | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 5 | BELEEMC525 | Microprocessors | 2.6 | 2.4 | 2.2 | 2.0 | 2.4 | 0.2 | 0.4 | 0.0 | 1.0 | 1.0 | 0.4 | 2.0 | **1.38** |
| 6 | BELEPIT525 | Industrial Training | 1.4 | 1.4 | 1.6 | 1.8 | 1.4 | 1.6 | 1.0 | 0.8 | 2.4 | 2.2 | 1.6 | 2.0 | **1.60** |
| **Avg PLO** | | | **2.6** | **2.4** | **2.0** | **1.9** | **1.9** | **0.8** | **1.0** | **0.2** | **1.0** | **1.2** | **0.5** | **1.9** | **1.45** |

## Semester VI — Average Course-wise Mapping of Programme Learning Outcomes

| S.No | Course Code | Course Title | Average Programme Learning Outcome (PLO) Score | | | | | | | | | | | | Cum. Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| 1 | BELECPS625 | Power Systems – II | 2.8 | 2.6 | 2.0 | 1.8 | 1.8 | 1.4 | 1.6 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.50** |
| 2 | BELECPG625 | Power System Protection & Switchgear | 2.8 | 2.6 | 2.0 | 1.8 | 1.8 | 1.4 | 1.6 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.50** |
| 3 | BELECAE625 | Advanced Power Electronics | 3.0 | 2.8 | 2.2 | 2.0 | 2.0 | 0.2 | 0.6 | 0.0 | 0.8 | 1.0 | 0.2 | 1.8 | **1.38** |
| 4 | BELED**625 | Professional Elective – I | 2.6 | 2.4 | 1.8 | 1.2 | 1.4 | 0.6 | 0.8 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.23** |
| 5 | BELEO**625 | Open Elective - I | 2.6 | 2.4 | 1.8 | 1.2 | 1.4 | 0.6 | 0.8 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.23** |
| 6 | BELELES625 | Embedded Systems | 2.2 | 2.0 | 2.2 | 1.8 | 2.6 | 0.2 | 0.4 | 0.0 | 1.2 | 1.0 | 0.4 | 2.0 | **1.33** |
| **Avg PLO** | | | **2.7** | **2.5** | **2.0** | **1.6** | **1.8** | **0.7** | **1.0** | **0.1** | **0.7** | **1.0** | **0.4** | **1.8** | **1.36** |

## Semester VII — Average Course-wise Mapping of Programme Learning Outcomes

| S.No | Course Code | Course Title | Average Programme Learning Outcome (PLO) Score | | | | | | | | | | | | Cum. Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| 1 | BELECPA725 | Power System Analysis | 2.8 | 2.6 | 2.0 | 1.8 | 1.8 | 1.4 | 1.6 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.50** |
| 2 | BELECEV725 | Electric Vehicles | 2.6 | 2.4 | 2.2 | 1.8 | 1.8 | 2.0 | 2.4 | 0.4 | 0.8 | 1.0 | 0.6 | 2.2 | **1.68** |
| 3 | BELEDSC725 | SCADA Systems | 2.6 | 2.4 | 1.8 | 1.2 | 1.4 | 0.6 | 0.8 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.23** |
| 4 | BELED**725 | Professional Elective – II | 2.6 | 2.4 | 1.8 | 1.2 | 1.4 | 0.6 | 0.8 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.23** |
| 5 | BELEO**725 | Open Elective – II | 2.6 | 2.4 | 1.8 | 1.2 | 1.4 | 0.6 | 0.8 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.23** |
| 6 | BELEPMP725 | Minor Project | 2.0 | 2.2 | 2.4 | 2.2 | 2.0 | 1.2 | 1.0 | 0.6 | 2.2 | 2.4 | 2.0 | 2.2 | **1.87** |
| **Avg PLO** | | | **2.5** | **2.4** | **2.0** | **1.6** | **1.6** | **1.1** | **1.2** | **0.3** | **0.9** | **1.2** | **0.7** | **1.9** | **1.45** |

## Semester VIII — Average Course-wise Mapping of Programme Learning Outcomes

| S.No | Course Code | Course Title | Average Programme Learning Outcome (PLO) Score | | | | | | | | | | | | Cum. Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| 1 | BELED**825 | Professional Elective – III | 2.6 | 2.4 | 1.8 | 1.2 | 1.4 | 0.6 | 0.8 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.23** |
| 2 | BELED**825 | Professional Elective – IV | 2.6 | 2.4 | 1.8 | 1.2 | 1.4 | 0.6 | 0.8 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.23** |
| 3 | BELEO**825 | Open Elective -III | 2.6 | 2.4 | 1.8 | 1.2 | 1.4 | 0.6 | 0.8 | 0.2 | 0.6 | 1.0 | 0.4 | 1.8 | **1.23** |
| 4 | BELEPMP825 | Major Project | 2.2 | 2.4 | 2.8 | 2.6 | 2.4 | 1.6 | 1.2 | 0.8 | 2.6 | 2.8 | 2.6 | 2.6 | **2.22** |
| **Avg PLO** | | | **2.5** | **2.4** | **2.0** | **1.5** | **1.6** | **0.8** | **0.9** | **0.4** | **1.1** | **1.4** | **1.0** | **2.0** | **1.47** |

## Semester III Marks Distribution Scheme

| S.No. | Course Code | Course Title | Hours per week (L T P Tot) | Credits | Course Type | Mid-Term Theory (15 CA + 35 Exam) | Mid-Term Lab (15 CA + 35 Exam) | Mid-Term (Total) | End-Term Theory | End-Term Lab | End-Term (Total) | Maximum Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BELEBMT325 | Engineering Mathematics-III | 2 1 0 3 | 3 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 2 | BELECNA325 | Network Analysis | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 3 | BELECAC325 | Analog Electronic Circuits | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 4 | BELECSS325 | Signals and Systems | 2 1 0 3 | 3 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 5 | BELECEM325 | Electrical Machines-I | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 6 | BELELMX325 | Introduction to Matrix Programming | 1 0 2 3 | 2 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |

## Semester IV Marks Distribution Scheme

| S.No. | Course Code | Course Title | Hours per week (L T P Tot) | Credits | Course Type | Mid-Term Theory (15 CA + 35 Exam) | Mid-Term Lab (15 CA + 35 Exam) | Mid-Term (Total) | End-Term Theory | End-Term Lab | End-Term (Total) | Maximum Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BELECDE425 | Digital Electronics | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 2 | BELECCS425 | Control Systems | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 3 | BELECME425 | Electrical Measurement | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 4 | BELECNC425 | Non Conventional Energy Sources | 1 1 0 2 | 2 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 5 | BELECEM425 | Electrical Machines-II | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 6 | BELELPY425 | Introduction to Python | 1 0 2 3 | 2 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |

## Semester V Marks Distribution Scheme

| S.No. | Course Code | Course Title | Hours per week (L T P Tot) | Credits | Course Type | Mid-Term Theory (15 CA + 35 Exam) | Mid-Term Lab (15 CA + 35 Exam) | Mid-Term (Total) | End-Term Theory | End-Term Lab | End-Term (Total) | Maximum Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BELECPS525 | Power Systems - I | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 2 | BELECPE525 | Power Electronics | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 3 | BELECPP525 | Power Station Practices | 2 1 0 3 | 3 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 4 | BELECED525 | Electric Drives & Control | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 5 | BELEEMC525 | Microprocessors | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 6 | BELEPIT525 | Industrial Training | 0 0 2 2 | 1 | Lab | 0 | 50 | 50 | 0 | 50 | 50 | 100 |

## Semester VI Marks Distribution Scheme

| S.No. | Course Code | Course Title | Hours per week (L T P Tot) | Credits | Course Type | Mid-Term Theory (15 CA + 35 Exam) | Mid-Term Lab (15 CA + 35 Exam) | Mid-Term (Total) | End-Term Theory | End-Term Lab | End-Term (Total) | Maximum Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BELECPS625 | Power Systems - II | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 2 | BELECPG625 | Power System Protection & Switchgear | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 3 | BELECAE625 | Advanced Power Electronics | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 4 | BELED**625 | Professional Elective - I | 2 1 0 3 | 3 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 5 | BELEO**625 | Open Elective - I | 1 1 0 2 | 2 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 6 | BELELES625 | Embedded Systems | 1 1 2 4 | 3 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |

## Semester VII Marks Distribution Scheme

| S.No. | Course Code | Course Title | Hours per week (L T P Tot) | Credits | Course Type | Mid-Term Theory (15 CA + 35 Exam) | Mid-Term Lab (15 CA + 35 Exam) | Mid-Term (Total) | End-Term Theory | End-Term Lab | End-Term (Total) | Maximum Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BELECPA725 | Power System Analysis | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 2 | BELECEV725 | Electric Vehicles | 2 1 2 5 | 4 | Theory & Lab | 50 | 50 | 100 | 50 | 50 | 100 | 200 |
| 3 | BELEDSC725 | SCADA Systems | 2 1 0 3 | 3 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 4 | BELED**725 | Professional Elective - II | 2 1 0 3 | 3 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 5 | BELEO**725 | Open Elective - II | 2 1 0 3 | 3 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 6 | BELEPMP725 | Minor Project | 0 0 6 6 | 3 | Lab | 0 | 50 | 50 | 0 | 50 | 50 | 100 |

## Semester VIII Marks Distribution Scheme

| S.No. | Course Code | Course Title | Hours per week (L T P Tot) | Credits | Course Type | Mid-Term Theory (15 CA + 35 Exam) | Mid-Term Lab (15 CA + 35 Exam) | Mid-Term (Total) | End-Term Theory | End-Term Lab | End-Term (Total) | Maximum Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | BELED**825 | Professional Elective - III | 2 1 0 3 | 3 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 2 | BELED**825 | Professional Elective - IV | 2 1 0 3 | 3 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 3 | BELEO**825 | Open Elective - III | 1 1 0 2 | 2 | Theory | 50 | 0 | 50 | 50 | 0 | 50 | 100 |
| 4 | BELEPMP825 | Major Project | 0 0 24 24 | 12 | Lab | 0 | 50 | 50 | 0 | 50 | 50 | 100 |

# *Semester III*

| *Course Code* | *BELEBMT325* | | | | | *Semester* | *Semester III* | |
|---|---|---|---|---|---|---|---|---|
| *Course Title* | **Engineering Mathematics–III** | | | | | | *Max marks* | |
| *Scheme & Credits* | *Hours Per Week* | | | | | *Credits* | *Theory* | *Practical* |
| | *L* | *T* | *P* | *Total* | | | | |
| | *2* | *1* | *0* | *3* | | *3* | *100* | |
| *Prerequisites* | *Nil* | | | | | | ***100*** | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| **CLO1** | Understand the Laplace transform and its properties. |
| **CLO2** | Apply the Laplace and inverse Laplace transformations to solve problems described by linear ODEs |
| **CLO3** | Understand the Fourier Transforms and its applications |
| **CLO4** | Understand the Z-Transforms for discrete systems |
| **CLO5** | Apply Z-transforms and its inverse for solving difference equations |

**Syllabus**

| **Units** | **Content** |
|---|---|
| 1 | Laplace Transforms: Definition of Laplace Transforms, Properties of Laplace Transforms, Laplace Transforms of standard inputs, Initial and Final value theorems |
| 2 | Inverse Laplace Transforms: Definition of Inverse Laplace Transforms, Convolution theorem and applications, use of Laplace Transforms in the solution of linear Differential equations. |
| 3 | Fourier Transform: Fourier series, Harmonic analysis, Definition of Fourier transform. Fourier sine and cosine transform. Fourier integral formula, Applications to solutions of boundary value problems. |
| 4 | Z- Transform: Definition, Linearity property, Z- transform of elementary functions, shifting theorems. Initial and Final value theorem. Convolution theorem. |
| 5 | Inverse Z-Transforms: Definition of Inverse Z-transforms, Finding the inverse operator using various methods, using the inverse Z-transforms to solve difference equations |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO 4 | PLO 5 | PLO 6 | PLO7 | PLO 8 | PLO 9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CLO1** | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0.9166666667 |
| **CLO2** | 3 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1 |
| **CLO3** | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| **CLO4** | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| **CLO5** | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| **Avg PLO** | **3** | **2.8** | **1.6** | **1.6** | **1** | **0** | **0.6** | **0** | **0** | **1** | **0** | **2** | 1.133333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | Erwin Kreyzing, Advanced Engineering Mathematics, 10th edition, Wiley Eastern Publications, 2020. |
| 2 | H. K. Das, Higher Engineering Mathematics, S. Chand |
| 3 | Murray R. Speigal, Laplace Transforms, Shaum's outlines, Mc-Graw Hill, 1965 |

**Teaching-Learning Strategies**

Interactive lectures integrating theory with demo sessions.
Case-based learning supported by seminars and discussion of real-world applications.

**Evaluation Scheme**

| | |
|---|---|
| **Theory** | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| **Practical** | NA |

| Course Code | BELECNA325 | | | | | Semester | Semester III | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Network Analysis | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 2 | 5 | | 4 | 100 | 100 |
| Prerequisites | Nil | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Recall and explain the basic network theorems, describe the Laplace transformation properties and their application in solving network problems. |
| CLO2 | Demonstrate an understanding of differential equations and their role in analyzing electrical circuits. Interpret the time domain behavior of circuits using pole-zero plots derived from network functions |
| CLO3 | Apply the knowledge of network theorems and impedance functions to analyze and solve complex electrical circuits. |
| CLO4 | Analyze synthesis problems and formulate strategies using positive real functions and Hurwitz polynomials. |
| CLO5 | Synthesize LC and RC circuits with desired specifications, considering filter design principles. Synthesize constant K & m derived filters to meet specific frequency response requirements |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Differential equation moddeling of networks: Review of the basic network theorems. First order differential equation: Differential equations as applied in solving networks, Application of initial conditions, Evaluating initial conditions in networks, Laplace Transformation properties, Solution of Network problems with Laplace transformation, Waveform analysis, and synthesis: The unit step, ramp, and impulse functions and their Laplace transforms, Initial and final value of f(t) from F(s), Convolution integral, convolution as summation |
| 2 | DC Circuit Analysis:Introduction, Star -Delta Transformation, Loop and Nodal methods of circuit analysis, Superposition theorem, Thevenin's and Norton's theorems, Maximum Power Theorem, Millmans Theorem, Tellegans Theorem, Reciprocity theorem, Substitution Theorem, |
| 3 | AC Circuit Analysis: Phasor and complex number representation, solutions of sinusoidally excited RLC circuits, Power and energy relations in A.C. circuits, Series and parallel AC circuits(RL,RC,RLC), Applications of network theorems to A.C. circuits, Power factor and its improvement, Concepts of active & reactive powers. Resonance in series and parallel circuits, Steady State A.C 3-phases Circuits: Concept of a 3-phase voltage, wye (Y) circuits. Delta (Δ) circuits, Current and voltage relations in Y and Δ Circuits, Characteristics of a 3-phase system |
| 4 | Two-port parameters: Introduction to two-port parameters - motivating real-world examples, Admittance, impedance, transmission, and hybrid parameters, Relationship between parameter sets, Parallel connection of two port Networks, Characteristics impedance of two-port networks |
| 5 | Filter fundamentals: Introduction to filters and motivating real-world examples, pass and stop band, filter classification based on their frequency characteristics, constant K & m derived filters, the behavior of characteristic impedance overpass & stop bands, design of filters, trade-offs between filter characteristics such as cutoff frequency and selectivity. Introduction to active filters, Practical applications of both passive and active filters in communication systems, audio engineering, and signal processing. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | To study and verify Thevenin's Theorem. |
| 2 | To study and verify Norton's Theorem. |
| 3 | To study and verify Maximum Power Transfer Theorem. |
| 4 | To study and verify Superposition Theorem. |
| 5 | To plot the resonance curve for series and parallel resonance in circuits. |
| 6 | To study the Star-Delta interconnections. |
| 7 | To measure power factor and AC power in single-phase circuits with different linear load combinations. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0.9166666667 |
| CLO2 | 3 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1 |
| CLO3 | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO4 | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO5 | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 3 | 2.8 | 1.6 | 1.6 | 1 | 0 | 0.6 | 0 | 0 | 1 | 0 | 2 | 1.133333333 |

**Suggested Reading**


| | |
|---|---|
| 1 | C. L. Van Valkenberg, Network Analysis, 3rd ed. Prentice-Hall,1959. |
| 2 | F. Kuo, Network Analysis & Synthesis, 2nd ed. Wiley, 2006. |
| 3 | A. Chakrabarti, "Circuit Theory (Analysis & Synthesis)," 7th edition, Dhanpat Rai & Co |


**Teaching-Learning Strategies**

Interactive lectures integrating theory with demo sessions.
Case-based learning supported by seminars and discussion of real-world applications.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELECAC325 | | | | | Semester | Semester III | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Analog Electronic Circuits | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 2 | 5 | | 4 | 100 | 100 |
| Prerequisites | Nil | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the linear and switch mode power supplies, basic rectifier circuits along with the filters and regulators |
| CLO2 | Learn about various power amplifier configurations and to analyze and design various power amplifier circuits for specific applications |
| CLO3 | Understand the concept of feedback in electronic circuits and to design and analyze different oscillator circuits |
| CLO4 | Learn and understand the OPAMP, its characteristics, and various applications. |
| CLO5 | Design and analyze various filter circuits using OPAMP, have a basic understanding of comparators, Schmitt triggers, and multi-vibrators. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Linear and Switch Mode Power Supplies: Constituents of a linear power supply, designing main transformer, Half wave and full wave rectifier circuits and their characteristic parameters, Filters: inductor filter, capacitive filter, LC filter, CLC filter, Regulators, Switch mode power supplies, Buck and boost regulators. |
| 2 | Power Amplifiers: Introduction- definitions and amplifier types, series fed class A amplifier. Transformer-coupled class A amplifier, Class B amplifiers, transformer-coupled push-pull amplifier circuit, class C and class D amplifiers. |
| 3 | Feedback and Oscillator Circuits: Feedback concept, advantages of negative feedback, feedback connection types, Oscillator theory, Barkhausen Criteria, RC phase shift Oscillator, LC Oscillator, Wien bridge Oscillator, Hartley Oscillator, Colpitts Oscillator. |
| 4 | Operational Amplifiers and their Applications: Ideal OPAMP versus practical OPAMP, OPAMP characteristics, CMRR, Inverting & Non-Inverting Amplifier, Unity/Voltage follower, Summing & Subtracting Amplifier, Integrator & Differentiator Amplifier, Instrumentation Amplifier, voltage to current converter, current to voltage converter using OPAMP. |
| 5 | Filters, Comparators and Wave Shaping Circuits: Active filters: Low pass, High pass, Band pass, All Pass using OPAMP, Butterworth first & Second order filter, Comparators -Inverting & Non-Inverting Schmitt Trigger, Multi-vibrators: A-stable, Mono-stable & Bi-stable multi-vibrators. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Study V-I characteristics of transistors (PNP and NPN) and calculate the performance parameters of a Transistor. |
| 2 | To assemble a CE amplifier and observe its performance |
| 3 | To obtain frequency response of a RC coupled CE amplifier. |
| 4 | To assemble an emitter follower circuit and observe its performance. |
| 5 | To assemble a differential amplifier and obtain its CMRR |
| 6 | To study different applications of OP AMPS.: inverting amplifier, non-inverting amplifier, integrator, differentiator. |
| 7 | To assemble an RC phase shift oscillator. |
| 8 | To assemble a Class A power amplifier and to determine its power gain. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO2 | 3 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.083333333 |
| CLO3 | 3 | 2 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.166666667 |
| CLO4 | 3 | 3 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.166666667 |
| CLO5 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 2.333333333 |
| Avg PLO | 3 | 2.4 | 2 | 1.8 | 1.6 | 0.8 | 1 | 0.2 | 0.4 | 1.2 | 0.4 | 2.2 | 1.416666667 |

**Suggested Reading**


| | |
|---|---|
| 1 | Electronic Devices and Circuit Theory by Boylestead and Nashelsky, 4th Edition, Longman Higher Education. |
| 2 | Electronic Devices and Circuit by Anil K. Maini and Varsha Agarwal, 2nd Edition, Wiley Publications. |
| 3 | Integrated Electronics by Millman & Halkias, 2nd Edition, Tata McGraw Hill Publications. |


**Teaching-Learning Strategies**

Interactive lectures integrating theory with demo sessions.
Case-based learning supported by seminars and discussion of real-world applications.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELECSS325 | | | | | Semester | Semester III | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Signals and Systems | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 0 | 3 | | 3 | 100 | |
| Prerequisites | Nil | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the historical context and evolution of signals and systems and recognize the contributions of key pioneers in the field. |
| CLO2 | Classify signals based on their properties and parameters and analyze their characteristics in the time and frequency domains. |
| CLO3 | Apply Fourier series, Fourier transform, Laplace transform, and Z-transform for signal and system analysis |
| CLO4 | Analyze the stability and causality of continuous-time and discrete-time systems using transform methods. |
| CLO5 | Evaluate real-world applications of signals and systems in various engineering disciplines and assess their societal impact and ethical considerations. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Signals and their Characteristics: Historical context and evolution of the discipline of signals and systems, Contributions of key pioneers in the field, Evolution of signal processing techniques and their impact on modern technology. Nature of signals: Continuous-time and discrete-time signals. Classification of signals: Periodic and non-periodic, even and odd, power and energy, Invertible and Noninvertible, Deterministic and Random. Elementary signals - exponential, sine, step, impulse, ramp, rectangular, sine, triangular, signum. Signal parameters: Amplitude, frequency, phase, and bandwidth. Signal properties: Symmetry, causality, and linearity. Signal operations: Amplitude scaling, addition, multiplication, time shifting, and time scaling. |
| 2 | Fourier Series and Fourier Transform: Historical development of Fourier series and its applications, Fourier series representation of continuous time periodic signals and their properties, Fourier series representation of discrete-time periodic signals and their properties. Fourier transform and its significance in signal analysis, Continuous-time Fourier transform (CTFT) and its properties, Discrete-Time Fourier Transform (DTFT) and its properties. |
| 3 | Linear Continuous-Time Systems: Systems: definition, classification – Linear and Nonlinear, Time Variant and Time-Invariant, Causal and Non-causal, Stable and Unstable, Static and Dynamic. The Convolution Integral. Properties of Linear Time-Invariant (LTI) systems. Causal LTI systems represented by linear constant-coefficient differential equations. Laplace transform, and its application in analyzing continuous-time LTI systems, Concept of Region of Convergence (ROC) for the Laplace transform. |
| 4 | Linear Discrete-Time Systems: Introduction to discrete-time systems and their classification, Analysis of Causal Linear discrete-time systems described by Linear constant-coefficient difference equations, The z-Transform, Region of Convergence (ROC). Properties of z-Transform: linearity, time shift, scaling, time-reversal, differentiation, Initial value theorem. Inverse z-Transform. Analysis and characterization of LTI systems using z-transforms. |
| 5 | Real-World Applications of Signals and Systems: Applications of signals and systems in communication systems, audio processing, and image processing, Signal processing in control systems and automation, Impact of signals and systems in medical imaging and biomedical engineering, Emerging trends and applications in signals and systems. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO2 | 3 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.083333333 |
| CLO3 | 3 | 2 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 3 | 1.25 |
| CLO4 | 2 | 3 | 3 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 2 | 3 | 1.416666667 |
| CLO5 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 2.333333333 |
| Avg PLO | 2.8 | 2.4 | 2.2 | 1.8 | 1.6 | 0.8 | 1 | 0.2 | 0.4 | 1.2 | 0.8 | 2.6 | 1.483333333 |

