CURRICULUM

&

SYLLABUS

2023 Scheme

(Autonomous)

Version 1.0

# B.TECH
# ELECTRICAL AND ELECTRONICS ENGINEERING

**MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY**

**Mar Ivanios Vidyanagar, Nalanchira, Thiruvananthapuram – 695015**

# CURRICULUM AND DETAILED SYLLABI

FOR

## B. TECH DEGREE PROGRAMME

IN

## ELECTRICAL AND ELECTRONICS ENGINEERING

## SEMESTERS V & VI

## 2023 SCHEME
## (AUTONOMOUS)


**MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY**

(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)

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## MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
## DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

**B. TECH DEGREE PROGRAMME**

**IN**

# ELECTRICAL AND ELECTRONICS ENGINEERING

# THIRD YEAR SYLLABUS

## 2023 SCHEME

| Items | Board of Studies (BOS) | Academic Council (AC) |
|---|---|---|
| Date of Approval | 09.05.2025 | 28.05.2025 |

Head of Department
Chairman, Board of Studies

Principal
Chairman, Academic Council

MAR BASELIOS COLLEGE OF ENGINEERING & TECHNOLOGY (AUTONOMOUS) ★ MAR IVANIOS VIDYANAGAR THIRUVANANTHAPURAM PIN: 695015

## MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

## Vision and Mission of the Institution

**Vision:**

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

**Mission:**

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

## DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

## Vision and Mission of the Department

**Vision:**

To be a Centre of Excellence in Electrical & Electronics Engineering Education, Research and Application of knowledge to benefit the society at large.

**Mission:**

To mould quality Electrical Engineers, fostering creativity and innovation to address global issues.

# PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

**PEO1:** Graduates will succeed as Engineering Professionals in Industry or as Entrepreneurs in Electrical and Computer Engineering and the related disciplines and exhibit an urge for innovation.

**PEO2:** Graduates will be able to adapt to the advances in Technology by acquiring knowledge and skills manifested through continuous learning and higher qualifications.

**PEO3:** Graduates will be serving community as socially committed individuals, exhibiting professional ethics in addressing the technical and engineering challenges.

# PROGRAMME OUTCOMES (POs)

**Engineering graduates will be able to:**

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

# PROGRAMME SPECIFIC OUTCOMES (PSOs)

**PSO1:** To apply the knowledge in Electrical Engineering and Computer Engineering for the design, development testing and operation of Power and Energy Systems in the areas of Generation, Transmission, Conversion, Distribution and Utilization systems.

**PSO2:** To apply the knowledge in Electrical Engineering and Computer Engineering for the design, development and operation of Industrial systems in the areas of Automation, Control, Energy Management and Economic operation.

# CURRICULUM

| SEMESTER V | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Slot | Cate-gory | Course Code | Courses | Credit Structure | | | | SS | Hours | Credit |
| | | | | L | T | P | J | | | |
| A | PCC | 23EEL30A | Power Electronics and Drives | 3 | 1 | 0 | 0 | 5 | 4 | 4 |
| B | PCC | 23EEL30B | Signals and System Analysis | 3 | 1 | 0 | 0 | 5 | 4 | 4 |
| C | PCC | 23EEL30C | Synchronous and Induction Machines | 3 | 1 | 0 | 0 | 5 | 4 | 4 |
| D | PEC | 23EEL31X | Program Elective I | 3 | 0 | 0 | 0 | 4.5 | 3 | 3 |
| E | HSC | 23HSL30A | Business Economics and Accountancy | 3 | 0 | 0 | 0 | 4.5 | 3 | 3 |
| S | PCC | 23EEP30A | Electrical Machines Lab | 0 | 0 | 3 | 0 | 1.5 | 3 | 2 |
| T | PCC | 23EEP30B | Power Electronics Lab | 0 | 0 | 3 | 0 | 1.5 | 3 | 2 |
| M/H | VAC | | Minor/Honours Course | 3 | 0 | 0 | 0 | 4.5 | 3 | 3 |
| **TOTAL** | | | | | | | | **27/ 31.5** | **24/27** | **22/25** |