**Suggested Reading**


| | |
|---|---|
| 1 | Oppenheim, A. V., Willsky, A. S., and Nawab, S. H., "Signals and Systems," 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1996. |
| 2 | Haykin, S., and Van Veen, B., "Signals and Systems," 2nd ed. Hoboken, NJ: Wiley, 2005. |
| 3 | Hsu, H. P., "Schaum's Outline of Signals and Systems," 3rd ed. New York: McGraw-Hill Education, 2013. |


**Teaching-Learning Strategies**

Interactive lectures integrating theory with demo sessions.
Case-based learning supported by seminars and discussion of real-world applications.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELECEM325 | | | | | Semester | Semester III | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Electrical Machines–I | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 2 | 5 | | 4 | 100 | 100 |
| Prerequisites | Nil | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Get acquainted with magnetic circuits, constructional features of transformers, electromotive force (e.m.f.) equation, equivalent circuit model, phasor diagrams, losses, efficiency, and voltage regulation of transformers |
| CLO2 | Learn how to carry out different tests on transformers and parallel operation of transformers. To get familiar with Autotransformers, distribution and power transformers, three-phase transformers, and their different types of |
| CLO3 | Understand the principles of operation, construction, windings, types, power stages, efficiency, commutation and armature reaction in DC generators and DC motors, torque equation, and electric braking of DC motors |
| CLO4 | Analyze different types of DC generators and DC motors, their characteristics, and their industrial applications. |
| CLO5 | Design the speed controlling techniques for various DC motors, the purpose of the starter in DC motors, and its design |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Single-phase Transformers: Fundamentals of magnetic circuits, magnetization curves, introduction to transformers, classification and construction of transformers, electromotive force (e. m. f.) equation, equivalent circuit model, phasor diagrams, KVA rating, losses and efficiency, voltage regulation. |
| 2 | Transformer tests and other types of Transformers: Transformer tests: polarity test, open circuit test, and short circuit test. Sumpner's back-to-back test, All day efficiency. Instrument transformers (Introduction), parallel operation of transformers, Autotransformers, saving of copper in autotransformers, distribution transformers, and power transformers. |
| 3 | Three-phase Transformers: Construction of three-phase transformers, different types of Connections: Star-Star, Star-Delta, Delta-Star, Delta-Delta, Vector group of transformers. Open delta connection, Scott connection, phase conversions: Three-phase to two-phase conversion and two-phase to three-phase conversion. |
| 4 | DC Generators: Introduction & principle of operation of DC Generators, construction of DC Generators, types of DC Generators, EMF equation, types of windings, power stages and efficiency, commutation and armature reaction, characteristics of DC Generators, applications of DC Generators. |
| 5 | DC Motors: Principles of operation of DC Motors, construction of DC Motors, types of DC Motors, Back EMF and torque equation, torque and speed of DC Motors, characteristics of various types of DC motors, speed control of DC motors, starting and electric braking. Performing the different tests to determine the efficiency of DC motors. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | To perform open circuit and short circuit tests on a single-phase transformer |
| 2 | To perform polarity test on a single phase transformer |
| 3 | To determine the efficiency and voltage regulation of a single phase transformer |
| 4 | To study three phase connections on a bank of three single phase transformers |
| 5 | To study various parts of a dc machine and draw sketches of the same |
| 6 | To plot the saturation curve of a dc machine |
| 7 | To plot the external characteristics of a separately excited dc generator. |
| 8 | To study the voltage build-up of a dc shunt generator |
| 9 | To plot the external characteristic of a dc shunt generator |
| 10 | To plot the external characteristics of a dc series generator |
| 11 | To plot the external characteristic of a dc compound generator |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO2 | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 1.333333333 |
| CLO3 | 2 | 2 | 3 | 2 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 3 | 1.333333333 |
| CLO4 | 2 | 3 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 2 | 3 | 1.333333333 |
| CLO5 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 2 | 2 | 3 | 2.5 |
| Avg PLO | 2.6 | 2.6 | 2.4 | 1.8 | 1.6 | 1 | 1.2 | 0.2 | 0.6 | 1.4 | 0.8 | 2.6 | 1.566666667 |

**Suggested Reading**

| | |
|---|---|
| 1 | Electric Machinery Fundamentals by Chapman, McGraw Hill Education. |
| 2 | Electrical Machinery by P. S. Bhimbra, Khanna Publishers. |
| 3 | Electric Machines by Nagrath and Kothari, McGraw Hill Education. |

**Teaching-Learning Strategies**

Interactive lectures integrating theory with demo sessions.
Case-based learning supported by seminars and discussion of real-world applications.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELELMX325 | | | | | Semester | Semester III | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Introduction to Matrix Programming | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 1 | 0 | 2 | 3 | | 2 | 100 | 100 |
| Prerequisites | Nil | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Familiarization with the basic MATLAB environment and tools. |
| CLO2 | Learn different matrix operations and manipulation. |
| CLO3 | Understand the logic and syntax of programming with examples of different functions. |
| CLO4 | Applying the programming skills in designing new polymorphic functions. |
| CLO5 | Visualize various functions using plotting commands. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to MATLAB: Layout, Command Window, Workspace, Current directory, functions of various windows, docking, and undocking of windows, Help in MATLAB. Simulink: Simulink Library and basic model design in Simulink. |
| 2 | Basics of programming: Rules for coding, syntax, variable types, initializing variables, editor programs, and operators. Matrices and Arrays: Arrays and matrices entries, manipulation of arrays and matrices, operations on matrices, transpose and inverse of a matrix, Displaying output data. |
| 3 | Building Codes with MATLAB: Control Flow/Branching Statements: If – else statements, switch – case construct, related examples. Loops: While and for loop, nested loops, break and continue statements, and related examples. |
| 4 | Functions and Subfunctions: How to define a function, Simple examples to demonstrate the use of user-defined functions, Nested functions, and Polymorphic functions. |
| 5 | Errors and Plotting: Different types of errors and debugging of a program. Plotting: Simple 2D Plots (line color, line style, markers, legend, labeling axes, title, controlling axes), multiple plots on the same figure, multiple figures, subplots, Logarithmic and Polar plots, 3D Plots |

**EXPERMINENTS**

| | |
|---|---|
| 1 | Introduction to the MATLAB workspace, command window, and basic Simulink model design. |
| 2 | Writing basic scripts to initialize variables and use arithmetic operators. |
| 3 | Performing matrix operations including addition, multiplication, transpose, and inverse. |
| 4 | Implementing if-else and switch-case branching statements for logical control. |
| 5 | Using for and while loops, along with break and continue statements, to solve iterative problems. |
| 6 | Designing simple user-defined functions and subfunctions to modularize code. |
| 7 | Implementing nested and polymorphic functions to handle dynamic inputs. |
| 8 | Creating basic 2D plots with customized line styles, colors, markers, and legends. |
| 9 | Generating multiple plots in a single figure using the subplot command. |
| 10 | Creating logarithmic, polar, and 3D plots, and practicing basic code debugging techniques. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 2.166666667 |
| CLO2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 2.166666667 |
| CLO3 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 3 | 1.833333333 |
| CLO4 | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 3 | 2.083333333 |
| CLO5 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2.416666667 |
| Avg PLO | 2.8 | 2.4 | 2.4 | 1.8 | 2.4 | 2.2 | 2.2 | 1.2 | 2 | 1.2 | 2 | 3 | 2.133333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | Getting Started with MATLAB: A Quick Introduction for Scientists & Engineering by Rudra Pratap, Oxford Press, 2010. |
| 2 | MATLAB Programming for Engineers, Stephen J Chapman, Cengage Publishers. |
| 3 | MATLAB For Dummies, Jim Sizemore and John Mueller |

**Teaching-Learning Strategies**

Interactive lectures integrating theory with demo sessions.
Case-based learning supported by seminars and discussion of real-world applications.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

# *Semester IV*

| *Course Code* | *BELECDE425* | | | | | *Semester* | *Semester IV* | |
|---|---|---|---|---|---|---|---|---|
| *Course Title* | **Digital Electronics** | | | | | | *Max marks* | |
| *Scheme & Credits* | *Hours Per Week* | | | | | *Credits* | *Theory* | *Practical* |
| | *L* | *T* | *P* | *Total* | | | | |
| | *2* | *1* | *2* | *5* | | *4* | *100* | *100* |
| *Prerequisites* | *Nil* | | | | | | ***200*** | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| **CLO1** | Apply number system conversions, coding techniques, and Boolean algebra principles to analyze and represent digital information. |
| **CLO2** | Simplify and implement Boolean functions using logic gates and standard minimization techniques for digital circuit design. |
| **CLO3** | Analyze and design combinational logic circuits using arithmetic circuits, encoders, decoders, multiplexers, and demultiplexers. |
| **CLO4** | Analyze and design sequential logic circuits using flip-flops, registers, counters, and data conversion systems. |
| **CLO5** | Explain the operation of memory devices and compare the characteristics and applications of different digital logic families. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Review of Number systems, Radix conversion Complements 9's & 10's, Subtraction using 1's & 2's complements. Binary codes, Error detecting and Correcting codes, Theorems of Boolean algebra, Canonical forms, |
| 2 | Logic gates and implementation of Boolean functions with various types of logic gates. Circuit equivalence. Simplification techniques and minimization by map methods. Tabular method. |
| 3 | Combination logic and arithmetic circuits. Encoders and Decoders, multiplexers & de-multiplexers. |
| 4 | Sequential circuits –state diagrams and state tables, design and analysis of flip-flops, registers, counters. Synchronous and asynchronous operation of sequential circuits,Analog to digital convertor, digital to analog convertor. |
| 5 | Latches and memory organisation. ROM's, EPROM's and RAM's –Dynamic and static. Digital Logic Families: Introduction to bipolar Logic families: RTL, DCTL, DTL, TTL, ECL and MOS Logic families (NMOS, PMOS, CMOS), Details of TTL logic family- Totem pole, Open collector outputs, TTL subfamilies, Comparison of different logic families. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | To verify the truth table of following logic gates: AND, OR and NOT NAND, NOR, XOR and XNOR |
| 2 | To realize the above gates using discrete active and passive components |
| 3 | To implement XOR and XNOR using universal logic gates |
| 4 | To verify DE Morgan's law using logic gates |
| 5 | To implement certain Boolean expressions and check their equality |
| 6 | To design and realize<br>a) Half adder and verify its truth table.<br>b) Full adder and verify its truth table.<br>c) Half subtractor and verify its truth table.<br>d) Full subtractor and verify its truth table |
| 7 | To design a multiplexer/ demultiplexer using two input NAND gates |
| 8 | To design a 4-bit binary to decimal convertor |
| 9 | To design a modulo 10 counter |
| 10 | Design and realize the following flip-flops using logic gates. a) RS flip flop b) JK flip flop. c) D flip flop d) T flip flop. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.9166666667 |
| CLO2 | 3 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.083333333 |
| CLO3 | 3 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| CLO4 | 3 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| CLO5 | 2 | 2 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0.9166666667 |
| Avg PLO | 2.8 | 2.6 | 2 | 1.4 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1.2 | 1.083333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | M.Moris Mano, Digital Logic, Pearson. |
| 2 | A.P. Malvino, Digital Principles and Applications, T.M.Hill |
| 3 | Anil K. Maini,Digital Electronics, Wiley |

**Teaching-Learning Strategies**

Interactive classroom lectures supported by numerical problem-solving and circuit design examples.
Laboratory experiments and simulation-based learning using digital circuit design software.

**Evaluation Scheme**

| | |
|---|---|
| **Theory** | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| **Practical** | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELECCS425 | | | | Semester | Semester IV | |
|---|---|---|---|---|---|---|---|
| Course Title | Control Systems | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 2 | 5 | 4 | 100 | 100 |
| Prerequisites | Nil | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Explain the fundamentals of control systems and develop mathematical models using transfer functions, block diagrams, and signal flow graphs |
| CLO2 | Analyze the time-domain response and steady-state performance of first- and second-order control systems. |
| CLO3 | Determine the stability of control systems using pole locations and the Routh stability criterion. |
| CLO4 | Analyze control system performance using frequency-response techniques and root locus methods. |
| CLO5 | Design basic PID controllers and compensators and explain the fundamentals of state-space modeling |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to continuous control systems: Definition of a control system, open-loop, closed loop (automatic and manual) control. Mathematical modeling: Transfer functions, block diagrams, Mason's signal flow graph |
| 2 | First and second order system: Example of first and second order systems, responses of these systems to step, ramp, parabolic and sinusoidal inputs, transient, steady state and error analysis |
| 3 | Stability studies: Definition of stability, stability and pole locations, Routh Table |
| 4 | Frequency response: Bode plot, polar plot, Nyquist's criterion, root locus. |
| 5 | Proportional, Integral, Derivative (P.I.D) control. Compensator design Lead – lag compensators. Modelling of dynamic systems in state space (Introduction). |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Use of MATLAB / SIMULINK /Control System tool boxes, neural & fuzzy toolboxes. |
| 2 | Analysis of Control Systems in MATLAB. |
| 3 | To study the computer simulation of a number of systems |
| 4 | To study the torque-speed characteristics of an AC servo motor. |
| 5 | To study the time response of a variety of simulated linear systems. |
| 6 | To study the role of feedback in a DC speed control system. |
| 7 | To study the role of feedback in a DC position control system. |
| 8 | To study the role of a combination of P,I and D control actions in a variety of simulated linear systems |
| 9 | System identification using frequency domain techniques |
| 10 | Lead/ lag compensator design |
| 11 | Computer control of systems |
| 12 | Control of stepper motor |
| 13 | Control system (State Space) study |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.916666667 |
| CLO2 | 3 | 3 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.083333333 |
| CLO3 | 3 | 3 | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.166666667 |
| CLO4 | 3 | 3 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| CLO5 | 3 | 2 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| Avg PLO | 3 | 2.6 | 1.6 | 2.2 | 2.2 | 0 | 0 | 0 | 0 | 1 | 0 | 1.2 | 1.15 |

**Suggested Reading**

| | |
|---|---|
| 1 | Norman S. Nise, Control Systems Engineering, John Wiley. |
| 2 | M. Gopal , Control Systems (Principles and Design) , Tata McGraw Hill. |
| 3 | A. Anand Kumar, Control Systems, PHI Learning Private Limited. |
| 4 | Stefani, Design of Feedback Control Systems, Oxford University Press. |

**Teaching-Learning Strategies**

Design basic PID controllers and compensators and explain the fundamentals of state-space modeling
Simulation-based learning using control system software tools for response and stability analysis.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELECME425 | | | | Semester | Semester IV | |
|---|---|---|---|---|---|---|---|
| Course Title | Electrical Measurement | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 2 | 5 | 4 | 100 | 100 |
| Prerequisites | Nil | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Explain the principles, standards, characteristics, and sources of error in electrical and electronic measurement systems. |
| CLO2 | Analyze and select suitable analog and digital instruments for measurement of electrical quantities. |
| CLO3 | Apply bridge methods, transducers, and sensor technologies for accurate measurements. |
| CLO4 | Evaluate modern electronic instruments including oscilloscopes, digital meters, signal analyzers and DAQ systems. |
| CLO5 | Design and interpret measurement systems for industrial automation, power systems and smart-grid applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Fundamentals of Measurements and Instrumentation: standards, calibration, accuracy, precision, uncertainty, errors and instrument characteristics |
| 2 | Electrical Measuring Instruments: PMMC, MI, Electrodynamometer, Electrostatic, Induction instruments, CTs, PTs, power, energy and power factor measurement |
| 3 | Measurement of Circuit Parameters: resistance measurement, bridges, Megger, inductance and capacitance measurement, Q-meter and LCR meter. |
| 4 | Electronic Instruments and Digital Measurement Systems: DVM, DMM, CRO, DSO, frequency counters, spectrum analyzers, DAQ and virtual instrumentation |
| 5 | Sensors, Transducers and Smart Instrumentation: RTD, thermocouple, LVDT, strain gauges, smart sensors, IoT instrumentation, PMU and SCADA overview |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Measurement of resistance by color coding & Ohm's Law. |
| 2 | Measurement of resistance by Wheat Stone bridge. |
| 3 | To find the Dielectric constant of different materials. |
| 4 | Perform an experiment to find very low resistance, medium resistance and very high resistance using suitable |
| 5 | LVDT and capacitance pickup – characteristics and Calibration and assessing the performance with a simulator. |
| 6 | Calibration and testing of single phase energy meters |
| 7 | Measurement of Inductance using Anderson Bridge. |
| 8 | Measurement of capacitance using Schering Bridge. |
| 9 | Measurement of Dielectric strength of oil using H.T testing kit. |
| 10 | Resistance Strain Gauge-Strain Measurements and Calibration and assessing the measurement with Strain Gauge simulator. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| CLO2 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.166666667 |
| CLO3 | 3 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| CLO4 | 3 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| CLO5 | 3 | 3 | 3 | 2 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.5 |
| Avg PLO | 3 | 2.8 | 2.6 | 1.8 | 2.2 | 0 | 0.2 | 0 | 0 | 1 | 0 | 1.2 | 1.233333333 |

**Suggested Reading**


1. Sawhney, A. K., Electrical and Electronic Measurements and Instrumentation, 19th ed., Dhanpat Rai Publications.
2. Bell, D. A., Electronic Instrumentation and Measurements, 2nd ed., Oxford University Press, New Delhi, 2013.
3. Nakra, B. C. and Chaudhry, K. K., Instrumentation, Measurement and Analysis, 5th ed., McGraw Hill Education


**Teaching-Learning Strategies**

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELECNC425 | | | | | Semester | Semester IV | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Non Conventional Energy Sources | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 1 | 1 | 0 | 2 | | 2 | 100 | |
| Prerequisites | Nil | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the energy scenario and the consequent growth of the power generation from renewable energy sources. |
| CLO2 | Understand the basic physics of wind and solar power generation. |
| CLO3 | Understand the power electronic interfaces for wind and solar generation. |
| CLO4 | Understand the issues related to the grid-integration of solar and wind energy systems. |
| CLO5 | Describe other non-conventional energy sources (small hydro, biomass, ocean energy) and the challenges of grid integration for renewable energy systems. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Classification of energy resources, Importance of non-conventional energy sources (NCES), present status and growth of energy sector, Various aspects of energy conservation. Energy Storage: Necessity and methods, Pumped storage, flywheel storage, Battery storage, Superconducting magnetic energy storages, super/ultra-capacitor storage, applications |
| 2 | Solar thermal systems: Introduction, Solar energy basics, classification, solar water heater, solar refrigeration and air-conditioning systems, solar cookers, solar pond electric-power plant, central receiver power plant |
| 3 | Solar Photovoltaic (PV) systems: introduction, solar cell characteristics and equivalent circuit, design of solar PV module and array in solar PV system, MPPT, standalone and grid connected solar PV system, Other Applications |
| 4 | Wind Energy: Introduction, Applications of wind power, power extraction from wind, torque developed by the wind turbine, wind turbine classifications, wind generators, wind energy conversion systems,Hybrid standalone and grid connected systems |
| 5 | Other NCES (small hydro resources, biomass, ocean energy and geothermal energy): introduction, classification, essential components and principle. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.8333333333 |
| CLO2 | 3 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.9166666667 |
| CLO3 | 3 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| CLO4 | 3 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| CLO5 | 3 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.166666667 |
| Avg PLO | 3 | 2.6 | 1.2 | 1.6 | 1.2 | 0 | 0 | 0 | 0 | 1 | 0 | 1.2 | 0.9833333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | B. H. Khan, Non-conventional energy resources, McGraw Hill |
| 2 | J.Twidell and T.Weir, Renewable Energy Resources, Taylor and Francis Group |
| 3 | M.Patel, Wind & Solar Power System, CRC Press |

**Teaching-Learning Strategies**

Case-Based Learning & Real-World Grid Integration Scenarios
Interactive Simulation-Based & Virtual Lab Learning

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELECEM425 | | | | | Semester | Semester IV | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Electrical Machines–II | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 2 | 5 | | 4 | 100 | 100 |
| Prerequisites | Nil | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Explain the fundamental principles of AC rotating electrical machines, including rotating magnetic fields, torque production, losses, and efficiency. |
| CLO2 | Analyze the construction, operation, performance characteristics, testing, and speed control of three-phase induction motors and induction generators. |
| CLO3 | Explain the operation, testing, and applications of single-phase motors and special-purpose AC motors. |
| CLO4 | Analyze the construction, operation, equivalent circuits, and performance characteristics of synchronous machines. |
| CLO5 | Evaluate the steady-state and transient performance of synchronous machines, including excitation control, parallel operation, and power-angle characteristics. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Basic Concepts in A.C. Rotating Electrical Machines: The rotating magnetic field, Magneto-motive force and flux distribution, Induced voltage, Production of torque, Leakage fluxes, losses and efficiency |
| 2 | Three Phase Induction Motors: Construction, Types, Principle of operation of an induction motor,Cogging and crawling, Equivalent circuit, Torque/speed characteristics, Induction motor tests, Speed control, Principle of operation of Induction generator. |
| 3 | Single-Phase Motors: Types of single phase induction motors, Starting of single phase induction motors, analysis and testing of single phase induction motors, universal motor, Schrage motor, Applications of single phase motors. |
| 4 | Synchronous Machines: Construction & Types, working principle, field and armature windings, Equivalent circuit, voltage regulation and its determination, Synchronous reactance, saturation effect, parallel operation, Two-axis theory. |
| 5 | Salient type machines, steady-state power-angle characteristics, Excitation systems, V-curves, synchronous capacitors,Hunting, synchronous Machine Transients, Analysis of sudden 3-phase short circuit, Transient power-angle characteristics. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | To study the different parts of an Induction motor. |
| 2 | To determine the equivalent–circuit parameters of a 3 -f Induction motor by (i) No load test (ii) Blocked rotor test |
| 3 | To determine the Torque / speed characteristics of a 3-f Induction motor |
| 4 | To study the speed control of an Induction motor by pole-changing method |
| 5 | To study the speed control of an Induction motor by varying voltage |
| 6 | To study the speed control of an Induction motor by changing rotor resistance |
| 7 | To Study of the construction of a synchronous machine |
| 8 | To obtain the OCC and SCC of a synchronous machine by Synchronous impedance method |
| 9 | To find voltage regulation of an alternator by actual loading |
| 10 | To obtain the V-curves and inverted V-curves of a synchronous motor |
| 11 | To conduct slip-test on a salient-pole synchronous machine and hence determine its direct and quadrature – axis reactances |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.8333333333 |
| CLO2 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.083333333 |
| CLO3 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.083333333 |
| CLO4 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.083333333 |
| CLO5 | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 3 | 2.8 | 1.8 | 1.8 | 1 | 0 | 0.2 | 0 | 0 | 1 | 0 | 1.2 | 1.066666667 |

**Suggested Reading**

| | |
|---|---|
| 1 | Kingslay Umans, Electric Machinery by Fitzgerald, T. M. Hill. |
| 2 | Nagrath and Kothari, Electric Machines, T.M. Hill. |
| 3 | Chapman, Electrical Machinery Fundamentals, T.M. Hill. |
| 4 | Irving Kosow, Electric Machinery and Transformers, Pearson. |

**Teaching-Learning Strategies**

Interactive classroom lectures supported by numerical problem-solving and phasor-diagram analysis.
Laboratory demonstrations and simulation-based studies of induction and synchronous machines.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELELPY425 | | | | | Semester | Semester IV | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Introduction to Python | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 1 | 0 | 2 | 3 | | 2 | 100 | 100 |
| Prerequisites | Nil | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand Python fundamentals, core data types, control flow statements, and basic syntax for problem-solving. |
| CLO2 | Develop modular Python programs using functions, modules, file handling techniques, and robust exception handling. |
| CLO3 | Apply scientific and numerical computing libraries such as NumPy for array operations and linear algebra problems. |
| CLO4 | Perform structured data manipulation, cleaning, and exploratory analysis using the Pandas library. |
| CLO5 | Create 2D and 3D data visualizations and graphical plots using Matplotlib and Seaborn for technical applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Python Basics<br>Introduction to Python, features, and advantages. Installing Python and using the IDLE/Interpreter. Basic syntax, comments, variables, and dynamic typing. Core data types: integers, floats, strings, and booleans. Basic input and output (print() and input()). Arithmetic, relational, and logical operators. |
| 2 | Control Flow Statements<br>Decision-making statements: if, if-else, and elif constructs. Looping structures: while loops and for loops. The range() function. Loop control statements: break, continue, and pass. Writing simple algorithms using control structures. |
| 3 | Basic Data Structures<br>Introduction to strings: indexing, slicing, and basic string methods. Lists: creating lists, accessing elements, appending, removing, and sorting. Tuples: creation, accessing, and immutability. Dictionaries: key-value pairs, adding, updating, and retrieving data. |
| 4 | Functions<br>Concept of modular programming. Defining and calling user-defined functions (def). Passing arguments (positional and default). Returning values from functions. Local and global variable scope. Overview of useful built-in functions (e.g., len(), type(), max(), min()). |
| 5 | File Handling and Modules<br>Introduction to file handling: opening, reading, writing, and appending text files (.txt). Closing files securely using the with statement. Introduction to importing standard modules (e.g., math, random). Basic error handling using try and except blocks. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Basics and Operators: Write a Python program to read user input, perform basic arithmetic operations (addition, subtraction, multiplication, division), and demonstrate the use of different data types. |
| 2 | Control Structures: Write a Python program using conditional statements to find the largest of three numbers, and a loop to generate the Fibonacci sequence up to N terms. |
| 3 | Data Structures: Write a Python program to create a list of numbers, append a new number, sort the list, and use a dictionary to store and retrieve a student's name and marks. |
| 4 | Functions: Write a Python program to create a user-defined function that accepts a number as an argument and calculates its factorial using a loop. |
| 5 | File Handling: Write a Python program to create a new text file, write a few lines of text into it, read the contents back, and print the total number of words on the screen. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO2 | 3 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO3 | 3 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 1.333333333 |
| CLO4 | 3 | 2 | 3 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1.416666667 |
| CLO5 | 2 | 2 | 3 | 2 | 3 | 0 | 0 | 0 | 1 | 2 | 1 | 2 | 1.5 |
| Avg PLO | 2.8 | 2.4 | 2.4 | 2 | 3 | 0 | 0 | 0 | 0.4 | 1.2 | 0.2 | 2.2 | 1.383333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | Eric Matthes, Python Crash Course: A Hands-On, Project-Based Introduction to Programming, 3rd Edition, No Starch Press. |
| 2 | Wes McKinney, Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter, 3rd Edition, O'Reilly Media. |
| 3 | Charles Severance, Python for Everybody: Exploring Data in Python 3, CreateSpace Independent Publishing. |
| 4 | Hans Petter Langtangen, A Primer on Scientific Programming with Python, 5th Edition, Springer. |

**Teaching-Learning Strategies**

Interactive classroom lectures integrating theoretical concepts with live coding sessions.
Hands-on computational problem-solving and algorithmic exercises.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

# *Semester V*

| *Course Code* | *BELECPS525* | | | | | *Semester* | *Semester V* | |
|---|---|---|---|---|---|---|---|---|
| *Course Title* | **Power Systems – I** | | | | | | *Max marks* | |
| *Scheme & Credits* | *Hours Per Week* | | | | | *Credits* | *Theory* | *Practical* |
| | *L* | *T* | *P* | *Total* | | | | |
| | *2* | *1* | *2* | *5* | | *4* | *100* | *100* |
| *Prerequisites* | *Nil* | | | | | | ***200*** | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| **CLO1** | Explain modern power systems and apply per-unit concepts . |
| **CLO2** | Calculate transmission line parameters and conductor configurations |
| **CLO3** | Analyze short, medium and long transmission lines using ABCD constants |
| **CLO4** | Evaluate voltage regulation, efficiency and power transfer capability |
| **CLO5** | Analyze insulation systems, underground cables and corona phenomena, smart grids, renewable integration and |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to modern power systems, generation, transmission and distribution, single line diagrams, impedance/reactance diagrams, per-unit system, interconnected grids, smart grid fundamentals and renewable energy integration.. |
| 2 | Transmission line parameters, conductor types, bundled conductors, resistance, inductance, capacitance calculations, transposition and line parameter evaluation. |
| 3 | Short, medium and long transmission lines, nominal π and T models, ABCD constants, Ferranti effect, surge impedance loading, voltage regulation, efficiency and power transfer capability.. |
| 4 | Mechanical design of transmission lines, sag-tension calculations, towers and insulators, string efficiency, underground cables, cable construction, insulation, grading, losses and fault location.. |
| 5 | Corona, critical voltages, corona loss, insulation coordination, overvoltages, AC distribution systems, feeders, distributors, ring main systems and distribution automation. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Study of various types of overhead line insulators and transmission line hardware. |
| 2 | Determination of string efficiency of suspension insulator strings. |
| 3 | Study of conductor materials used in overhead transmission lines. |
| 4 | Measurement of transmission line parameters using transmission line models |
| 5 | Study of corona phenomenon using corona demonstration kit (if available) |
| 6 | Study of underground cable construction and cable accessories. |
| 7 | Study of different types of distribution systems: Radial distribution, Ring main distribution, Interconnected distribution |
| 8 | Study of transmission line towers and tower components. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0.9166666667 |
| CLO2 | 3 | 3 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.166666667 |
| CLO3 | 3 | 3 | 1 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO4 | 3 | 3 | 2 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO5 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 2.8 | 2.6 | 1.4 | 1.6 | 1.6 | 0.2 | 0.8 | 0.2 | 0 | 1 | 0 | 2 | 1.183333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | Wadhwa, C. L., Electrical Power Systems, 7th ed., New Age International Publishers, New Delhi, 2021. |
| 2 | Nagrath, I. J. and Kothari, D. P., Modern Power System Analysis, 6th ed., McGraw Hill Education, New Delhi, 2022. |
| 3 | Grainger, J. J. and Stevenson, W. D., Power System Analysis, International ed., McGraw-Hill Education, New York, 2017. |
| 4 | Kundur, Prabha, Power System Stability and Control, 2nd ed., McGraw-Hill Education, New York, 2022. |

**Teaching-Learning Strategies**

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

**Evaluation Scheme**

| | |
|---|---|
| **Theory** | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| **Practical** | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELECPE525 | | | | Semester | Semester V | |
|---|---|---|---|---|---|---|---|
| Course Title | Power Electronics | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 2 | 5 | 4 | 100 | 100 |
| Prerequisites | Nil | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Explain the operating principles, characteristics, switching behavior, gate-drive circuits, and protection methods of power semiconductor devices used in power electronic converters. |
| CLO2 | Analyze and evaluate the performance of single-phase and three-phase AC–DC converters under different loading conditions. |
| CLO3 | Design and analyze single-phase and three-phase DC–AC inverters, and evaluate PWM techniques and harmonic reduction methods for improved converter performance. |
| CLO4 | Analyze the operation and applications of AC voltage controllers, cycloconverters, and DC–DC converters for industrial and renewable energy applications. |
| CLO5 | Apply power electronic converters using simulation tools for modern applications such as electric vehicles, renewable energy systems, motor drives, and power supplies. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Review of power semiconductor devices including Diode, SCR, TRIAC, MOSFET, IGBT, and introduction to SiC and GaN devices. Static and switching characteristics, gate-drive circuits, protection techniques, snubber circuits, and thermal management with heat sink design. |
| 2 | Single-phase and three-phase uncontrolled, semi-controlled, and fully controlled rectifiers with R and RL loads. Performance analysis, effect of source inductance, input power factor, and industrial applications of controlled rectifiers. |
| 3 | Single-phase half-bridge and full-bridge inverters, three-phase voltage source inverters with 180° and 120° conduction modes. PWM techniques, harmonic reduction methods, and applications in UPS, motor drives, and renewable energy systems. |
| 4 | Principle and operation of AC voltage controllers using ON–OFF and phase-angle control techniques. Performance analysis with different loads, introduction to cycloconverters, and their industrial applications. |
| 5 | Operation and performance of buck, boost, and buck–boost converters under continuous and discontinuous conduction modes. Introduction to modern DC–DC converters and their applications in battery charging, electric vehicles, renewable energy systems, and switched-mode power supplies. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Study of power semiconductor devices (Diode, SCR, TRIAC, MOSFET, and IGBT) and their V–I |
| 2 | Performance analysis of single-phase half-wave and full-wave uncontrolled rectifiers with R and RL loads. |
| 3 | Performance analysis of single-phase fully controlled bridge rectifier using SCRs. |
| 4 | Performance analysis of three-phase uncontrolled and controlled rectifiers. |
| 5 | Study of single-phase half-bridge and full-bridge voltage source inverters with R and RL loads. |
| 6 | Performance analysis of three-phase voltage source inverter using 180° and 120° conduction modes (simulation/hardware). |
| 7 | Implementation and analysis of PWM techniques for harmonic reduction in inverters. |
| 8 | Study and performance evaluation of single-phase AC voltage controller with resistive and inductive loads. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0.9166666667 |
| CLO2 | 3 | 3 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.166666667 |
| CLO3 | 3 | 3 | 1 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO4 | 3 | 3 | 2 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO5 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 2.8 | 2.6 | 1.4 | 1.6 | 1.6 | 0.2 | 0.8 | 0.2 | 0 | 1 | 0 | 2 | 1.183333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | Power Electronics: Converters, Applications and Design, Ned Mohan, Tore M. Undeland & William P. Robbins, 2023. |
| 2 | Power Electronics: Circuits, Devices and Applications, Muhammad H. Rashid, Pearson Education, 4th Edition, 2014. |
| 3 | Power Electronics, P. S. Bimbhra, Khanna Publishers, 6th Edition, 2022. |
| 4 | Power Electronics Handbook, Muhammad H. Rashid (Ed.), Butterworth-Heinemann (Elsevier), 4th Edition, 2018. |

**Teaching-Learning Strategies**

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELECPP525 | | | | | Semester | Semester V | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Power Station Practices | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 0 | 3 | | 3 | 100 | |
| Prerequisites | Nil | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Explain the principles of power generation economics, including cost components, load curves, interconnection of generating stations and the selection of generating unit size and number |
| CLO2 | Analyze the impact of power factor on power system performance and evaluate suitable power factor improvement methods and tariff structures for economical operation |
| CLO3 | Compare and evaluate operating principles, characteristics, and application of various power generating stations and their auxillary systems |
| CLO4 | Explain and analyze different neutral grounding and earthing methods, and select appropriate grounding schemes for ensuring safety and reliable power system operation |
| CLO5 | Classify and evaluate different types of electrical substations, their configurations and applications for efficient transmission and distribution of electrical power |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Factors affecting cost of generation, fixed capital, running capital, annual cost, running charges, fixed charges, reduction of costs by interconnection of stations, curves useful in system operation, choice of of size and number of generating units |
| 2 | Disadvantages of low-power factor, methods of improving power factor, location of power factor improvement apparatus, and economics of power factor improvement, power tariff, factors influencing the rate of tariff, designing tariff, different types of tariff, flat rate tariff, block rate tariff, two part tariff, maximum demand tariff, |
| 3 | Thermal power plants, Hydroelectric stations, Nuclear power stations, Deisel power stations, and Gas turbine plant |
| 4 | Neutral Grounding, solid grounding, resistance grounding, reactance grounding, arc suppression coil, earthing transformers, choice of methods of neutral grounding equipment, grounding for safety |
| 5 | Classification of substation, comparison of indoor and outdoor substation, transformer substation, pole mounted substation, underground substation |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0.9166666667 |
| CLO2 | 3 | 3 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.166666667 |
| CLO3 | 3 | 3 | 1 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO4 | 3 | 3 | 2 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO5 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 2.8 | 2.6 | 1.4 | 1.6 | 1.6 | 0.2 | 0.8 | 0.2 | 0 | 1 | 0 | 2 | 1.183333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | V.K.Mehta Principles of Power Systems |
| 2 | A, Chakrabarti et.al, A text book on Power System Engineering. |

**Teaching-Learning Strategies**

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

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| Course Code | BELECED525 | | | | | Semester | Semester V | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Electric Drives & Control | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 2 | 5 | | 4 | 100 | 100 |
| Prerequisites | Nil | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Explain the fundamentals of electric drives, industrial drive systems, load characteristics, energy-efficient operation, thermal considerations, and selection of motors for diverse industrial applications. |
| CLO2 | Analyze the performance, speed–torque characteristics, and control of DC motor drives using conventional, converter-fed, and regenerative techniques. |
| CLO3 | Design and evaluate closed-loop DC drive systems employing power electronic converters, digital controllers, current, torque, speed, and position control strategies. |
| CLO4 | Analyze and implement speed control, braking, and efficiency enhancement techniques for three-phase induction motor drives using variable-frequency drives (VFDs), PWM inverters, and industrial control methods. |
| CLO5 | Evaluate advanced induction motor drive systems, vector control, direct torque control (DTC), sensorless control, industrial automation interfaces, and Industry 4.0 enabled electric drive applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Fundamentals of Electric Drives<br>Introduction to electric drives; classification and applications; components of electric drive systems; drive dynamics; duty cycles (continuous, short-time, intermittent); load characteristics; thermal loading; motor rating and selection; energy efficiency; IE motor classes; introduction to EV and renewable energy drive applications; industrial safety and relevant IEC/IS standards. |
| 2 | DC Motor Drives<br>Characteristics of DC motors; armature, field and voltage control; converter-fed DC drives; phase-controlled rectifiers; regenerative, plugging and dynamic braking; four-quadrant operation; industrial case studies and laboratory simulation. |
| 3 | Chopper Controlled DC Drives and Digital Control<br>DC-DC chopper drives; PWM techniques; closed-loop current, torque, speed and position control using PI/PID controllers; digital implementation using DSP/microcontrollers; multi-motor coordination; comparison of converter technologies; MATLAB/Simulink based analysis. |
| 4 | AC Drives and Variable Frequency Drives<br>Three-phase induction motor characteristics; scalar (V/f) control; PWM VSI drives; regenerative and dynamic braking; variable frequency drives (VFDs); energy-efficient motor operation; industrial automation using PLC/VFD integration; harmonics and power quality |
| 5 | Advanced Induction Motor Drives<br>Rotor resistance and slip power recovery methods; Kramer and Scherbius drives; vector control (FOC); direct torque control (DTC); sensorless control; current regulated VSI drives; electric vehicle traction drives; Industry 4.0, IoT-enabled condition monitoring, predictive maintenance, and smart manufacturing applications. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Determine the torque-speed characteristics for various types of mechanical loads to evaluate appropriate motor ratings and thermal loading. |
| 2 | Implement and analyze speed control, regenerative braking, and dynamic braking of a DC motor using a fully controlled converter. |
| 3 | Perform a MATLAB/Simulink-based analysis of a DC-DC chopper drive, utilizing PI/PID controllers to achieve closed-loop current and speed control. |
| 4 | Evaluate the performance, speed regulation, and energy efficiency of a three-phase induction motor using scalar (V/f) control via a Variable Frequency Drive (VFD). |
| 5 | Simulate Field-Oriented Control (FOC) or Direct Torque Control (DTC) strategies for an induction motor to analyze its dynamic response and suitability for electric vehicle traction drives. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0.9166666667 |
| CLO2 | 3 | 3 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.166666667 |
| CLO3 | 3 | 3 | 1 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO4 | 3 | 3 | 2 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO5 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 2.8 | 2.6 | 1.4 | 1.6 | 1.6 | 0.2 | 0.8 | 0.2 | 0 | 1 | 0 | 2 | 1.183333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | G. K. Dubey, Fundamentals of Electric Drives, Narosa Publishing. |
| 2 | Vedam Subrahmanyam, Electric Drives: Concepts and Applications, McGraw Hill. |
| 3 | R. Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Pearson. |
| 4 | Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson. |

**Teaching-Learning Strategies**

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELEEMC525 | | | | | Semester | Semester V | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Microprocessors | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 2 | 5 | | 4 | 100 | 100 |
| Prerequisites | Nil | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Explain architecture and operation of microprocessors and microcontrollers. |
| CLO2 | Develop assembly language programs. |
| CLO3 | Analyze interrupt handling and memory organization. |
| CLO4 | Design interfacing schemes for peripheral devices. |
| CLO5 | Develop embedded applications using modern microcontrollers. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Microprocessors and Microcontrollers, 8085 architecture, buses, registers, memory organization, machine cycle and instruction cycle. |
| 2 | Instruction set, addressing modes, assembly language programming, stack operations, subroutines and delay routines. |
| 3 | Interrupts, memory interfacing, memory mapped I/O and I/O mapped I/O. |
| 4 | 8255, 8259, 8254, DMA controller, peripheral interfacing and serial communication. |
| 5 | 8086 introduction, ARM Cortex, Arduino, ESP32, embedded systems, IoT and industrial applications. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Study of 8085 Architecture and Instruction Set |
| 2 | Addition and subtraction of 8-bit and 16-bit numbers |
| 3 | Multiplication and division programs |
| 4 | Largest and smallest number in an array |
| 5 | ADC and DAC interfacing |
| 6 | Stack and subroutine programming |
| 7 | Interrupt handling, Arduino programming |
| 8 | Seven-segment display interfacing |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0.9166666667 |
| CLO2 | 3 | 3 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.166666667 |
| CLO3 | 3 | 3 | 1 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO4 | 3 | 3 | 2 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO5 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 2.8 | 2.6 | 1.4 | 1.6 | 1.6 | 0.2 | 0.8 | 0.2 | 0 | 1 | 0 | 2 | 1.183333333 |

**Suggested Reading**


| | |
|---|---|
| 1 | Hall, D. V., Microprocessors and Interfacing: Programming and Hardware, 3rd ed., McGraw-Hill Education, New York, 2017. |
| 2 | Gaonkar, R. S., Microprocessor Architecture, Programming and Applications with the 8085, 6th ed., Penram International Publishing (India) Pvt. Ltd., Mumbai, 2013. |
| 3 | Raj Kamal, Embedded Systems: Architecture, Programming and Design, 3rd ed., McGraw-Hill Education, New Delhi, 2018. |
| 4 | Mazidi, M. A., Mazidi, J. G., and McKinlay, R. D., The 8051 Microcontroller and Embedded Systems: Using Assembly and C, 2nd ed., Pearson Education, Noida, 2011. |


**Teaching-Learning Strategies**

Interactive lectures integrating theory with coding and simulation sessions.
Hands-on laboratory sessions and simulation exercises (using open-source tools).
Case-based learning supported by seminars and discussion of real-world design challenges.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELEPIT525 | | | | | Semester | Semester V | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Industrial Training | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 0 | 0 | 2 | 2 | | 1 | | 100 |
| Prerequisites | Nil | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the organizational structure, workflow, safety practices, and professional ethics followed in industries or organizations. |
| CLO2 | Apply theoretical knowledge of electrical engineering to observe, analyze, and understand industrial processes, equipment, and engineering practices. |
| CLO3 | Develop technical, communication, teamwork, and problem-solving skills through active participation in industrial training or internship activities. |
| CLO4 | Prepare a comprehensive internship report and effectively present the learning outcomes, observations, and practical experiences gained during the training. |
| CLO5 | Demonstrate the ability to identify engineering problems, propose practical solutions, and exhibit lifelong learning and adaptability in professional work environments. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Provide exposure to industrial and professional work environments. |
| 2 | Bridge the gap between classroom learning and industry practices. |
| 3 | Develop technical and communication skills. |
| 4 | Documentation: Maintenance of a daily/weekly training diary; documentation of processes, equipment specifications, and observations; collection of relevant technical data. |
| 5 | Reporting and Presentation: Preparation of the industrial training report as per the prescribed format; seminar presentation of the training experience before the departmental committee; viva-voce. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0.9166666667 |
| CLO2 | 3 | 3 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.166666667 |
| CLO3 | 3 | 3 | 1 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO4 | 3 | 3 | 2 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO5 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 2.8 | 2.6 | 1.4 | 1.6 | 1.6 | 0.2 | 0.8 | 0.2 | 0 | 1 | 0 | 2 | 1.183333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | Training/technical manuals and documentation provided by the host organization, specific to the processes observed. |
| 2 | Relevant IS/IEC/IEEE standards applicable to the host organization's operations, as identified during training. |

**Teaching-Learning Strategies**

- Structured industrial exposure under the supervision of a designated industry mentor.
- Periodic monitoring by a faculty coordinator through the training diary.
- Guided observation and documentation of industrial processes and equipment.
- Post-training seminar and group discussion on the industrial experience.
- Feedback-based report writing under faculty guidance.