## PROGRAM ELECTIVE I

| Slot | Category Code | Course Code | Courses | L-T-P-J | Hours | Credit | Stream Code |
|---|---|---|---|---|---|---|---|
| D | PEC | 23EEL31A | Renewable Energy Systems | 3-0-0-0 | 3 | 3 | PES |
| | | 23EEL31B | Material Science | 3-0-0-0 | 3 | 3 | PED |
| | | 23EEL31C | Embedded Systems | 3-0-0-0 | 3 | 3 | CSA |
| | | 23EEL31D | Sensors and Sensing Techniques | 3-0-0-0 | 3 | 3 | EIN |
| | | 23EEL31E | Biomedical Instrumentation | 3-0-0-0 | 3 | 3 | EIN |
| | | 23EEL31F | Object Oriented Programming | 3-0-0-0 | 3 | 3 | AML |
| | | 23EEL31G | Data Structures | 2-1-0-0 | 3 | 3 | AML |

| SEMESTER VI | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Slot | Cate-gory | Course Code | Courses | Credit Structure | | | | SS | Hours | Credit |
| | | | | L | T | P | J | | | |
| A | PCC | 23EEL30D | Linear Control Systems | 3 | 1 | 0 | 0 | 5 | 4 | 4 |
| B | PCC | 23EEL30E | Power Systems I | 3 | 1 | 0 | 0 | 5 | 4 | 4 |
| C | PCC | 23EEL30F | Electromagnetic Theory and Compatibility | 3 | 1 | 0 | 0 | 5 | 4 | 4 |
| D | PEC | 23EEL32X | Program Elective II | 3 | 0 | 0 | 0 | 4.5 | 3 | 3 |
| E | IEC | 23IEL31X | Institute Elective I | 3 | 0 | 0 | 0 | 4.5 | 3 | 3 |
| S | PCC | 23EEP30C | Control Systems Lab | 0 | 0 | 3 | 0 | 1.5 | 3 | 2 |
| T | PWS | 23EES38A | Seminar | 0 | 0 | 4 | 0 | 2 | 4 | 2 |
| U | PWS | 23EEJ38B | Mini Project | 0 | 0 | 4 | 0 | 4 | 4 | 2 |
| M/H | VAC | | Minor/Honours Course | 3 | 0 | 0 | 0 | 4.5 | 3 | 3 |
| **TOTAL** | | | | | | | | **31.5/ 36** | **29/32** | **24/27** |

## PROGRAM ELECTIVE II

| Slot | Category Code | Course Code | Courses | L-T-P-J | Hours | Credit | Stream Code |
|---|---|---|---|---|---|---|---|
| D | PEC | 23EEL32A | Illumination Engineering | 2-1-0-0 | 3 | 3 | PES |
| | | 23EEL32B | Electrical Drawing with CAD | 2-1-0-0 | 3 | 3 | PED |
| | | 23EEL32C | Electric Drives | 3-0-0-0 | 3 | 3 | PED |
| | | 23EEL32D | Industrial Instrumentation and Automation | 3-0-0-0 | 3 | 3 | CSA |
| | | 23EEL32E | Digital System Design Using Verilog | 2-1-0-0 | 3 | 3 | CSA |
| | | 23EEL32F | Introduction to Nanotechnology | 3-0-0-0 | 3 | 3 | EIN |
| | | 23EEL32G | Introduction to Soft Computing | 3-0-0-0 | 3 | 3 | AML |
| | | 23EEL32H | Internet of Things | 3-0-0-0 | 3 | 3 | AML |

## INSTITUTE ELECTIVE I

| Slot | Category Code | Course Code | Courses | L-T-P-J | Hours | Credit |
|---|---|---|---|---|---|---|
| E | IEC | 23IEL31A | Introduction to Flight Dynamics and Control | 3-0-0-0 | 3 | 3 |
| | | 23IEL31B | Introduction to Power Processing | 3-0-0-0 | 3 | 3 |
| | | 23IEL31C | Electrical Drives and Control for Automation | 3-0-0-0 | 3 | 3 |
| | | 23IEL31D | Artificial Intelligence in Power Systems | 3-0-0-0 | 3 | 3 |

# SEMESTER V

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL30A | POWER ELECTRONICS AND DRIVES | PCC | 3 | 1 | 0 | 0 | 4 | 2023 |