**Evaluation Scheme**

| | |
|---|---|
| Theory | NA |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

# *Semester VI*

| *Course Code* | *BELECPS625* | | | | | *Semester* | *Semester VI* | |
|---|---|---|---|---|---|---|---|---|
| *Course Title* | **Power Systems – II** | | | | | | *Max marks* | |
| *Scheme & Credits* | *Hours Per Week* | | | | | *Credits* | *Theory* | *Practical* |
| | *L* | *T* | *P* | *Total* | | | | |
| | *2* | *1* | *2* | *5* | | *4* | *100* | *100* |
| *Prerequisites* | *Power Systems – I* | | | | | | *200* | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| **CLO1** | Describe the layout and equipment of electrical substations of various types. |
| **CLO2** | Analyze methods of neutral grounding and their effect on system performance. |
| **CLO3** | Describe overvoltage phenomena and insulation coordination in power systems. |
| **CLO4** | Analyze the design and operation of primary and secondary distribution systems. |
| **CLO5** | Evaluate methods of power-factor improvement and voltage control in distribution systems. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Per Unit Representation of Power Systems: Single line diagram, impedance and reactance diagram of a system, per unit calculations, per unit representation of a power system. |
| 2 | Fault Analysis (Balanced & Unsymmetrical Faults): Faults, types of faults, symmetrical 3-phase balanced faults calculation of fault currents, current limiting reactors. Symmetrical components, sequence impedances, sequence networks, unsymmetrical faults single line to ground, line to-line, double line to ground faults on unloaded alternators and on power systems |
| 3 | Insulation Coordination: Generation of overvoltages in a power system, lightning phenomena, lightning surges, switching surges-interruption of short circuits and switching operations, switching surges interruption of capacitive circuits, resonance over voltages, protection of power system components against over voltages ground wires, lightning arrestors. Concept of insulation coordination, Basic impulse insulation level, standard impulse test wave, volt-time curve, location and rating of lightning arrestors |
| 4 | Surge Performance of Transmission Lines: Traveling waves on transmission lines, open-end line, short-circuited line, line terminated through a resistance, line connected to a cable, reflection and refraction at a T-junction, line terminated through a capacitance, line terminated through an inductance, Attenuation of traveling waves. |
| 5 | Interference of Power Lines with Communication Circuit: Electrostatic and Electromagnetic effects. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Formulation of the impedance and reactance diagram for a given multi-machine power system and computation of its per-unit representation using MATLAB. |
| 2 | Simulation and analysis of balanced three-phase faults on a power system network to calculate fault currents and size current-limiting reactors using ETAP or MATLAB/Simulink. |
| 3 | Computation of positive, negative, and zero sequence impedances, and the simulation of unsymmetrical faults (Single Line-to-Ground, Line-to-Line, and Double Line-to-Ground) on unloaded alternators and interconnected systems. |
| 4 | MATLAB/Simulink-based modeling and analysis of the propagation, reflection, and refraction of traveling waves on transmission lines under various termination conditions (open-circuited, short-circuited, and resistive/capacitive terminations). |
| 5 | Simulation of lightning and switching surges in a power network to evaluate overvoltage generation, resonance effects, and the protective performance and volt-time characteristics of lightning arresters. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1.083333333 |
| CLO2 | 3 | 3 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1.083333333 |
| CLO3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| CLO4 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1.416666667 |
| CLO5 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1.333333333 |
| Avg PLO | 2.8 | 2.6 | 2.2 | 1.4 | 1.4 | 1 | 0.8 | 0 | 0 | 1 | 0 | 1 | 1.183333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | C.L. Wadhwa, Electrical Power Systems, New Age International. |
| 2 | S.N. Singh, Electric Power Generation, Transmission and Distribution, PHI Learning. |
| 3 | Turan Gönen, Electric Power Distribution Engineering, CRC Press. |
| 4 | William D. Stevenson, Elements of Power System Analysis, McGraw Hill. |
| 5 | J.B. Gupta, Transmission and Distribution of Electrical Power, S.K. Kataria & Sons. |

**Teaching-Learning Strategies**

- Classroom lectures supported by substation single-line diagrams and equipment photographs.
- Tutorial sessions on grounding, distribution, and power-factor-correction numericals.
- Laboratory sessions/simulation on distribution-system load-flow and voltage-profile studies.
- Case studies of substation layouts and lightning-protection schemes.
- Site visit to a substation/distribution facility, wherever feasible.

**Evaluation Scheme**

| | |
|---|---|
| **Theory** | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| **Practical** | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELECPG625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Power System Protection & Switchgear | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 2 | 5 | | 4 | 100 | 100 |
| Prerequisites | Power Systems – I | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Describe the fundamentals of power system protection and the characteristics of protective relays. |
| CLO2 | Analyze overcurrent, differential, and distance protection schemes for power system elements. |
| CLO3 | Design protection schemes for generators, transformers, and busbars. |
| CLO4 | Analyze protection schemes for transmission and distribution feeders. |
| CLO5 | Describe the construction, operation, and rating of circuit breakers used in power systems. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Protective Relaying: Function, fundamental principle, primary and backup relaying, characteristics. Classification of relays, operating principles and characteristics of the following electromechanical relays: Current, voltage, directional, current balance, voltage balance, differential relays, and distance relays. |
| 2 | Protection of Generators: Short-circuit protection of stator windings, protection against turn-to-turn fault, stator ground-fault protection, stator open circuit protection. |
| 3 | Transformer Protection: Short circuit protection, over current and earth-fault protection differential protection, Use of biased relay for differential protection, Buchholz relay, protection of parallel transformer banks. |
| 4 | Protection of Feeders, Busbars and Transmission lines: Protection of feeders, time limit fuse, overcurrent protection for radial feeders, protection of parallel feeders, differential protection for parallel feeders, protection of ring mains, differential pilot wire protection, Circulating current protection, protection for bus-bars, frame leakage protection, differential protection, for bus bars, protection for double bus-bar system, transmission line protection, using over- current relays, using distance relays. Setting of overcurrent and distance relays, coordination of relays. Phase fault and earth fault protection. |
| 5 | Fuses & Circuit Breakers: Fusing element, classification of fuses, current carrying capacity of fuses, high rupturing capacity, characteristics of H.R.C. fuses, selection of HRC fuses. Types of circuit breakers, basic principle of operation, phenomena of arc, initiation, maintenance & arc extinction, d. c. circuit breaking, a.c. circuit breaking, arc voltage and current waveforms in a.c. circuit breaking, restriking and recovery voltages, deionization and current chopping, ratings of circuit breakers, oil circuit breakers, air blast circuit breakers, SF6 Circuit breakers Vacuum breakers. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Study of various types of relays. |
| 2 | Characteristics of fuses. |
| 3 | Characteristics of inverse time over current relays. |
| 4 | Time graded protection using inverse time O/C relay. |
| 4 | Study of circuit breakers. |
| 5 | Study of differential protection schemes. |
| 6 | Study of an oil circuit breaker. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| CLO2 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.166666667 |
| CLO3 | 3 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| CLO4 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1.333333333 |
| CLO5 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.75 |
| Avg PLO | 2.8 | 2.6 | 1.8 | 1.6 | 1.8 | 0.2 | 0.4 | 0 | 0 | 1 | 0 | 1 | 1.1 |

**Suggested Reading**


| | |
|---|---|
| 1 | Badri Ram, D.N. Vishwakarma, Power System Protection and Switchgear, McGraw Hill. |
| 2 | Y.G. Paithankar, S.R. Bhide, Fundamentals of Power System Protection, PHI Learning. |
| 3 | Sunil S. Rao, Switchgear and Protection, Khanna Publishers. |
| 4 | J.L. Blackburn, T.J. Domin, Protective Relaying: Principles and Applications, CRC Press. |
| 5 | C.L. Wadhwa, Electrical Power Systems, New Age International. |


**Teaching-Learning Strategies**

- Classroom lectures integrating relay theory with protection-coordination case studies.
- Tutorial sessions on relay-setting and grading calculations.
- Laboratory sessions on characteristics of overcurrent/differential relays using relay test kits or simulation.
- Simulation of distance and differential protection schemes using MATLAB or relay-simulation software.
- Case studies of major protection mal-operations/blackouts and their analysis.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELECAE625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Advanced Power Electronics | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 2 | 5 | | 4 | 100 | 100 |
| Prerequisites | Power Electronics | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Explain the operation and control of DC–DC switched-mode converters under different operating conditions. |
| CLO2 | Analyze the performance of switched DC power supply converters used in isolated power conversion. |
| CLO3 | Evaluate the operation and design aspects of Uninterruptible Power Supply (UPS) systems and battery backup requirements. |
| CLO4 | Analyze the operation and modulation techniques of cascaded H-bridge multilevel inverters for power conversion applications. |
| CLO5 | Compare diode-clamped and flying-capacitor multilevel inverters based on topology, modulation, and applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | DC-DC Switched Mode Converters: Introduction, control of dc-dc converters, Continuous and discontinuous conditions of buck, boost and buck-boost converters, Cuk dc-dc converter, full bridge dc-dc converter Study and simulation of Buck, Boost, and Buck-Boost DC-DC converters under continuous and discontinuous conduction |
| 2 | Switched DC Power Supplies: Flyback converter, forward and push-pull converter |
| 3 | Uninterruptible Power Supply (UPS): Off-line UPS, On-line UPS, rating of battery bank and calculation of backup time. |
| 4 | Cascaded H-Bridge Multilevel Inverters: Introduction, bipolar and unipolar modulation for H-bridge inverters, multilevel inverter topologies, carrier-based PWM schemes, staircase modulation and applications. |
| 5 | Diode-Clamped and Flying-Capacitor Multilevel Inverters: Introduction, three-level inverter, neutral-point voltage control, carrier-based PWM schemes, other modulation schemes and applications. |

**EXPERIMENTS**

| | |
|---|---|
| 1 | Study and simulation of Buck, Boost, and Buck–Boost DC–DC converters under continuous and discontinuous conduction modes. |
| 2 | Study and performance analysis of Cuk and Full-Bridge DC–DC converters. |
| 3 | Study and comparison of Flyback, Forward, and Push–Pull converters. |
| 4 | Design of battery bank rating and calculation of backup time for an Uninterruptible Power Supply (UPS). |
| 5 | Study and performance analysis of Off-line and On-line UPS systems under different loading conditions. |
| 6 | Simulation of a Single-Phase Cascaded H-Bridge Multilevel Inverter using Bipolar and Unipolar PWM techniques. |
| 7 | Implementation and comparison of Carrier-Based PWM and Staircase Modulation techniques for Cascaded H-Bridge Multilevel Inverters. |
| 8 | Simulation and performance evaluation of Three-Level Diode-Clamped and Flying-Capacitor Multilevel Inverters with Neutral-Point Voltage Control. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO2 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO3 | 3 | 3 | 2 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| CLO4 | 3 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO5 | 3 | 2 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 3 | 2.8 | 2.4 | 2 | 2 | 0 | 0.2 | 0 | 0 | 1 | 0 | 1.8 | 1.266666667 |

**Suggested Reading**

| | |
|---|---|
| 1 | Bin Wu, High-Power Converters and AC Drives, Wiley-IEEE Press. |
| 2 | Ned Mohan, T.M. Undeland, W.P. Robbins, Power Electronics: Converters, Applications and Design, Wiley. |

**Teaching-Learning Strategies**

Interactive lectures using multimedia presentations and concept-based discussions to explain power electronic converters and inverter topologies.
Tutorial sessions focusing on numerical problem-solving and design-oriented exercises related to converter and UPS systems.
Laboratory experiments to study the operation and performance of DC–DC converters, UPS systems, and multilevel inverters.
Simulation-based learning using MATLAB/Simulink, PSIM, or PLECS to analyze converter performance and modulation techniques.
Seminars, assignments, and technical presentations on emerging trends and applications in power electronics and renewable energy systems.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

| Course Code | BELEDAC625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Advanced Control Systems | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 0 | 3 | | 3 | 100 | |
| Prerequisites | Control Systems | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Develop state-space models of dynamic systems from transfer functions and block diagrams. |
| CLO2 | Analyze state variable systems and design state feedback controllers. |
| CLO3 | Evaluate controllability, observability and state estimation techniques. |
| CLO4 | Analyze sampled-data and digital control systems. |
| CLO5 | Design digital controllers and understand modern control strategies. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | State Space Modelling:<br>State variable modelling, state space representation, state equations, conversion of transfer functions to state-space form, block diagrams, transfer functions and signal flow graphs in state space. |
| 2 | State Variable Analysis and Design:<br>Solution of state vector equations, state transition matrix, state variable analysis, system response, design using state variable feedback, state feedback control. |
| 3 | Controllability and Observability:<br>Concepts of controllability and observability, state estimation, pole allocation, stability and reproducibility, design of full state observers, reduced order observers, design using separation principle. |
| 4 | Digital Control Systems:<br>Hardware elements of digital control systems, advantages of digital control systems, practical aspects of sampling, choice of sampling rate, multirate sampling, basic discrete-time signals, quantization and sampling. |
| 5 | Discrete Data Systems and Advanced Controllers:<br>Zero-order hold, pulse transfer functions, difference equations, design of discrete data systems, digital P, PI and PID controllers, introduction to fuzzy logic control, neural network control and predictive control. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 2 | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO2 | 2 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO3 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 3 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1.083333333 |
| Avg PLO | 2.2 | 2.4 | 2.2 | 1.6 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1.2 | 1.05 |

**Suggested Reading**


| | |
|---|---|
| 1 | M. Gopal, State Variable Methods and Digital Control, Tata McGraw Hill. |
| 2 | Norman S. Nise, Control Systems Engineering, John Wiley. |
| 3 | K. Ogata, Discrete Time Control Systems, Pearson. |
| 4 | A. Anand Kumar, Control Systems, PHI Learning Pvt. Ltd. |
| 5 | Franklin, Powell and Emami-Naeini, Feedback Control of Dynamic Systems, Pearson. |


**Teaching-Learning Strategies**

- Classroom lectures supported by numerical examples.
- Tutorial sessions on state-space analysis and controller design.
- Simulation-based learning using MATLAB/Simulink.
- Assignment-based problem solving.
- Seminar presentations on modern control techniques.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDPQ625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Power Quality | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 0 | 3 | | 3 | 100 | |
| Prerequisites | Basic Electrical Circuits, Power Electronics, Control Systems | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Identify and analyze various power quality disturbances. |
| CLO2 | Understand standards and recommended practices related to power quality. |
| CLO3 | Evaluate passive and active compensation techniques. |
| CLO4 | Analyze operation and control of custom power devices. |
| CLO5 | Apply power quality improvement techniques in modern power systems. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Power Quality:<br>Definition of power quality, power quality problems, causes and consequences, voltage sags, voltage swells, interruptions, flicker, reactive power and harmonics, load current compensation, reactive power compensation |
| 2 | Shunt Compensation Techniques:<br>Passive compensation techniques, active load compensation, D-STATCOM, operating principles, design aspects, control strategies and phasor analysis. |
| 3 | Series Compensation Techniques:<br>Source voltage compensation, dynamics of voltage sags and swells, passive series compensation, active series compensation, Dynamic Voltage Restorer (DVR) with and without energy support, design, control and phasor |
| 4 | Unified Power Quality Conditioner:<br>Combined compensation techniques, Unified Power Quality Conditioner (UPQC), right shunt and left shunt topologies, operating characteristics and applications. |
| 5 | Power Quality Monitoring and Applications:<br>Harmonic mitigation techniques, power quality monitoring, IEEE power quality standards, applications of custom power devices, case studies on power quality improvement. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.083333333 |
| CLO2 | 3 | 1 | 1 | 1 | 1 | 3 | 0 | 2 | 1 | 1 | 0 | 1 | 1.25 |
| CLO3 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1 |
| Avg PLO | 2.4 | 2.4 | 1.2 | 1.6 | 1 | 0.6 | 0 | 0.4 | 1 | 1 | 0 | 1.2 | 1.066666667 |

**Suggested Reading**

| | |
|---|---|
| 1 | B. Singh and A. Chandra, Power Quality Problems and Mitigation Techniques, Wiley. |
| 2 | Math H. J. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, Wiley. |
| 3 | A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices, Springer. |
| 4 | C. Sankaran, Power Quality, CRC Press. |
| 5 | Roger C. Dugan, Mark F. McGranaghan and H. Wayne Beaty, Electrical Power Systems Quality, McGraw Hill. |

**Teaching-Learning Strategies**

- Classroom lectures with practical examples from utility systems.
- Tutorial sessions on power quality calculations.
- Simulation studies of custom power devices.
- Assignments based on power quality standards and case studies.
- Seminar presentations on emerging power quality solutions.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDPV625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Design of Photovoltaic Systems | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 0 | 3 | | 3 | 100 | |
| Prerequisites | Power Electronics | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the operating principles and characteristics of photovoltaic cells and modules. |
| CLO2 | Analyze series and parallel interconnections of PV cells and modules. |
| CLO3 | Estimate solar energy availability using solar geometry concepts. |
| CLO4 | Design standalone and grid-connected photovoltaic systems. |
| CLO5 | Understand MPPT techniques and PV system applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Fundamentals of Photovoltaic Cells:<br>Historical development of photovoltaic technology, PV cell characteristics, equivalent circuit, short-circuit current, open-circuit voltage, maximum power point, datasheet study, cell efficiency, fill factor, effect of temperature and PV cell simulation. |
| 2 | PV Cell and Module Interconnections:<br>Series and parallel interconnection of PV cells and modules, identical and non-identical cells, load line analysis, protection of cells, interconnection techniques and performance analysis. |
| 3 | Solar Radiation and Energy Estimation:<br>Solar radiation fundamentals, insolation and irradiance, solar geometry, declination angle, sunrise and sunset hour angles, energy estimation on horizontal and tilted surfaces, atmospheric effects and clearness index. |
| 4 | PV System Design and Sizing:<br>Sizing of PV systems, load profiling, battery selection, battery capacity and efficiency, days of autonomy, PV array sizing, energy storage options and PV system design considerations. |
| 5 | MPPT and PV Applications:<br>MPPT concepts and algorithms, DC-DC converters for PV systems, PV-battery interface, PV water pumping systems, grid-connected PV systems and life-cycle costing. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 2 | 2 | 1 | 1 | 3 | 0 | 3 | 0 | 1 | 1 | 0 | 1 | 1.25 |
| CLO4 | 2 | 2 | 3 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO5 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.8333333333 |
| Avg PLO | 2.4 | 1.8 | 1.4 | 1.2 | 2.2 | 0 | 0.6 | 0 | 1 | 1 | 0 | 1 | 1.05 |

**Suggested Reading**


| | |
|---|---|
| 1 | Chetan Singh Solanki, Solar Photovoltaic Technology and Systems, Prentice Hall India. |
| 2 | Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall India. |
| 3 | L. Umanand, Design of Photovoltaic Systems, NPTEL Course Material. |
| 4 | Gilbert M. Masters, Renewable and Efficient Electric Power Systems, Wiley. |
| 5 | Roger Messenger and Jerry Ventre, Photovoltaic Systems Engineering, CRC Press. |


**Teaching-Learning Strategies**

- Classroom lectures supported by numerical examples.
- Tutorial sessions on PV system design calculations.
- Software-based simulations of PV systems.
- Assignments and case studies on solar energy applications.
- Seminar presentations on emerging photovoltaic technologies.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDMD625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Electrical Machine Design | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 0 | 3 | | 3 | 100 | |
| Prerequisites | Electrical Machines | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the principles and considerations involved in electrical machine design. |
| CLO2 | Design transformers based on electrical, magnetic and thermal requirements. |
| CLO3 | Design induction motors considering performance and operational constraints. |
| CLO4 | Design synchronous machines and estimate their performance parameters. |
| CLO5 | Apply machine design principles to practical engineering problems. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Fundamentals of Electrical Machine Design:<br>Major considerations in machine design, electrical engineering materials, space factor, specific electrical and magnetic loading, thermal considerations, heat flow, temperature rise and rating of electrical machines. |
| 2 | Design of Transformers:<br>Output equation, main dimensions, window space factor, overall dimensions, operating characteristics, regulation, no-load current, temperature rise, cooling methods and design of cooling tanks. |
| 3 | Design of Induction Motors:<br>Output equation, main dimensions, air-gap selection, rotor slots, squirrel cage rotor design, wound rotor design, leakage reactance, magnetizing current, short-circuit current and operating characteristics. |
| 4 | Design of Synchronous Machines:<br>Output equation, main dimensions, salient pole machines, short-circuit ratio, armature design, air-gap length, rotor design, field winding design and turbo alternator design. |
| 5 | Performance Evaluation and Computer-Aided Design:<br>Estimation of machine performance, optimization of design parameters, introduction to computer-aided design of electrical machines and contemporary design practices. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO2 | 2 | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 2 | 2 | 3 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO4 | 2 | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| Avg PLO | 2.2 | 1.8 | 3 | 1 | 1.4 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.033333333 |

**Suggested Reading**


| | |
|---|---|
| 1 | A. K. Sawhney, A Course in Electrical Machine Design, Dhanpat Rai Publications. |
| 2 | V. N. Mittle, Design of Electrical Machines, Standard Publishers. |
| 3 | R. K. Agarwal, Principles of Electrical Machine Design, Kataria & Sons. |
| 4 | S. K. Sen, Principles of Electrical Machine Design, Oxford & IBH Publishing. |
| 5 | M. G. Say, The Performance and Design of Alternating Current Machines, CBS Publishers. |


**Teaching-Learning Strategies**

- Classroom lectures emphasizing design procedures.
- Tutorial sessions involving machine design calculations.
- Design-oriented assignments and problem-solving exercises.
- Use of design software and computational tools.
- Case studies on transformer and motor design.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDMA625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Electrical Materials | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 2 | 1 | 0 | 3 | | 3 | 100 | |
| Prerequisites | Nil | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand crystal structures and energy band theory of solids. |
| CLO2 | Analyze properties and applications of insulating materials. |
| CLO3 | Understand dielectric materials and polarization mechanisms. |
| CLO4 | Analyze magnetic materials and their characteristics. |
| CLO5 | Select suitable electrical materials for engineering applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Crystal Structure and Energy Bands:<br>Atomic packing, crystal lattices, crystal structures, silicon and germanium structures, energy band theory, electrons in periodic potentials, concept of holes, Brillouin zones and elementary concepts of elastic waves and photons. |
| 2 | Insulating Materials:<br>Introduction to insulating materials, dielectric behaviour, properties of insulating materials, insulators in static and alternating electric fields, classification based on temperature rise and practical insulating materials including solids, liquids and gases. |
| 3 | Dielectric Materials:<br>Polarization mechanisms, dielectric constants, internal fields in solids and liquids, ferroelectric and piezoelectric materials, dielectric losses, dipolar relaxation and dielectric breakdown mechanisms. |
| 4 | Magnetic Materials:<br>Magnetic field concepts, orbital magnetic moments, classification of magnetic materials, spontaneous magnetism, Curie-Weiss law, ferromagnetic, antiferromagnetic materials, ferrites and their applications. |
| 5 | Advanced Electrical Materials and Applications:<br>Conducting, semiconducting and magnetic materials used in electrical engineering, material selection criteria and applications in modern electrical equipment. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0.9166666667 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.8333333333 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.9166666667 |
| Avg PLO | 2.4 | 2 | 1.2 | 1.4 | 1 | 0 | 0.2 | 0 | 1 | 1 | 0 | 1 | 0.9333333333 |

**Suggested Reading**


| | |
|---|---|
| 1 | S. P. Seth and P. V. Gupta, Electrical Engineering Materials, Dhanpat Rai Publications. |
| 2 | Raghavan, Electrical Engineering Materials, PHI Learning. |
| 3 | Allison, Materials, Electronics Engineering and Devices. |
| 4 | A. J. Dekker, Electrical Engineering Materials, Prentice Hall. |
| 5 | Ian P. Jones, Materials Science for Electrical and Electronic Engineers, Oxford University Press. |


**Teaching-Learning Strategies**

- Classroom lectures supported by illustrations and material samples.
- Tutorial sessions on material properties and applications.
- Assignments based on material selection and comparison.
- Seminar presentations on advanced electrical materials.
- Case studies involving materials used in electrical equipment.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEOCS625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Communication Systems | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 1 | 1 | 0 | 2 | | 2 | 100 | |
| Prerequisites | Nil | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the fundamentals of analog and digital communication systems. |
| CLO2 | Analyze various analog modulation and demodulation techniques. |
| CLO3 | Evaluate the performance of communication systems in the presence of noise. |
| CLO4 | Understand pulse modulation and digital communication techniques. |
| CLO5 | Analyze and compare various digital modulation schemes. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Fundamentals of Communication Systems:<br>Introduction to Fourier series and Fourier transform, properties of Fourier transform, modulation theorem, amplitude spectrum of pulse train and pulse waveform, introduction to communication systems, basic elements of analog and digital communication systems, importance and applications of communication systems in electrical engineering. |
| 2 | Amplitude Modulation Techniques:<br>Need for modulation, amplitude modulation (AM), DSB-SC, SSB and VSB systems, generation, detection, waveforms, mathematical representation and applications. |
| 3 | Angle Modulation Techniques:<br>Frequency modulation and phase modulation, narrowband FM, wideband FM, mathematical representation, generation, detection, applications and comparison of modulation techniques. |
| 4 | Radio Receivers and Noise Analysis:<br>AM and FM transmitters, AM and FM radio receivers, noise and its types, performance of AM and FM systems in the presence of noise, threshold effect, pre-emphasis and de-emphasis techniques. |
| 5 | Digital Communication and Digital Modulation:<br>Sampling, quantization, quantization noise, coding, PCM, DPCM, ADPCM, delta modulation, PWM and PPM. Digital modulation techniques including ASK, FSK, PSK, QPSK, DPSK, GMSK and QAM, constellation diagrams and comparative analysis. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.8333333333 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO4 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.8333333333 |
| CLO5 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| Avg PLO | 2.4 | 2.2 | 1 | 1.6 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.9333333333 |

**Suggested Reading**

| | |
|---|---|
| 1 | George Kennedy and Bernard Davis, Electronic Communication Systems, McGraw Hill Education. |
| 2 | Taub and Schilling, Principles of Communication Systems, McGraw Hill Education. |
| 3 | Simon Haykin, Communication Systems, Wiley India. |
| 4 | B. P. Lathi, Modern Digital and Analog Communication Systems, Oxford University Press. |
| 5 | Wayne Tomasi, Electronic Communication Systems, Pearson Education. |

**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Numerical problem-solving sessions.
- Tutorial assignments on modulation techniques.
- Simulation-based demonstrations of communication systems.
- Student seminars and presentations on modern communication technologies.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEOTE625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Thermal Engineering | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 1 | 1 | 0 | 2 | | 2 | 100 | |
| Prerequisites | Nil | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the fundamentals of thermodynamics and steam properties. |
| CLO2 | Analyze thermodynamic cycles used in power generation systems. |
| CLO3 | Understand the construction and performance of steam turbines. |
| CLO4 | Analyze the operation and performance of internal combustion engines. |
| CLO5 | Understand gas turbine cycles and their engineering applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Fundamentals of Thermodynamics:<br>System and surroundings, Zeroth law of thermodynamics, temperature scales, equation of state, first law of thermodynamics, steady flow energy equation, isochoric, isobaric, isothermal, adiabatic and polytropic processes. |
| 2 | Steam Power Cycles:<br>Properties of steam, second law of thermodynamics, entropy and entropy change, reversible and irreversible processes, Carnot cycle, Rankine cycle, modified Rankine cycle, flow through nozzles. |
| 3 | Steam Turbines:<br>Impulse and reaction turbines, velocity and pressure compounding, work output, losses and efficiency, degree of reaction, regenerative and reheat cycles, governing of steam turbines and fields of application. |
| 4 | Internal Combustion Engines:<br>Otto, Diesel and Dual cycles, ignition systems, detonation and pre-ignition, octane number, diesel knock, cetane number, fuels, carburetion and fuel injection systems, lubrication, cooling, governing and applications of I.C. engines. |
| 5 | Gas Turbines:<br>Introduction to gas turbines, basic gas turbine cycles, thermal refinements, jet propulsion systems, present status, future trends and applications of gas turbines. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.8333333333 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.8333333333 |
| Avg PLO | 2.6 | 1.8 | 1.4 | 1.4 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.9333333333 |

**Suggested Reading**


| | |
|---|---|
| 1 | Bartlett, Steam Turbine Performance and Economics, McGraw Hill. |
| 2 | Kearton, Steam Turbine Theory and Practice, CBS Publishers. |
| 3 | W. W. Loe, Theory and Design of Steam and Gas Turbines, McGraw Hill. |
| 4 | Cohn and Rogers, Gas Turbines: Theory and Practice, Pearson. |
| 5 | S. M. Yahya, Turbomachines, McGraw Hill. |
| 6 | P. K. Nag, Engineering Thermodynamics, McGraw Hill. |
| 7 | R. K. Rajput, Thermal Engineering, Laxmi Publications. |


**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Numerical problem-solving sessions.
- Tutorials on thermodynamic cycles and turbine performance.
- Case studies on thermal power plants and propulsion systems.
- Student seminars and assignments on modern thermal engineering technologies.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEOEA625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Energy Audit and Management | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 1 | 1 | 0 | 2 | | 2 | 100 | |
| Prerequisites | Nil | | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the present energy scenario and the importance of energy conservation. |
| CLO2 | Apply principles of energy management and energy auditing. |
| CLO3 | Analyze financial aspects of energy conservation projects. |
| CLO4 | Identify energy-saving opportunities in electrical systems. |
| CLO5 | Evaluate the performance of energy-efficient technologies and practices. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Energy Scenario and Conservation:<br>Energy needs of a growing economy, long-term energy scenario, energy pricing, energy sector reforms, energy and environment, air pollution, climate change, energy security, importance of energy conservation, energy strategies for the future, Energy Conservation Act 2001 and its features. |
| 2 | Energy Management and Energy Audit:<br>Energy management concepts, definition and need of energy audit, types of energy audits, energy management approach, understanding energy costs, benchmarking, energy performance evaluation, matching energy use to requirements, maximizing system efficiency, fuel and energy substitution. |
| 3 | Energy Audit Methodology and Instruments:<br>Energy audit instruments, facility as an energy system, process flow diagrams, identification of energy conservation opportunities, data collection, analysis and reporting procedures. |
| 4 | Financial Management for Energy Projects:<br>Investment need, project appraisal criteria, simple payback period, return on investment, net present value, internal rate of return, cash flow analysis, risk and sensitivity analysis, financing options, energy performance contracts and role of ESCOs. |
| 5 | Energy Efficiency in Electrical Systems:<br>Electricity tariff, load management and maximum demand control, power factor improvement, transformer and distribution losses, induction motor efficiency, rewinding and motor replacement issues, energy-efficient motors, lighting systems, luminance requirements, energy conservation opportunities in lighting applications. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 2 | 3 | 0 | 1 | 1 | 0 | 1 | 1.25 |
| CLO2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 3 | 1 | 1.416666667 |
| CLO3 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 0 | 1 | 1 | 0 | 1 | 1.416666667 |
| CLO4 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 1 | 1.083333333 |
| CLO5 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 1 | 1.25 |
| Avg PLO | 2.4 | 2 | 1.2 | 1.4 | 1 | 2 | 1.8 | 0 | 1 | 1 | 0.6 | 1 | 1.283333333 |

**Suggested Reading**


| | |
|---|---|
| 1 | S. C. Tripathy, Utilization of Electrical Energy and Conservation, McGraw Hill. |
| 2 | Bureau of Energy Efficiency (BEE), Success Stories of Energy Conservation, New Delhi. |
| 3 | Guide Book for National Certification Examination for Energy Managers and Energy Auditors – Book 1: General Aspects, Bureau of Energy Efficiency. |
| 4 | Guide Book for National Certification Examination for Energy Managers and Energy Auditors – Book 3: Electrical Utilities, Bureau of Energy Efficiency. |
| 5 | W. R. Murphy and G. Mckay, Energy Management, Butterworth-Heinemann. |
| 6 | Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Guide to Energy Management, CRC Press. |


**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Case studies on industrial and commercial energy audits.
- Problem-solving sessions on energy performance evaluation.
- Analysis of real-world energy conservation projects.
- Student seminars, assignments and technical presentations.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELELES625 | | | | | Semester | Semester VI | |
|---|---|---|---|---|---|---|---|---|
| Course Title | Embedded Systems | | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | | |
| | 1 | 1 | 2 | 4 | | 3 | 100 | 100 |
| Prerequisites | Microprocessors, Digital Electronics | | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Describe the architecture of embedded systems and microcontroller-based system design. |
| CLO2 | Develop embedded C programs for microcontroller-based applications. |
| CLO3 | Interface sensors and actuators with a microcontroller. |
| CLO4 | Implement communication protocols for embedded system interfacing. |
| CLO5 | Design and demonstrate a simple embedded system application. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Embedded Systems:<br>Characteristics of embedded systems; embedded system design process; classification — microcontroller-based, DSP-based, FPGA-based systems; introduction to real-time operating systems (RTOS) — basic concepts. |
| 2 | Microcontroller Architecture and Programming:<br>Architecture of a typical microcontroller (e.g., ARM Cortex-M/AVR); memory organization, GPIO, timers; embedded C programming — data types and control structures specific to embedded programming; programming using an IDE and toolchain. |
| 3 | Sensor and Actuator Interfacing:<br>Interfacing of digital and analog sensors (temperature, light, proximity); ADC/DAC interfacing; interfacing of actuators — relays, DC motors, servo motors, stepper motors via driver circuits; PWM-based control. |
| 4 | Communication Protocols:<br>Serial communication — UART; interfacing protocols — I2C, SPI; wireless communication modules — Bluetooth/Wi-Fi — basic interfacing for IoT-enabled applications. |
| 5 | Embedded System Design Project:<br>Requirement analysis and design of a simple embedded application; integration of sensors, actuators, and communication modules; testing and debugging; demonstration of the developed embedded system. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 2 | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.9166666667 |
| CLO2 | 2 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO3 | 2 | 2 | 3 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1.333333333 |
| CLO4 | 2 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1.25 |
| CLO5 | 2 | 2 | 3 | 2 | 3 | 0 | 0 | 0 | 2 | 2 | 1 | 2 | 1.583333333 |
| Avg PLO | 2 | 2 | 2.4 | 1.8 | 2.8 | 0 | 0 | 0 | 1 | 1.2 | 0.2 | 1.6 | 1.25 |

**Suggested Reading**


| | |
|---|---|
| 1 | Rajkamal, Embedded Systems: Architecture, Programming and Design, McGraw Hill. |
| 2 | Shibu K.V., Introduction to Embedded Systems, McGraw Hill. |
| 3 | Joseph Yiu, The Definitive Guide to ARM Cortex-M Microcontrollers, Newnes. |
| 4 | Simon Monk, Programming Arduino: Getting Started with Sketches, McGraw Hill. |
| 5 | Michael Barr, Anthony Massa, Programming Embedded Systems, O'Reilly. |


**Teaching-Learning Strategies**

- Interactive lectures integrating embedded-architecture concepts with hands-on coding demonstrations.
- Laboratory sessions on embedded C programming and sensor/actuator interfacing using development boards.
- Hands-on exercises on serial and wireless communication interfacing.
- Case-based learning through small interfacing challenges.
- Mini-project on an integrated embedded system application.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks. |

# *Semester VII*

| *Course Code* | BELECPA725 | | | | *Semester* | *Semester VII* | |
|---|---|---|---|---|---|---|---|
| *Course Title* | Power System Analysis | | | | | *Max marks* | |
| *Scheme & Credits* | *Hours Per Week* | | | | *Credits* | *Theory* | *Practical* |
| | *L* | *T* | *P* | *Total* | | | |
| | 2 | 1 | 2 | 5 | 4 | 100 | 100 |
| *Prerequisites* | *Power Systems – I, Power Systems – II* | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| **CLO1** | Represent power system components in per-unit and formulate the bus admittance (Ybus) and impedance (Zbus) matrices. |
| **CLO2** | Perform load-flow analysis of power systems using the Gauss–Seidel and Newton–Raphson methods. |
| **CLO3** | Analyze symmetrical (three-phase) fault conditions using per-unit and Zbus-based methods. |
| **CLO4** | Analyze unsymmetrical faults using the method of symmetrical components. |
| **CLO5** | Evaluate power system stability using the swing equation and the equal-area criterion. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Per-Unit System and Network Modelling:<br>Per-unit representation and selection of base quantities; conversion of per-unit impedances between bases; one-line diagrams and impedance/reactance diagrams; formation of Ybus by inspection; network graphs, incidence matrices, and the building algorithm for Zbus. |
| 2 | Load-Flow Analysis:<br>Formulation of the load-flow problem; classification of buses (slack, PV, PQ); Gauss–Seidel iterative method; Newton–Raphson method in polar form; fast decoupled load flow; comparison of methods and convergence behaviour. |
| 3 | Symmetrical Fault Analysis:<br>Transients in RL circuits during short circuits; three-phase symmetrical fault analysis using Thevenin's theorem and the Zbus matrix; fault-current calculations; selection criteria for circuit breakers and current-limiting reactors. |
| 4 | Unsymmetrical Fault Analysis:<br>Symmetrical components and their properties; sequence impedances and sequence networks of generators, lines and transformers; analysis of single line-to-ground, line-to-line, and double line-to-ground faults using sequence networks. |
| 5 | Power System Stability:<br>Steady-state and transient stability concepts; the swing equation and its derivation; equal-area criterion for transient stability assessment; factors affecting transient stability; methods of improving system stability. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CLO1** | 3 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.08 |
| **CLO2** | 3 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1.5 |
| **CLO3** | 3 | 3 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| **CLO4** | 3 | 3 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| **CLO5** | 2 | 3 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1.166666667 |
| **Avg PLO** | 2.8 | 3.0 | 2.2 | 1.8 | 2.0 | 0.6 | 0.2 | 0.0 | 0.2 | 1.0 | 0.0 | 1.2 | 1.3 |

**Suggested Reading**

| | |
|---|---|
| 1 | Hadi Saadat, Power System Analysis, McGraw Hill. |
| 2 | J. Duncan Glover, M.S. Sarma, T.J. Overbye, Power System Analysis and Design, Cengage Learning. |
| 3 | I.J. Nagrath, D.P. Kothari, Modern Power System Analysis, McGraw Hill. |
| 4 | C.L. Wadhwa, Electrical Power Systems, New Age International. |
| 5 | William D. Stevenson, Elements of Power System Analysis, McGraw Hill. |

**Teaching-Learning Strategies**

- Classroom lectures integrating theoretical concepts with numerical problems.
- Tutorial sessions on load-flow and fault-analysis computations.
- Simulation-based laboratory sessions using MATLAB/ETAP/PSCAD for load-flow and fault studies.
- Assignment-based problem solving on standard IEEE test systems (e.g., 5-bus, 14-bus).
- Case studies of real power system disturbances and blackouts.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, |

| Course Code | BELECEV725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | Electric Vehicles | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 2 | 5 | 4 | 100 | 100 |
| Prerequisites | Power Electronics, Electric Drives & Control | | | | | 200 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Describe the architecture and configurations of electric and hybrid electric vehicles. |
| CLO2 | Analyze vehicle dynamics and estimate the power and energy requirements for propulsion. |
| CLO3 | Evaluate electric machines and motor drives used in EV propulsion systems. |
| CLO4 | Analyze energy storage systems and battery management systems used in EVs. |
| CLO5 | Describe EV charging infrastructure, charging standards, and vehicle-to-grid integration. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Electric and Hybrid Vehicles:<br>Limitations of conventional vehicles; brief history and drivers for electrification; EV configurations — BEV, HEV, PHEV, FCEV; hybrid architectures — series, parallel, series-parallel; concept and degree of hybridization. |
| 2 | Vehicle Dynamics and Propulsion:<br>Vehicle mechanics and forces resisting motion; tractive effort and road-load equation; power and energy requirements for propulsion; gradeability and acceleration performance; vehicle performance characteristics. |
| 3 | Electric Machines and Drives for EVs:<br>DC motor drives; induction motor drives; permanent magnet synchronous motor drives; switched reluctance motor drives; comparative evaluation of motor/drive types for EV traction applications. |
| 4 | Energy Storage Systems:<br>Battery types and characteristics — lead-acid, NiMH, Li-ion; battery modelling and state-of-charge estimation; battery management systems; ultracapacitors and hybrid energy-storage combinations; introduction to fuel cells. |
| 5 | Charging Infrastructure and Grid Integration:<br>Conductive and inductive charging methods; charging standards — CCS, CHAdeMO, Type 2/IEC 62196; levels of charging; vehicle-to-grid (V2G) concept; impact of EV charging on the distribution grid; smart/coordinated charging. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 2 | 1.17 |
| CLO2 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1.333333333 |
| CLO3 | 3 | 2 | 3 | 2 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1.333333333 |
| CLO4 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 0 | 0 | 1 | 0 | 2 | 1.416666667 |
| CLO5 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 0 | 1 | 1 | 1 | 2 | 1.583333333 |
| Avg PLO | 2.6 | 2.2 | 2.4 | 1.6 | 1.8 | 1.0 | 1.6 | 0.0 | 0.2 | 1.0 | 0.2 | 1.8 | 1.4 |

**Suggested Reading**


1. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press.
2. Mehrdad Ehsani, Yimin Gao, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley.
4. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles, Wiley.
5. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer.


**Teaching-Learning Strategies**

- Classroom lectures supported by case studies of commercial EV models.
- Tutorial sessions on vehicle dynamics and propulsion power/energy calculations.
- Laboratory/simulation sessions on motor drives and battery modelling using MATLAB/Simulink.
- Assignment-based problem solving on EV design and range estimation.
- Seminar presentations on emerging trends in EV technology and charging infrastructure.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, |

| Course Code | BELEDSC725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | SCADA Systems | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Basic Electrical Engineering | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the fundamentals of SCADA systems. |
| CLO2 | Understand communication technologies used in SCADA. |
| CLO3 | Analyze SCADA architecture and components. |
| CLO4 | Understand data acquisition and supervisory control functions. |
| CLO5 | Apply SCADA systems in industrial and power system applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to SCADA Systems:<br>Introduction, evolution of SCADA systems, supervisory control, data acquisition concepts, advantages and applications. |
| 2 | SCADA Components and Architecture:<br>SCADA architecture, remote terminal units (RTUs), programmable logic controllers (PLCs), master stations, communication interfaces and human machine interfaces. |
| 3 | Communication Systems for SCADA:<br>Communication media, communication protocols, telemetry systems, Modbus, DNP3, IEC standards and networking concepts. |
| 4 | Data Acquisition and Supervisory Control:<br>Data collection, monitoring, alarms and event management, database systems, supervisory control functions and visualization. |
| 5 | Applications of SCADA Systems:<br>SCADA applications in power systems, substations, industries, water systems and smart grid environments, cyber security considerations. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.00 |
| CLO2 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 2 | 3 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO4 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .833333333 |
| CLO5 | 2 | 2 | 2 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.083333333 |
| Avg PLO | 2.6 | 1.6 | 1.2 | 1.2 | 2.6 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 1.0 |

**Suggested Reading**

| | |
|---|---|
| 1 | Stuart A. Boyer, SCADA: Supervisory Control and Data Acquisition. |
| 2 | Gordon Clarke, Deon Reynders and Edwin Wright, Practical Modern SCADA Protocols. |
| 3 | Bailey and Wright, Practical SCADA for Industry. |
| 4 | Krishna Kant, Computer-Based Industrial Control. |
| 5 | David Bailey and Edwin Wright, Practical SCADA for Industry, Elsevier. |

**Teaching-Learning Strategies**

- Classroom lectures.
- Demonstrations of SCADA software.
- Assignments on industrial automation.
- Case studies on SCADA implementation.
- Seminar presentations.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDPP725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | Power Plant Engineering | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Nil | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the layout and operation of thermal power plants. |
| CLO2 | Analyze diesel, gas turbine and combined cycle power plants. |
| CLO3 | Understand nuclear power plant systems and reactor technologies. |
| CLO4 | Analyze hydroelectric power plants and their components. |
| CLO5 | Compare different power generation technologies and their applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Coal Based Thermal Power Plants:<br>Rankine cycle, modern thermal power plant layout, supercritical boilers, FBC boilers, turbines, condensers, fuel and ash handling systems, feed water treatment, cogeneration and binary cycles. |
| 2 | Diesel, Gas Turbine and Combined Cycle Plants:<br>Otto, Diesel, Dual and Brayton cycles, components of diesel and gas turbine plants, combined cycle power plants and integrated gasifier combined cycle systems. |
| 3 | Nuclear Power Plants:<br>Basics of nuclear engineering, nuclear plant layout, BWR, PWR, CANDU, breeder reactors, gas-cooled reactors, liquid metal cooled reactors and safety measures. |
| 4 | Hydroelectric Power Plants:<br>Classification of hydroelectric plants, plant layout, turbines, governing systems and operational characteristics. |
| 5 | Emerging Power Generation Technologies:<br>Renewable energy power plants, environmental aspects, hybrid power generation systems and future trends in power generation. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.83 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .833333333 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| Avg PLO | 2.4 | 2.2 | 1.0 | 1.6 | 1.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 0.9 |

**Suggested Reading**


| | |
|---|---|
| 1 | P. K. Nag, Power Plant Engineering, Tata McGraw Hill. |
| 2 | M. M. El-Wakil, Power Plant Technology, McGraw Hill. |
| 3 | Arora and Domkundwar, Power Plant Engineering, Dhanpat Rai Publications. |
| 4 | Frederick T. Morse, Power Plant Engineering Handbook. |
| 5 | Black and Veatch, Power Plant Engineering, Springer. |


**Teaching-Learning Strategies**

- Classroom lectures.
- Numerical and design tutorials.
- Industrial case studies.
- Power plant layout analysis.
- Seminar presentations and assignments.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDOE725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | Optimization for Engineering Design | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Engineering Mathematics | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Formulate complex electrical and engineering design problems into rigorous mathematical optimization models. |
| CLO2 | Analyze the mathematical properties of optimization problems, distinguishing between convex and non-convex sets and functions. |
| CLO3 | Apply linear programming techniques and the simplex method to solve resource allocation and design problems. |
| CLO4 | Solve constrained and unconstrained non-linear optimization problems utilizing Karush-Kuhn-Tucker (KKT) conditions and numerical methods. |
| CLO5 | Evaluate and implement modern heuristic optimization techniques (e.g., Genetic Algorithms) for practical engineering design scenarios. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Optimization and Convexity<br>Need for optimization in engineering design, formulation of optimization problems: design variables, objective functions, constraints, and bounds. Classification of optimization problems. Mathematical foundations: Taylor series, gradient and Hessian matrices. Introduction to convex optimization: convex sets, convex functions, and generalized inequalities. |
| 2 | Classical and Unconstrained Optimization<br>Necessary and sufficient conditions for local and global extrema in single and multivariable functions. Unconstrained numerical optimization techniques: Steepest Descent (Gradient) method, Newton's method, Quasi-Newton methods (BFGS), and Conjugate Gradient method. Line search methods and convergence analysis. |
| 3 | Linear Programming (LP)<br>Standard form of linear programming problems, geometry of linear programs, and convex polyhedra. The Simplex algorithm: basic feasible solutions, pivoting, and two-phase method. Duality theory in linear programming, dual simplex method, and sensitivity analysis. Applications of LP in electrical network design and power dispatch. |
| 4 | Constrained Non-linear Optimization<br>Optimization with equality and inequality constraints. Method of Lagrange multipliers. Karush-Kuhn-Tucker (KKT) optimality conditions. Convex optimization problems: linear programming, quadratic programming, and quadratically constrained quadratic programming (QCQP). Numerical methods for constrained optimization: penalty function methods, barrier function methods, and interior-point methods. |
| 5 | Modern Optimization Techniques<br>Introduction to heuristic and meta-heuristic search methods for complex, non-differentiable, and non-convex engineering problems. Genetic Algorithms (GA): representation, fitness function, selection, crossover, and mutation operators. Particle Swarm Optimization (PSO) and Simulated Annealing (SA). Application of modern optimization techniques to power system operation, smart grids, and machine design. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.08 |
| CLO2 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.08 |
| CLO3 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1.33 |
| CLO4 | 3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.5 |
| CLO5 | 3 | 2 | 3 | 3 | 3 | 0 | 1 | 0 | 0 | 1 | 0 | 3 | 1.58 |
| Avg PLO | 3.0 | 2.8 | 2.4 | 2.4 | 2.0 | 0.0 | 0.2 | 0.0 | 0.0 | 1.0 | 0.2 | 1.8 | 1.3 |

**Suggested Reading**

| | |
|---|---|
| 1 | Stephen Boyd and Lieven Vandenberghe, Convex Optimization, Cambridge University Press. |
| 2 | Singiresu S. Rao, Engineering Optimization: Theory and Practice, 4th Edition, John Wiley & Sons. |
| 3 | Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, 2nd Edition, PHI Learning. |
| 4 | Edwin K. P. Chong and Stanislaw H. Zak, An Introduction to Optimization, 4th Edition, Wiley. |

**Teaching-Learning Strategies**

Interactive classroom lectures focusing on the rigorous mathematical derivation of optimal control laws.
Numerical problem-solving sessions analyzing continuous and discrete-time system formulations.
Simulation-based exercises using MATLAB to solve the Riccati equation, simulate LQR control, and visualize switching curves for bang-bang control.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDES725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | Energy Storage Systems | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Basic Electrical Engineering, Renewable Energy Systems | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the need and applications of energy storage systems. |
| CLO2 | Analyze electrochemical energy storage technologies. |
| CLO3 | Understand mechanical and thermal energy storage systems. |
| CLO4 | Evaluate energy storage integration with renewable energy systems. |
| CLO5 | Assess energy storage technologies for smart grid applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Energy Storage Systems:<br>Need for energy storage, applications, classification of storage technologies, role in renewable energy integration and smart grids. |
| 2 | Electrochemical Energy Storage:<br>Lead-acid batteries, lithium-ion batteries, sodium-sulphur batteries, flow batteries, battery characteristics and performance parameters. |
| 3 | Mechanical and Thermal Energy Storage:<br>Pumped hydro storage, compressed air energy storage, flywheel energy storage, thermal energy storage systems. |
| 4 | Hydrogen and Emerging Storage Technologies:<br>Hydrogen storage systems, fuel cells, supercapacitors, hybrid energy storage systems and emerging technologies. |
| 5 | Grid Integration and Applications:<br>Energy storage for renewable integration, microgrids, peak shaving, load leveling, frequency regulation and smart grid applications. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0.92 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1.083333333 |
| CLO3 | 3 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | .916666666 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 3 | 0 | 1 | 1 | 0 | 1 | 1.25 |
| CLO5 | 2 | 3 | 1 | 3 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 2.4 | 2.2 | 1.0 | 1.8 | 1.0 | 0.0 | 1.4 | 0.0 | 1.0 | 1.0 | 0.0 | 1.2 | 1.1 |

**Suggested Reading**


| | |
|---|---|
| 1 | Ru-Shiii Liu et al., Energy Storage Devices for Future Hybrid Electric Vehicles, CRC Press. |
| 2 | Trevor M. Letcher, Storing Energy, Elsevier. |
| 3 | Henrik Sørensen, Energy Storage, Academic Press. |
| 4 | Robert Huggins, Energy Storage, Springer. |
| 5 | James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley. |


**Teaching-Learning Strategies**

- Interactive lectures.
- Case studies on energy storage projects.
- Design-oriented assignments.
- Simulation exercises.
- Student seminars.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDSM725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | Special Electrical Machines | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Electrical Machines | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the construction and operation of synchronous reluctance motors. |
| CLO2 | Analyze the characteristics and control of stepper motors. |
| CLO3 | Understand the operation of brushless DC motors. |
| CLO4 | Analyze permanent magnet synchronous motors. |
| CLO5 | Select suitable special machines for industrial applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Synchronous Reluctance Motors:<br>Constructional features, axial and radial flux motors, operating principles, variable reluctance motors, voltage and torque equations, phasor diagram, characteristics and applications. |
| 2 | Stepper Motors:<br>Construction, principle of operation, variable reluctance and hybrid stepper motors, torque equations, excitation modes, drive circuits, microprocessor control, closed-loop control and applications. |
| 3 | Brushless DC Motors:<br>Permanent magnet materials, magnetic characteristics, operating principle, types, magnetic circuit analysis, EMF and torque equations, commutation, converter circuits, characteristics and applications. |
| 4 | Permanent Magnet Synchronous Motors:<br>Principle of operation, EMF and torque equations, armature MMF, synchronous reactance, phasor diagram, torque-speed characteristics and applications. |
| 5 | Control and Applications of Special Machines:<br>Power controllers, converter requirements, control strategies, industrial applications and comparison of special electrical machines. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.00 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .833333333 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 2 | 2 | 1 | 1 | 3 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| Avg PLO | 2.4 | 2.0 | 1.6 | 1.4 | 1.0 | 0.6 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 1.0 |

**Suggested Reading**


| | |
|---|---|
| 1 | Fitzgerald, Kingsley and Umans, Electric Machinery, Tata McGraw Hill. |
| 2 | Stephen J. Chapman, Electric Machinery Fundamentals, McGraw Hill. |
| 3 | I. J. Nagrath and D. P. Kothari, Electric Machines, Tata McGraw Hill. |
| 4 | K. Venkataratnam, Special Electrical Machines, Universities Press. |
| 5 | E. G. Janardanan, Special Electrical Machines, PHI Learning. |


**Teaching-Learning Strategies**

- Classroom lectures.
- Tutorials on machine characteristics.
- Simulation exercises.
- Case studies and industrial applications.
- Student presentations.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDHV725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | High Voltage Engineering | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Nil | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand breakdown mechanisms in gaseous, liquid and solid dielectrics. |
| CLO2 | Analyze insulating materials used in high-voltage equipment. |
| CLO3 | Understand generation and measurement of high voltages and currents. |
| CLO4 | Apply non-destructive testing techniques for insulation assessment. |
| CLO5 | Evaluate testing procedures of high-voltage electrical apparatus. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Breakdown in Gaseous Dielectrics:<br>Gases as insulators, ionization processes, Townsend breakdown, Paschen's law, streamer theory, corona discharge and insulation applications. |
| 2 | Breakdown in Liquid and Solid Dielectrics:<br>Conduction and breakdown in liquid dielectrics, intrinsic, thermal and electromechanical breakdown of solid dielectrics, composite insulation systems. |
| 3 | Insulating Materials and Applications:<br>Insulating materials used in transformers, rotating machines, circuit breakers, cables, capacitors and electronic equipment. |
| 4 | Generation and Measurement of High Voltages:<br>Generation of high AC, DC and impulse voltages and currents, measurement techniques for high voltages and currents. |
| 5 | High Voltage Testing and Diagnostics:<br>Measurement of dielectric properties, partial discharge measurement, non-destructive testing, testing of insulators, bushings, circuit breakers, cables, transformers and surge arresters. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.83 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 1 | 3 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO4 | 2 | 3 | 2 | 3 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO5 | 2 | 3 | 1 | 3 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.083333333 |
| Avg PLO | 2.4 | 2.2 | 1.2 | 2.4 | 1.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 1.0 |

**Suggested Reading**

| | |
|---|---|
| 1 | E. Kuffel and W. S. Zaengl, High Voltage Engineering Fundamentals, Newnes. |
| 2 | M. S. Naidu and V. Kamaraju, High Voltage Engineering, Tata McGraw Hill. |
| 3 | Dieter Kind and Kurt Feser, High Voltage Test Techniques, Newnes. |
| 4 | Subir Ray, An Introduction to High Voltage Engineering, PHI. |
| 5 | C. L. Wadhwa, High Voltage Engineering, New Age International. |

**Teaching-Learning Strategies**

- Classroom lectures.
- Tutorial sessions.
- Laboratory demonstrations.
- Case studies on insulation failures.
- Seminar presentations on modern HV technologies.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEODS725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | Digital Signal Processing | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Nil | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the fundamentals of discrete-time signals and systems. |
| CLO2 | Analyze signals and systems using Fourier and Z-transform techniques. |
| CLO3 | Understand sampling and signal reconstruction processes. |
| CLO4 | Analyze and realize discrete-time systems using suitable structures. |
| CLO5 | Design and evaluate digital filters for signal processing applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Discrete-Time Signals and Systems:<br>Discrete-time signals and sequence operations, discrete-time systems, linear time-invariant systems, impulse response, causality and stability, frequency-domain representation of discrete-time signals and systems, Fourier transform and its properties. |
| 2 | Sampling and Signal Reconstruction:<br>Sampling of continuous-time signals, periodic sampling, frequency-domain representation of sampling, signal reconstruction, discrete-time processing of continuous-time signals, continuous-time processing of discrete-time signals, sampling rate conversion. |
| 3 | Z-Transform and System Analysis:<br>Z-transform, region of convergence, properties of Z-transform, inverse Z-transform, frequency response of LTI systems, system functions, linear constant coefficient difference equations, FIR and IIR systems. |
| 4 | Realization of Discrete-Time Systems:<br>Block diagram representation of linear constant coefficient difference equations, signal flow graph representation, realization structures for IIR systems, transposed forms, realization structures for FIR systems. |
| 5 | Digital Filter Design:<br>Design of discrete-time IIR filters from continuous-time filters, impulse invariance method, bilinear transformation, Butterworth, Chebyshev and Elliptic approximations, low-pass, high-pass, band-pass and band-stop filters, FIR filter design using window techniques, Hamming, Hanning and Kaiser windows. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.83 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| Avg PLO | 2.4 | 2.2 | 1.8 | 1.6 | 1.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 1.0 |

**Suggested Reading**

| | |
|---|---|
| 1 | A. V. Oppenheim and R. W. Schafer, Discrete-Time Signal Processing, Prentice Hall. |
| 2 | John G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall. |
| 3 | L. R. Johnson, Introduction to Digital Signal Processing, Prentice Hall. |
| 4 | L. R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall. |
| 5 | S. Salivahanan, A. Vallavaraj and C. Gnanapriya, Digital Signal Processing, McGraw Hill. |
| 6 | Sanjit K. Mitra, Digital Signal Processing: A Computer-Based Approach, McGraw Hill. |

**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Tutorial sessions on transform analysis and filter design.
- Numerical problem-solving exercises.
- MATLAB/Octave-based demonstrations of DSP concepts.
- Student assignments and seminar presentations on signal processing applications.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEOEB725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | Energy Management in Buildings | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Basic understanding of Energy Sustainability and Risk Management | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand energy consumption patterns and conservation opportunities in buildings. |
| CLO2 | Analyze heat transfer mechanisms and thermal performance of buildings. |
| CLO3 | Evaluate lighting systems and daylight utilization techniques for energy-efficient buildings. |
| CLO4 | Understand heating, cooling and ventilation requirements of buildings. |
| CLO5 | Apply building energy management principles and relevant standards for sustainable building design. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Energy Use in Buildings:<br>Energy consumption in buildings, factors affecting energy use, energy conservation opportunities, climatic factors, climatic zones, building orientation, shading and sizing of shading devices. |
| 2 | Thermal Comfort and Heat Transmission:<br>Thermal comfort criteria and parameters, psychrometric chart, indoor air quality requirements in residential, commercial and hospital buildings. Heat transmission through walls, windows and roofs, surface coefficients, air cavities, overall thermal transmittance, heat transfer due to ventilation and infiltration. |
| 3 | Building Thermal Performance:<br>Internal heat gains, solar temperature effects, steady-state methods for building heat transfer analysis, Trombe wall, water wall and solarium concepts, thermal performance improvement techniques. |
| 4 | Lighting and Daylighting Systems:<br>Lighting fundamentals, visual performance, illumination calculations, energy-efficient lighting systems, estimation of available daylight, daylighting systems, advantages and limitations of daylight utilization in buildings. |
| 5 | HVAC Systems and Building Energy Codes:<br>ASHRAE methods and standards for heating, cooling and ventilation load estimation, ventilation requirements for different building types, air quality control equipment, conditioned air distribution systems, building design considerations for different climatic zones, thumb rules for building system design and building energy codes. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 1 | 1.08 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 2 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO3 | 2 | 3 | 1 | 2 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 1 | 1.25 |
| CLO4 | 3 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 2 | 3 | 1 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 1 | 2.083333333 |
| Avg PLO | 2.4 | 2.0 | 1.4 | 1.4 | 1.4 | 2.2 | 1.0 | 0.4 | 1.0 | 1.0 | 0.6 | 1.0 | 1.3 |

**Suggested Reading**


| | |
|---|---|
| 1 | M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive: Building Science and Design, Pergamon Press. |
| 2 | J. A. Markus and R. N. Morris, Building, Climate and Energy, Spottiswoode Ballantyne Ltd., London. |
| 3 | D. Buddhi, Energy Storage Technologies, School of Energy and Environmental Studies, DAVV, Indore. |
| 4 | J. L. Threlkeld, Thermal Environmental Engineering, Prentice Hall. |
| 5 | B. Givoni, Man, Climate and Architecture, Elsevier. |
| 6 | ASHRAE Handbook – Fundamentals, American Society of Heating, Refrigerating and Air-Conditioning Engineers. |


**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Case studies on energy-ef
- Interactive classroom lectures.
- Case studies on energy-efficient and green buildings.
- Numerical exercises on heat transfer and lighting calculations.
- Analysis of building energy performance and conservation measures.
- Student seminars and assignments on sustainable building technologies.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEOIT725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | Internet of Things for Engineers | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Basic Knowledge of Computers and Communication Systems | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the fundamentals and architecture of Internet of Things (IoT). |
| CLO2 | Explain the role of sensors, actuators and embedded devices in IoT systems. |
| CLO3 | Understand communication protocols and networking technologies used in IoT. |
| CLO4 | Analyze cloud-based IoT platforms and data management techniques. |
| CLO5 | Design simple IoT solutions for engineering and industrial applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Internet of Things:<br>Evolution of IoT, definition and characteristics of IoT, IoT architecture, enabling technologies, components of IoT systems, applications of IoT in smart homes, smart cities, healthcare, agriculture and industry. |
| 2 | Sensors, Actuators and Embedded Systems:<br>Introduction to sensors and actuators, sensor characteristics, embedded systems for IoT, microcontrollers and single-board computers, data acquisition, interfacing techniques and IoT hardware platforms. |
| 3 | IoT Communication and Networking:<br>IoT communication models, wired and wireless communication technologies, Wi-Fi, Bluetooth, ZigBee, RFID, NFC, LoRaWAN, cellular IoT, MQTT, CoAP and other application layer protocols. |
| 4 | Cloud Computing and Data Analytics for IoT:<br>Introduction to cloud computing, IoT cloud platforms, data storage and management, IoT data analytics, real-time monitoring, visualization techniques and cybersecurity considerations in IoT systems. |
| 5 | Industrial and Engineering Applications of IoT:<br>Industrial Internet of Things (IIoT), smart energy systems, smart grid applications, remote monitoring and control, predictive maintenance, IoT-based automation systems, case studies and emerging trends in IoT. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.00 |
| CLO2 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO4 | 2 | 3 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 3 | 1 | 1.416666667 |
| CLO5 | 2 | 2 | 3 | 1 | 3 | 3 | 0 | 0 | 1 | 1 | 0 | 1 | 1.416666667 |
| Avg PLO | 2.6 | 1.6 | 1.4 | 1.2 | 3.0 | 0.6 | 0.0 | 0.0 | 1.0 | 1.0 | 0.6 | 1.0 | 1.2 |

**Suggested Reading**


| | |
|---|---|
| 1 | Arshdeep Bahga and Vijay Madisetti, Internet of Things: A Hands-On Approach, Universities Press. |
| 2 | Raj Kamal, Internet of Things: Architecture and Design Principles, McGraw Hill Education. |
| 3 | David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton and Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things, Cisco Press. |
| 4 | Olivier Hersent, David Boswarthick and Omar Elloumi, The Internet of Things: Key Applications and Protocols, Wiley. |
| 5 | Srinivasa K. G. and Siddesh G. M., Internet of Things, Cengage Learning. |
| 6 | Samuel Greengard, The Internet of Things, MIT Press. |


**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Demonstrations of IoT hardware and software platforms.
- Case studies on industrial and smart system applications.
- Mini-projects involving IoT-based monitoring and control systems.
- Student seminars, assignments and technical presentations.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEPMP725 | | | | Semester | Semester VII | |
|---|---|---|---|---|---|---|---|
| Course Title | Minor Project | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 0 | 0 | 3 | 3 | 3 | 100 | |
| Prerequisites | As per relevant core courses of Semesters III–VI | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Identify a real-world electrical engineering problem and conduct a literature survey to establish the project's scope and objectives. |
| CLO2 | Formulate a design or investigation methodology appropriate to the identified problem. |
| CLO3 | Implement or simulate the proposed design/investigation using appropriate tools and techniques. |
| CLO4 | Test, validate and analyze the results obtained from the implemented work. |
| CLO5 | Document the project work and present the findings through a technical report and viva-voce. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Problem Identification and Literature Survey:<br>Identification of a problem in the domain of electrical/electronics engineering; preliminary literature survey; formulation of objectives and scope; feasibility study and identification of required resources. |
| 2 | Project Planning and Design:<br>Detailed literature review; selection of methodology/approach; system design or theoretical formulation; planning of resources, tools, and timeline; submission of the project proposal/synopsis. |
| 3 | Implementation:<br>Development of the hardware/software/simulation model as applicable; execution of the proposed design; iterative refinement based on preliminary results and supervisor feedback. |
| 4 | Testing and Validation:<br>Testing of the developed system or model; validation against the stated objectives; analysis of results; comparison with existing approaches where applicable. |
| 5 | Documentation and Presentation:<br>Preparation of the project report as per the prescribed departmental format; preparation of presentation material; viva-voce examination before the departmental evaluation committee. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1.25 |
| CLO2 | 2 | 2 | 3 | 2 | 2 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 1.5 |
| CLO3 | 1 | 2 | 2 | 3 | 3 | 1 | 1 | 0 | 2 | 1 | 2 | 2 | 1.666666667 |
| CLO4 | 1 | 2 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1.5 |
| CLO5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 | 2 | 1.5 |
| Avg PLO | 1.4 | 2.0 | 1.8 | 2.2 | 1.8 | 1.0 | 1.0 | 0.4 | 1.6 | 1.6 | 1.4 | 1.6 | 1.5 |

**Suggested Reading**

| | |
|---|---|
| 1 | Relevant technical literature (journals, standards, patents) identified through the literature survey specific to the chosen project topic, in consultation with the supervisor. |
| 2 | Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications. |

**Teaching-Learning Strategies**

- Periodic one-on-one guidance and review meetings with the project supervisor.
- Milestone-based progress reviews before a departmental committee.
- Peer review and group discussion of project proposals and progress.
- Hands-on implementation/simulation work carried out under supervision.
- Structured technical report writing and presentation practice.

# *Semester VIII*

| *Course Code* | BELEDSG825 | | | | *Semester* | *Semester VIII* | |
|---|---|---|---|---|---|---|---|
| *Course Title* | Smart Grid | | | | | *Max marks* | |
| *Scheme & Credits* | *Hours Per Week* | | | | *Credits* | *Theory* | *Practical* |
| | *L* | *T* | *P* | *Total* | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| *Prerequisites* | *Power Systems* | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| **CLO1** | Understand the architecture and components of smart grids. |
| **CLO2** | Analyze distributed generation and wide-area monitoring systems. |
| **CLO3** | Understand smart grid protection and energy storage integration. |
| **CLO4** | Analyze operation and control of AC, DC and hybrid microgrids. |
| **CLO5** | Apply demand-side management and energy management techniques in smart grids. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Smart Grids:<br>Evolution of electric power systems, concept of smart grid, architecture of smart grid systems, standards, technologies and key components of smart grids. |
| 2 | Monitoring and Protection Systems:<br>Distributed generation resources, wide area monitoring systems, phasor measurement units, phasor estimation, digital relays and smart grid protection. |
| 3 | Smart Grid Components and Storage:<br>Islanding detection techniques, smart grid protection, modelling of energy storage devices, modelling of DC smart grid components. |
| 4 | Microgrid Operation and Control:<br>Operation and control of AC microgrids, DC microgrids and AC–DC hybrid microgrids, distributed energy resource management. |
| 5 | Demand Side Management and Energy Management:<br>Demand side management, demand response, energy management systems, smart grid design considerations and analysis of AC/DC smart grids. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CLO1** | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0.92 |
| **CLO2** | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| **CLO3** | 3 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 1 |
| **CLO4** | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| **CLO5** | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 3 | 2 | 1.333333333 |
| **Avg PLO** | 2.4 | 2.0 | 1.2 | 1.4 | 1.0 | 0.0 | 0.4 | 0.0 | 1.0 | 1.0 | 0.6 | 1.6 | 1.1 |

**Suggested Reading**

| | |
|---|---|
| 1 | Ali Keyhani and Mohammad Marwali, Smart Power Grids. |
| 2 | Arun G. Phadke and James S. Thorp, Computer Relaying for Power Systems. |
| 3 | Nikos Hatziargyriou, Microgrids: Architecture and Control, Wiley. |
| 4 | Fang Lin Luo and Hong Ye, Renewable Energy Systems. |
| 5 | James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley. |

**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Tutorials on smart grid applications.
- Simulation studies using software tools.
- Case studies on smart grid projects.
- Seminar presentations on emerging smart grid technologies.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDDM825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Distribution System Modelling & Analysis | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Power Systems – I, Power Systems – II | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Model the series impedance of overhead and underground distribution lines using Carson's equations and matrix (Kron) reduction. |
| CLO2 | Develop shunt admittance and generalized line models for radial distribution feeders. |
| CLO3 | Represent distribution loads and construct three-phase transformer and step-voltage-regulator models. |
| CLO4 | Apply the ladder iterative technique to perform unbalanced three-phase power-flow analysis on radial feeders. |
| CLO5 | Perform short-circuit analysis on distribution feeders and model center-tapped transformers and secondaries. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Distribution Systems and Load Characteristics:<br>Distribution substation, primary and secondary feeders, distribution transformers and their role in the power system; the nature of loads: demand, maximum demand, diversity factor, load factor, loss factor; individual customer load and distribution transformer loading; approximate/balanced methods of feeder analysis. |
| 2 | Series Impedance of Distribution Lines:<br>Series impedance of overhead lines, Carson's equations and modified Carson's equations, primitive impedance matrix, Kron reduction to the phase impedance matrix; series impedance of underground cables — concentric neutral and tape-shielded cable models. |
| 3 | Shunt Admittance and Distribution Line Models:<br>Shunt admittance of overhead and underground lines, calculation of the capacitance matrix; the generalized (two-port) line model, exact and modified line-segment models, approximate line-segment model; application of line models in feeder studies. |
| 4 | Voltage Regulation and Three-Phase Transformer Models:<br>Step-voltage regulators, single-phase and three-phase regulator models, line-drop compensation; three-phase transformer models for standard connections — grounded wye–delta, ungrounded wye–delta, open-delta — and generalized transformer matrices. |
| 5 | Load Models, Feeder Analysis and Center-Tapped Transformers:<br>Load models — constant impedance, constant current, constant power and combination loads; induction machine as motor and generator; the ladder iterative technique for unbalanced three-phase power-flow analysis; short-circuit analysis of distribution feeders; center-tapped transformer and secondary models. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 3 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.08 |
| CLO2 | 3 | 2 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.083333333 |
| CLO3 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1.25 |
| CLO4 | 3 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1.5 |
| CLO5 | 2 | 3 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1.166666667 |
| Avg PLO | 2.6 | 2.8 | 2.4 | 1.6 | 2.2 | 0.4 | 0.2 | 0.0 | 0.2 | 1.0 | 0.0 | 1.2 | 1.2 |

**Suggested Reading**

| | |
|---|---|
| 1 | William H. Kersting, Distribution System Modeling and Analysis, 4th ed., CRC Press, 2018. [Prescribed text — course content and unit structure follow this book] |
| 2 | Turan Gönen, Electric Power Distribution Engineering, 3rd ed., CRC Press, 2014. |
| 3 | IEEE Std 399, IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (Brown Book). |
| 4 | A. Anand Kumar, Control Systems, PHI Learning Pvt. Ltd. |
| 5 | Franklin, Powell and Emami-Naeini, Feedback Control of Dynamic Systems, Pearson. |

**Teaching-Learning Strategies**

- Classroom lectures integrating theory with the worked numerical examples from Kersting's text.
- Tutorial sessions on per-unit-length impedance/admittance calculations and Kron reduction.
- Computational exercises (MATLAB or equivalent) implementing the ladder iterative technique for feeder power-flow.
- Assignment-based problem solving using standard IEEE test feeders (e.g., 4-bus, 13-bus).
- Seminar presentations on smart-grid and distributed-generation impacts on distribution analysis.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDMG825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Microgrids and Distributed Generation | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Power Systems | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand distributed generation technologies. |
| CLO2 | Analyze planning and integration of distributed generation. |
| CLO3 | Understand microgrid architecture and components. |
| CLO4 | Analyze operation and control of microgrids. |
| CLO5 | Evaluate protection and energy management strategies in microgrids. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Distributed Generation Fundamentals:<br>Introduction to distributed generation, technologies, benefits, challenges, renewable and non-renewable distributed energy resources. |
| 2 | Integration of Distributed Generation:<br>Grid interconnection requirements, power quality issues, voltage regulation, protection coordination and standards. |
| 3 | Microgrid Architecture and Components:<br>AC microgrids, DC microgrids, hybrid microgrids, distributed energy resources, storage systems and control architecture. |
| 4 | Operation and Control of Microgrids:<br>Grid-connected and islanded modes of operation, power sharing, frequency and voltage control, energy management systems. |
| 5 | Protection and Applications:<br>Protection of microgrids, reliability considerations, smart microgrids, community microgrids and practical applications. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.83 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 3 | 1 | 1.25 |
| CLO3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .833333333 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 3 | 1 | 2 | 1 | 0 | 1 | 0 | 1 | 1 | 3 | 1 | 1.333333333 |
| Avg PLO | 2.4 | 2.2 | 1.0 | 1.6 | 1.0 | 0.0 | 0.2 | 0.0 | 1.0 | 1.0 | 1.2 | 1.0 | 1.1 |

**Suggested Reading**

| | |
|---|---|
| 1 | Nikos Hatziargyriou, Microgrids: Architecture and Control, Wiley. |
| 2 | S. Chowdhury, S. P. Chowdhury and P. Crossley, Microgrids and Active Distribution Networks. |
| 3 | Math Bollen and Fainan Hassan, Integration of Distributed Generation in the Power System, Wiley. |
| 4 | James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley. |
| 5 | H. Lee Willis and Walter G. Scott, Distributed Power Generation, CRC Press. |

**Teaching-Learning Strategies**

- Classroom lectures.
- Tutorials and design exercises.
- Simulation studies.
- Case studies on operational microgrids.
- Student seminars.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDFS825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | FACTS | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Power Electronics, Power Systems | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the need and applications of FACTS controllers. |
| CLO2 | Analyze power flow in compensated transmission systems. |
| CLO3 | Understand the operation and characteristics of shunt FACTS devices. |
| CLO4 | Analyze series compensation techniques and FACTS controllers. |
| CLO5 | Evaluate advanced FACTS devices for power flow and stability improvement. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to FACTS Technology:<br>Introduction to FACTS technology, types of FACTS controllers, FACTS versus HVDC, benefits of FACTS technology, transmission line performance equations, active and reactive power flow, uncompensated transmission lines, need and functions of compensation. |
| 2 | Shunt Compensation Techniques:<br>Ideal shunt compensation, ideal series compensation, phase angle control, advantages of shunt and series compensation, Thyristor Controlled Reactor (TCR), Thyristor Switched Capacitor (TSC). |
| 3 | Static VAR Systems and Series Controllers:<br>Static VAR Compensator (SVC), Static Synchronous Compensator (STATCOM), comparison of SVC and STATCOM, GTO Controlled Series Capacitor (GCSC), Thyristor Switched Series Capacitor (TSSC), Thyristor Controlled Series Capacitor (TCSC), Static Synchronous Series Compensator (SSSC). |
| 4 | Voltage and Phase Angle Controllers:<br>Thyristor Controlled Voltage Regulator (TCVR), Thyristor Controlled Phase Angle Regulator (TCPAR), voltage regulation and phase angle control. |
| 5 | Advanced FACTS Controllers:<br>Series-shunt compensators, Unified Power Flow Controller (UPFC), Interline Power Flow Controller (IPFC), Thyristor Controlled Braking Resistor (TCBR), applications of FACTS controllers in modern power systems. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.83 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .833333333 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1.083333333 |
| Avg PLO | 2.4 | 2.2 | 1.0 | 1.6 | 1.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.2 | 1.0 |

**Suggested Reading**

| | |
|---|---|
| 1 | N. G. Hingorani and L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, Wiley. |
| 2 | K. R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International. |
| 3 | Xiao-Ping Zhang, Christian Rehtanz and Bikash Pal, Flexible AC Transmission Systems: Modelling and Control, Springer. |
| 4 | R. Mohan Mathur and Rajiv K. Varma, Thyristor-Based FACTS Controllers for Electrical Transmission Systems, Wiley. |
| 5 | Narain G. Hingorani, Flexible AC Transmission, IEEE Press. |

**Teaching-Learning Strategies**

- Classroom lectures with numerical examples.
- Tutorial sessions on power flow and compensation calculations.
- Simulation studies using MATLAB/Simulink.
- Case studies on FACTS installations.
- Seminar presentations on emerging FACTS technologies.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDOC825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Optimal Control | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Control Systems, Engineering Mathematics | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Formulate optimal control problems by defining appropriate state variable models, physical constraints, and performance measures. |
| CLO2 | Apply the principle of optimality and dynamic programming to solve discrete-time and continuous-time optimal control problems. |
| CLO3 | Utilize the fundamental concepts of the calculus of variations to derive necessary conditions for the extremization of functionals. |
| CLO4 | Apply Pontryagin's Minimum Principle to determine optimal control laws for constrained and unconstrained dynamic systems. |
| CLO5 | Design Linear Quadratic Regulators (LQR) and time-optimal (bang-bang) controllers for linear systems |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Optimal Control and Performance Measures<br>Introduction to the optimal control problem, state variable representation of dynamic systems. Formulation of the optimal control problem: plant, performance index, and constraints. Typical performance measures: minimum-time, minimum-energy, minimum-fuel, and tracking problems. Formulating the objective function and basic mathematical prerequisites. |
| 2 | Dynamic Programming<br>The principle of optimality, application of the principle of optimality to decision-making. Discrete-time linear quadratic regulator (LQR) problem, discrete dynamic programming approach. Continuous-time systems: the Hamilton-Jacobi-Bellman (HJB) equation, closed-loop optimal control, and numerical solution of the HJB equation. |
| 3 | The Calculus of Variations<br>Fundamental concepts of the calculus of variations, functionals, the variation of a functional. Necessary conditions for an extremum: the Euler-Lagrange equation. Boundary conditions, transversality conditions, piecewise-smooth extremals. Constrained extremization of functionals using Lagrange multipliers. |
| 4 | The Variational Approach and Pontryagin's Minimum Principle<br>Necessary conditions for optimal control using the variational approach. State and costate (adjoint) equations. Boundary condition equations. Pontryagin's Minimum Principle: formulation of the Hamiltonian, necessary conditions for unconstrained and control-constrained systems. State-variable inequality constraints. |
| 5 | Linear Quadratic Regulator (LQR) and Minimum-Time Problems<br>The Continuous-Time Linear Quadratic Regulator (LQR) problem, derivation of the matrix Riccati equation, steady-state Riccati equation, and closed-loop pole placement. Minimum-time control of linear time-invariant systems, bang-bang control, switching curves and surfaces, minimum-effort control problems. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.08 |
| CLO2 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1.16 |
| CLO3 | 3 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| CLO4 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.25 |
| CLO5 | 3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1.5 |
| Avg PLO | 3.0 | 3.0 | 2.0 | 2.2 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 1.4 | 1.2 |

**Suggested Reading**


1. Donald E. Kirk, Optimal Control Theory: An Introduction, Dover Publications.
2. Desineni Subbaram Naidu, Optimal Control Systems, CRC Press.
3. Frank L. Lewis, Draguna Vrabie, and Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley.
4. Arthur E. Bryson and Yu-Chi Ho, Applied Optimal Control: Optimization, Estimation and Control, Taylor & Francis.


**Teaching-Learning Strategies**

- Interactive classroom lectures focusing on the rigorous mathematical derivation of optimal control laws.
- Numerical problem-solving sessions analyzing continuous and discrete-time system formulations.
- Simulation-based exercises using MATLAB to solve the Riccati equation, simulate LQR control, and visualize switching curves for bang-bang control.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDHV825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | HVDC Transmission | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Power Systems | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the need and advantages of HVDC transmission. |
| CLO2 | Analyze converter and inverter operation in HVDC systems. |
| CLO3 | Understand control and protection of HVDC transmission. |
| CLO4 | Analyze reactive power requirements and harmonics in HVDC systems. |
| CLO5 | Evaluate the impact of HVDC transmission on power system performance and stability. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to HVDC Transmission:<br>Comparison of AC and DC transmission, economic considerations, advantages and limitations of HVDC systems, types of HVDC links, applications of HVDC transmission. |
| 2 | HVDC Converters and Inverters:<br>Line commutated converters, converter and inverter operation, converter circuits, converter transformers, converter characteristics and performance. |
| 3 | Control and Protection of HVDC Systems:<br>Control characteristics, firing angle control, extinction angle control, power control, current control, protection of HVDC systems and converter stations. |
| 4 | Reactive Power and Harmonics:<br>Reactive power requirements, harmonic generation, harmonic filters, smoothing reactors and reactive power compensation techniques. |
| 5 | Modern HVDC Systems and Applications:<br>Voltage source converter (VSC) based HVDC systems, multi-terminal HVDC systems, HVDC for renewable integration and improvement of power system stability. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.83 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .833333333 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| Average | 2.4 | 2.2 | 1.0 | 1.6 | 1.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 0.9 |

**Suggested Reading**


| | |
|---|---|
| 1 | K. R. Padiyar, HVDC Power Transmission Systems, New Age International. |
| 2 | J. Arrillaga, High Voltage Direct Current Transmission, IET Publications. |
| 3 | E. W. Kimbark, Direct Current Transmission, Wiley. |
| 4 | Prabha Kundur, Power System Stability and Control, McGraw Hill. |
| 5 | Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International. |


**Teaching-Learning Strategies**

- Classroom lectures and tutorials.
- Numerical problems on HVDC performance.
- Simulation studies using software tools.
- Case studies of existing HVDC projects.
- Student seminars on modern HVDC technologies.

**Evaluation Scheme**

Theory: Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)
Semester End Examination (SEE): 50 marks

Practical: NA

| Course Code | BELEDFL825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Fuzzy Logic and Neural Networks | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Digital Logic | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the fundamentals of artificial neural networks. |
| CLO2 | Analyze various neural network architectures and learning strategies. |
| CLO3 | Apply neural network models to engineering problems. |
| CLO4 | Understand fuzzy logic concepts and inference systems. |
| CLO5 | Analyze hybrid intelligent systems based on neural networks and fuzzy logic. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Neural Networks:<br>Humans and computers, biological neurons, artificial neuron models, characteristics of ANN, McCulloch-Pitts model, historical development and applications of neural networks. |
| 2 | Fundamentals of Artificial Neural Networks:<br>Artificial neuron operation, activation functions, ANN architectures, neural dynamics, supervised, unsupervised and reinforcement learning strategies, learning rules. |
| 3 | Learning Paradigms and ANN Models:<br>Back propagation algorithm, pattern classification, clustering, Kohonen self-organizing maps, radial basis function networks, support vector machines, Hopfield networks, associative memory and engineering applications. |
| 4 | Fuzzy Logic Systems:<br>Fuzzy sets, membership functions, fuzzy relations, operations on fuzzy sets, fuzzification, defuzzification, fuzzy inference systems and applications. |
| 5 | Hybrid Intelligent Systems:<br>Genetic algorithms, neuro-fuzzy systems, adaptive neuro-fuzzy inference systems, evolutionary neural networks and applications in engineering and power systems. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.00 |
| CLO2 | 2 | 3 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO3 | 2 | 2 | 2 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.083333333 |
| CLO4 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 2 | 3 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 1.25 |
| Avg PLO | 2.4 | 2.0 | 1.2 | 1.4 | 3.0 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.2 | 1.1 |

**Suggested Reading**

| | |
|---|---|
| 1 | Jacek M. Zurada, Introduction to Artificial Neural Systems, PWS Publishing Company. |
| 2 | S. Haykin, Neural Networks: A Comprehensive Foundation, Pearson. |
| 3 | Valluru Rao and Hayagriva Rao, Neural Networks and Fuzzy Logic, BPB Publications. |
| 4 | Freeman, Neural Networks, Pearson Education. |
| 5 | Rajasekaran and Pai, Genetic Algorithms: Concepts and Applications, Prentice Hall India. |

**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Tutorials on neural network algorithms.
- Software-based demonstrations and simulations.
- Assignments on fuzzy and intelligent systems.
- Seminar presentations and case studies.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDRP825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Restructuring of Power Systems | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Power Systems – I, Power Systems – II | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the concept of restructuring and deregulation of electricity markets and the need for reforms in the power sector. |
| CLO2 | Analyze various market models for electricity trading and evaluate transmission congestion management techniques. |
| CLO3 | Apply Locational Marginal Pricing (LMP) and Financial Transmission Rights (FTR) to solve transmission pricing problems. |
| CLO4 | Evaluate ancillary service management, pricing of network usage, loss allocation, and market power issues. |
| CLO5 | Assess the reforms in the Indian power sector and understand the regulatory framework and challenges of deregulation. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Restructuring of the Power Industry and Fundamentals of Economics:<br>Overview of traditional vertically integrated power systems; Motivation for restructuring and deregulation; Objectives and challenges of electricity market reform; Key players in a deregulated power system; Money, power and information flow; Basic economics of electricity: supply, demand, cost curves, marginal cost, price elasticity; Economic efficiency and welfare concepts applied to electricity markets. |
| 2 | Philosophy of Market Models and Transmission Congestion Management:<br>Pool model, bilateral contracts model and hybrid models; Single buyer model, competitive wholesale market, retail competition; Spot market, day-ahead market, real-time market; Role of system operator and market operator; Transmission congestion: definition, causes and impacts; Congestion management methods — pro-rata curtailment, locational pricing, market splitting, transmission rights; Security-constrained economic dispatch. |
| 3 | Locational Marginal Prices (LMP) and Financial Transmission Rights (FTR):<br>Concept and calculation of Locational Marginal Prices (LMP); LMP components — energy, congestion and loss components; DC optimal power flow for LMP calculation; Impact of congestion on LMPs; Financial Transmission Rights (FTR): definition, types (obligations and options); FTR revenue adequacy; Simultaneous feasibility test; Ancillary service management: definition and types — frequency regulation, voltage support, black-start, spinning reserve, reactive power supply; Procurement and pricing of ancillary services. |
| 4 | Pricing of Transmission Network Usage, Loss Allocation and Market Power:<br>Transmission pricing approaches — postage stamp, MW-mile method, contract path method; Distribution factors: PTDF, OTDF; Marginal cost-based and embedded cost-based transmission pricing; Loss allocation methods — pro-rata, marginal loss coefficients; Revenue reconciliation; Market power in electricity markets: definition, indicators and measurement (Lerner index, HHI); Generator bidding strategies — single-unit and multi-unit bidding; Mitigating market power: regulatory and market-based solutions. |
| 5 | Reforms in the Indian Power Sector:<br>Historical overview of the Indian power sector; Electricity Act 2003 and its key provisions; Unbundling of generation, transmission and distribution; State Electricity Regulatory Commissions (SERCs) and Central Electricity Regulatory Commission (CERC); Availability Based Tariff (ABT) mechanism; Open access and its implementation; Power exchanges in India — IEX and PXIL; Renewable energy integration challenges in the deregulated framework; Future roadmap and challenges of power sector reforms in India. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 2 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 1 | 1 | 1.25 |
| CLO2 | 2 | 3 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 1.25 |
| CLO3 | 3 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.25 |
| CLO4 | 2 | 3 | 2 | 2 | 2 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1.416666667 |
| CLO5 | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 2 | 1.5 |
| Avg PLO | 2.4 | 2.6 | 1.6 | 1.6 | 1.4 | 1.4 | 0.4 | 0.4 | 1.0 | 1.0 | 0.8 | 1.4 | 1.3 |

**Suggested Reading**


1. Daniel Kirschen and Goran Strbac, Fundamentals of Power System Economics, John Wiley & Sons.
2. Kankar Bhattacharya, Jaap E. Daadler and Math H. J. Bollen, Operation of Restructured Power Systems, Kluwer Academic Publishers.
3. Mohammad Shahidehpour and Muwaffaq Alomoush, Restructured Electrical Power Systems, Marcel Dekker.
4. Allen J. Wood, Bruce F. Wollenberg and Gerald B. Sheblé, Power Generation, Operation and Control, John Wiley & Sons.
5. A. J. Conejo, E. Castillo, R. Minguez and R. Garcia-Bertrand, Decomposition Techniques in Mathematical Programming, Springer.


**Teaching-Learning Strategies**

- Interactive classroom lectures with real-world electricity market case studies.
- Tutorial sessions on LMP calculation, FTR problems and transmission pricing methods.
- Case studies on deregulated power markets (PJM, UK, Nordpool) and India's ABT mechanism.
- Assignments on market model analysis and generator bidding strategy problems.
- Seminars and group discussions on Indian power sector reform and regulatory issues.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDUT825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Utilization and Traction | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Electrical Machines | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand electric drives and their industrial applications. |
| CLO2 | Analyze electric traction systems and performance characteristics. |
| CLO3 | Understand electric and hybrid electric vehicle technologies. |
| CLO4 | Design and analyze illumination systems. |
| CLO5 | Understand electric heating and welding applications. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Electric Drives:<br>Factors governing selection of electric drives, control devices for industrial motors, motors for particular services and applications of electric drives. |
| 2 | Electric Traction:<br>Requirements of ideal traction, systems of traction, speed-time curves, tractive effort, adhesion, traction motors, speed control methods, braking methods and energy consumption. |
| 3 | Electric and Hybrid Vehicles:<br>Configuration and performance of electric vehicles, traction motor characteristics, transmission requirements, vehicle performance and energy consumption. |
| 4 | Illumination Engineering:<br>Laws of illumination, lighting calculations, factory lighting, flood lighting, street lighting, incandescent, fluorescent, CFL and LED lamps, glare and its remedies. |
| 5 | Electric Heating and Welding:<br>Resistance heating, induction heating, dielectric heating, arc furnaces, electric welding, arc welding, welding equipment and control devices. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 3 | 0 | 0 | 1 | 1 | 0 | 1 | 1.08 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .833333333 |
| CLO4 | 2 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO5 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .833333333 |
| Avg PLO | 2.6 | 1.8 | 1.4 | 1.4 | 1.0 | 0.6 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 1.0 |

**Suggested Reading**

| | |
|---|---|
| 1 | E. Openshaw Taylor, Utilization of Electric Energy. |
| 2 | Mehrdad Ehsani et al., Modern Electric, Hybrid Electric and Fuel Cell Vehicles. |
| 3 | H. Partab, Art and Utilization of Electric Energy. |
| 4 | J. B. Gupta, Utilization of Electric Power and Electric Traction. |
| 5 | C. L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy. |

**Teaching-Learning Strategies**

- Classroom lectures.
- Numerical tutorials.
- Design assignments.
- Industrial application case studies.
- Seminar presentations.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEDIE825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Insulation Engineering and Diagnostics | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 2 | 1 | 0 | 3 | 3 | 100 | |
| Prerequisites | Electrical Materials, High Voltage Engineering | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand insulation systems used in electrical equipment. |
| CLO2 | Analyze insulation ageing and degradation mechanisms. |
| CLO3 | Apply insulation testing and diagnostic techniques. |
| CLO4 | Evaluate insulation condition of power apparatus. |
| CLO5 | Understand condition-based maintenance practices for insulation systems. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Fundamentals of Insulation Engineering:<br>Electrical insulating materials, dielectric properties, insulation systems, electric stress and insulation coordination. |
| 2 | Insulation Ageing and Failure Mechanisms:<br>Thermal ageing, electrical ageing, moisture effects, contamination, mechanical degradation and insulation failures. |
| 3 | Insulation Testing and Diagnostics:<br>Insulation resistance measurement, polarization index, dielectric loss measurement, capacitance testing and partial discharge testing. |
| 4 | Diagnostics of Electrical Equipment:<br>Transformer insulation diagnostics, dissolved gas analysis, cable insulation testing, rotating machine insulation assessment and switchgear diagnostics. |
| 5 | Condition Monitoring and Asset Management:<br>Thermal imaging, online monitoring techniques, condition assessment, remaining life estimation, predictive maintenance and asset management practices. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.83 |
| CLO2 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO3 | 2 | 2 | 2 | 3 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.083333333 |
| CLO4 | 2 | 3 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO5 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 3 | 1 | 1.25 |
| Avg PLO | 2.4 | 2.0 | 1.2 | 1.8 | 1.4 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.6 | 1.0 | 1.0 |

**Suggested Reading**

| | |
|---|---|
| 1 | A. J. Kelen, Insulation Coordination for Power Systems. |
| 2 | M. S. Naidu and V. Kamaraju, High Voltage Engineering. |
| 3 | E. Kuffel and W. S. Zaengl, High Voltage Engineering Fundamentals. |
| 4 | T. J. Gallagher and A. J. Pearmain, High Voltage Measurement, Testing and Design. |
| 5 | A. H. Sharbaugh, Electrical Insulation and Dielectric Phenomena. |

**Teaching-Learning Strategies**

- Classroom lectures.
- Demonstrations of diagnostic techniques.
- Case studies on insulation failures.
- Technical assignments.
- Seminar presentations.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEOAI825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Artificial Intelligence Applications in Engineering | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 1 | 1 | 0 | 2 | 2 | 100 | |
| Prerequisites | Basic Knowledge of Mathematics, Programming and Engineering Systems | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand the fundamental concepts and techniques of Artificial Intelligence. |
| CLO2 | Apply search and knowledge representation techniques to engineering problems. |
| CLO3 | Understand machine learning and neural network concepts. |
| CLO4 | Analyze the role of AI in automation, optimization and decision-making. |
| CLO5 | Evaluate engineering applications of AI in various domains. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Introduction to Artificial Intelligence:<br>Introduction to Artificial Intelligence, history and evolution of AI, intelligent agents, characteristics of intelligent systems, AI problem-solving approaches, applications of AI in engineering, opportunities and challenges of AI technologies. |
| 2 | Knowledge Representation and Search Techniques:<br>Problem formulation, state space representation, uninformed search techniques, informed search techniques, heuristic search, knowledge representation methods, semantic networks, rule-based systems and expert systems. |
| 3 | Machine Learning Fundamentals:<br>Introduction to machine learning, supervised and unsupervised learning, classification and regression concepts, clustering techniques, model evaluation, engineering applications of machine learning. |
| 4 | Neural Networks and Intelligent Systems:<br>Artificial neural networks, perceptron model, multilayer neural networks, learning algorithms, deep learning concepts, fuzzy logic systems, neuro-fuzzy systems and intelligent decision-making techniques. |
| 5 | AI Applications in Engineering:<br>AI applications in power systems, renewable energy systems, industrial automation, robotics, predictive maintenance, fault diagnosis, smart manufacturing, intelligent transportation systems, smart grids and emerging trends in AI. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0.83 |
| CLO2 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .916666666 |
| CLO3 | 3 | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| CLO4 | 2 | 3 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| CLO5 | 2 | 3 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1.166666667 |
| Avg PLO | 2.4 | 2.0 | 1.2 | 1.4 | 2.2 | 0.0 | 0.0 | 0.0 | 1.0 | 1.0 | 0.0 | 1.0 | 1.0 |

**Suggested Reading**

| | |
|---|---|
| 1 | Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson Education. |
| 2 | Elaine Rich and Kevin Knight, Artificial Intelligence, McGraw Hill. |
| 3 | S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI Learning. |
| 4 | Simon Haykin, Neural Networks and Learning Machines, Pearson Education. |
| 5 | Ethem Alpaydin, Introduction to Machine Learning, MIT Press. |
| 6 | S. Kaushik and Sunita Jain, Artificial Intelligence, Cengage Learning. |

**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Demonstrations of AI tools and engineering applications.
- Case studies on AI-based industrial and engineering solutions.
- Mini-projects involving AI-based problem-solving.
- Student seminars, assignments and technical presentations.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEOSC825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Electrical Safety and Energy Conservation | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 1 | 1 | 0 | 2 | 2 | 100 | |
| Prerequisites | Nil | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Understand electrical hazards and safety requirements in domestic, commercial and industrial installations. |
| CLO2 | Apply safe working practices and electrical protection techniques. |
| CLO3 | Understand relevant electrical safety standards and regulations. |
| CLO4 | Analyze energy consumption patterns and identify energy conservation opportunities. |
| CLO5 | Evaluate energy-efficient technologies and sustainable energy management practices. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Fundamentals of Electrical Safety:<br>Introduction to electrical safety, electrical hazards, effects of electric shock on the human body, causes of electrical accidents, safe working practices, safety procedures and personal protective equipment (PPE). |
| 2 | Electrical Protection and Safety Standards:<br>Earthing and grounding systems, protection against electric shock, overcurrent and short-circuit protection, fuses, MCBs, ELCBs and RCCBs, electrical safety regulations, Indian Electricity Rules and safety standards. |
| 3 | Industrial and Domestic Electrical Safety:<br>Safety in residential, commercial and industrial installations, electrical fire hazards, hazardous locations, maintenance safety, lockout-tagout procedures, first aid and emergency response during electrical accidents. |
| 4 | Energy Conservation Principles:<br>Energy scenario and conservation, importance of energy efficiency, energy conservation techniques in electrical systems, energy-efficient motors, transformers, lighting systems and appliances, power factor improvement and demand-side management. |
| 5 | Energy Management and Sustainable Practices:<br>Energy auditing basics, energy performance assessment, renewable energy for energy conservation, green buildings, sustainable energy management practices, energy conservation policies and case studies. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 3 | 1 | 1 | 1 | 1 | 3 | 0 | 2 | 1 | 1 | 0 | 1 | 1.25 |
| CLO2 | 2 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | .916666666 |
| CLO3 | 3 | 1 | 1 | 1 | 1 | 3 | 0 | 2 | 1 | 1 | 0 | 1 | 1.25 |
| CLO4 | 3 | 3 | 1 | 2 | 1 | 2 | 3 | 0 | 1 | 1 | 0 | 1 | 1.5 |
| CLO5 | 2 | 3 | 1 | 2 | 3 | 2 | 3 | 0 | 1 | 1 | 3 | 1 | 1.833333333 |
| Avg PLO | 2.6 | 2.0 | 1.2 | 1.4 | 1.4 | 2.0 | 1.2 | 0.8 | 1.0 | 1.0 | 0.6 | 1.0 | 1.4 |

**Suggested Reading**

| | |
|---|---|
| 1 | S. Rao, Electrical Safety, Fire Safety Engineering and Safety Management, Khanna Publishers. |
| 2 | B. L. Theraja and A. K. Theraja, A Textbook of Electrical Technology, S. Chand. |
| 3 | S. C. Tripathy, Utilization of Electrical Energy and Conservation, McGraw Hill. |
| 4 | Bureau of Energy Efficiency (BEE), Energy Conservation Building Code and Energy Efficiency Manuals. |
| 5 | Guide Books for National Certification Examination for Energy Managers and Energy Auditors, Bureau of Energy Efficiency. |
| 6 | John Cadick et al., Electrical Safety Handbook, McGraw Hill. |

**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Demonstrations of electrical safety equipment and protection devices.
- Case studies on electrical accidents and safety practices.
- Energy conservation audits and analysis exercises.
- Student seminars, assignments and technical presentations.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEOHR825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Organisation of Engineering Systems and Human Resource Management | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 1 | 1 | 0 | 2 | 2 | 100 | |
| Prerequisites | Nil | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | An understanding of the principles of Organisation of engineering systems & HR Management |
| CLO2 | The ability to perceive issues from an overall management perspective. |
| CLO3 | The means to analyse developments in an organisation's systems, functioning and capabilities |
| CLO4 | The means to effectively understand organizational functioning and its human elements |
| CLO5 | The ability to become a performance-oriented manager of systems |

**Syllabus**

| Units | Content |
|---|---|
| 1 | **Introduction to Organization of Engineering Systems and HR Management:** Introducing the core concepts of organisation and HRM. |
| 2 | **Organization Structure and Engineering Business Systems:** Basics of organizations and HR management: Understanding organizations: nature and functions, Concerns of organising engineering business and systems, Concerns of organising engineering business and systems, Structure and process issues in running organisations, Design issues in running organisations Operating organizations |
| 3 | **Organizational Effectiveness and Systems Approach:** Effectiveness and performance: Cybernetics and systems framework,Socio-technical systems, Dealing with efficiency and excellence, Man-machine relationship, Longitudinal Thinking. |
| 4 | **Human Resource Management in Engineering Organizations:** Human elements of functioning organizations: Recruitment and Concerns of recruitment, selection and its process, skill formation and redeployment, Employee engagement and retention. |
| 5 | **Leadership, Motivation and Industrial Relations:** Developing teams and leadership, Understanding motivation, Motivation theories and applications, Elements of HR planning, Indian Industrial Law and managing industrial relations |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 3 | 2 | 0.83 |
| CLO2 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 2 | 3 | 2 | 1 |
| CLO3 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 3 | 2 | 0.92 |
| CLO4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 3 | 2 | 3 | 1 | 1 |
| CLO5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 3 | 2 | 3 | 3 | 1.17 |
| Avg PLO | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 1.4 | 2.4 | 1.6 | 3.0 | 2.0 | 1.0 |

**Suggested Reading**

| | |
|---|---|
| 1 | The Heart of Enterprise by Stafford Beer (1975) — Penguin Press, London |
| 2 | The Future of Organisation: Achieving Excellence through Business Transformation by Colin Coulson-Thomas — Kogan Page |
| 3 | Cybernetics and Applied Systems by Constantin Virgil Negoita — CRC Press, USA |
| 4 | Business, Marketing, and Management Principles for IT and Engineering by Dimitris N. Chorafas — Taylor & Francis, USA |
| 5 | Comparative Manpower Planning Practices: Select Indian Experiences by Vinayshil Gautam — National Publishing House, New Delhi |

**Teaching-Learning Strategies**

- Interactive classroom lectures.
- Case studies.
- Student seminars, assignments and technical presentations.

**Evaluation Scheme**

| | |
|---|---|
| Theory | Continuous Internal Evaluation (CIE): 35 Marks (Mid-term Examination) + 15 Marks (Class Assessment: Attendance, Viva, Quiz, Presentation, Surprise Test, Open-book Test, Mini-project, etc)<br>Semester End Examination (SEE): 50 marks |
| Practical | NA |

| Course Code | BELEPMP825 | | | | Semester | Semester VIII | |
|---|---|---|---|---|---|---|---|
| Course Title | Major Project | | | | | Max marks | |
| Scheme & Credits | Hours Per Week | | | | Credits | Theory | Practical |
| | L | T | P | Total | | | |
| | 0 | 0 | 12 | 12 | 12 | | 100 |
| Prerequisites | Minor Project | | | | | 100 | |

**Course Learning Outcomes (CLOs)**

| | |
|---|---|
| CLO1 | Formulate a comprehensive, original engineering problem in electrical engineering with defined objectives, scope, and an in-depth literature review. |
| CLO2 | Design a complete solution methodology, including system architecture and the theoretical, simulation, or experimental approach. |
| CLO3 | Execute the design through implementation, integrating hardware, software, or simulation components as required. |
| CLO4 | Rigorously test, validate, and analyze the developed system against the defined objectives and performance metrics. |
| CLO5 | Communicate project outcomes through a comprehensive technical report, public demonstration, and viva-voce defense, while demonstrating professional and ethical project-management competence. |

**Syllabus**

| Units | Content |
|---|---|
| 1 | Problem Formulation and Comprehensive Literature Review:<br>Identification of an original, substantial engineering problem; in-depth literature survey and critical review; gap analysis; formulation of objectives, scope and expected outcomes; feasibility and resource assessment. |
| 2 | System Design and Methodology:<br>Detailed system architecture or theoretical framework; selection and justification of design methodology, tools and platforms; preparation of design specifications; risk assessment and mitigation planning. |
| 3 | Implementation:<br>Development and integration of hardware/software/simulation components; iterative development with milestone-based progress reviews; troubleshooting and design refinement. |
| 4 | Testing, Validation and Performance Evaluation:<br>Comprehensive testing protocols; validation against design specifications and objectives; performance evaluation using relevant metrics; comparative analysis with existing solutions or benchmarks. |
| 5 | Documentation, Demonstration and Viva-Voce:<br>Preparation of the comprehensive project report as per the prescribed format; public demonstration of the working system or outcome; defense of the work through viva-voce before an expert committee; reflection on project management, ethics, and teamwork. |

**CLO-PLO Mapping Matrix**

| CLO/PLO | PLO1 | PLO2 | PLO3 | PLO4 | PLO5 | PLO6 | PLO7 | PLO8 | PLO9 | PLO10 | PLO11 | PLO12 | Avg CLO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLO1 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 0 | 1 | 2 | 1 | 2 | 1.58 |
| CLO2 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 0 | 1 | 2 | 2 | 2 | 1.75 |
| CLO3 | 2 | 2 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| CLO4 | 2 | 3 | 2 | 3 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1.75 |
| CLO5 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 1.916666667 |
| Avg PLO | 1.8 | 2.4 | 2.2 | 2.2 | 2.2 | 1.2 | 1.0 | 0.8 | 1.6 | 2.2 | 1.8 | 2.2 | 1.8 |

**Suggested Reading**

| | |
|---|---|
| 1 | Relevant technical literature (journals, standards, patents) identified through the literature survey specific to the chosen project topic, in consultation with the supervisor. |
| 2 | Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications. |

**Teaching-Learning Strategies**

- Regular supervisory guidance with documented progress reviews at defined milestones.
- Mid-semester evaluation before a departmental expert committee.
- Peer benchmarking and technical seminars on related work.
- Independent hands-on implementation, integration, and testing carried out under supervision.
- Comprehensive report writing, public demonstration, and viva-voce preparation.