**i) COURSE OVERVIEW**: This course provides an in-depth understanding of power electronic circuits with a strong emphasis on analysis, design, and simulation. Course also provides an overview on the concepts of AC and DC drives. Course also provides an insight on simulation using MATLAB/Simscape to evaluate converter performance in real-world scenarios

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the operation of various power semiconductor devices and its characteristics. | Understand |
| CO2 | Model and simulate the various controlled rectifier and AC voltage controller topologies. | Apply |
| CO3 | Explain the working of various inverter topologies and PWM techniques. | Understand |
| CO4 | Identify the performance of various DC - DC Converter topologies. | Apply |
| CO5 | Explain basic drive schemes for AC and DC motors. | Understand |
| CO6 | Develop various inverter topologies and perform harmonic analysis. | Apply |

**iii) SYLLABUS**

Power electronics scope and applications, power vs signal electronics, characteristics and comparison of power diodes, MOSFETs, IGBTs, and wide bandgap devices like SiC and GaN, SCR characteristics, two-transistor model, protection techniques, gate drive and isolation circuits, single-phase and three-phase controlled rectifiers with R, RL, and RLE loads, AC voltage controllers, voltage source and current source inverters with PWM techniques including single, multiple, and sinusoidal PWM, modulation indices and harmonic analysis, DC-DC converters including buck, boost, buck-boost, single/two/four-quadrant choppers, switching regulators and component selection, electric drives overview, DC drives using controlled rectifiers and choppers, AC drives with stator voltage, frequency, V/f control, MATLAB Simscape simulations of converters and drive systems

**iv) (a) TEXT BOOKS**

1) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley India, 3rd Edition, 2018.
2) Dubey G K, *Fundamentals of Electrical Drives*, Narosa Publishing House, New Delhi, 2nd Edition, 2012.
3) Robert W. Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer, 3rd Edition, 2001.

**(b) REFERENCES**

1) Rashid M H, *Power Electronics – Circuits, Devices and Applications*, Prentice Hall of India, New Delhi, 4th edition, 2014.
2) Robert Bausiere, Francis Labrique, Guy Seguier, *Power Electronic Converters: DC-DC Conversion*, Springer, 2013.
3) P.S. Bimbhra, *Power Electronics*, Khanna Publishers, New Delhi, 6th edition, 2010.
4) Joseph Vithayathil, *Power Electronics*, Tata McGraw-Hill, New Delhi, 2010.
5) M.D. Singh and K.B. Khanchandani, *Power Electronics*, Tata McGraw Hills Publishing Company Limited, 2006.
6) MATLAB Documentation – *Simscape Electrical Toolbox* and online resources.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Power electronic devices:** Power electronics scope and applications, Power electronics vs signal electronics - Power Diode, Power MOSFET, IGBT: structure, principle of operation, comparison, wide bandgap devices: SiC, GaN. <br> **SCR**: structure, static and switching characteristics, di/dt and dv/dt protection-snubber circuit, SCR triggering methods, UJT triggering, Opto-coupler and pulse transformer-based isolation, Two transistor analogy. Heat sinks and thermal design. | **11** |
| II | **Controlled Rectifiers:** Single-phase half-wave, full-wave controlled rectifiers, half controlled rectifiers with R, RL, RLE loads (continuous & discontinuous conduction) – Output voltage equations – Three-phase half-wave and bridge converters – Fully controlled and half-controlled configurations with RLE load in continuous conduction mode– Waveforms for various firing angles, <br> **AC Voltage Controllers:** Single phase AC Voltage Controller with R, RL load – RMS output voltage, input power factor. <br> MATLAB Simscape simulation of single and three-phase rectifiers. | **13** |
| III | **Inverters and PWM Techniques:** Voltage Source Inverters – Single-phase half-bridge & full-bridge with R and RL loads – THD analysis – Three-phase bridge inverter – 120° and 180° conduction – Current Source Inverter (1-φ) with capacitor commutation. <br> **PWM strategies:** Single-pulse, multiple-pulse, and sinusoidal PWM – Modulation index and frequency modulation ratio. <br> MATLAB Simscape modeling of VSI, THD analysis using FFT tool. | **13** |
| IV | **DC-DC Converters and Switching Regulators:** Step-down, step-up choppers – Single, two, and four-quadrant operations – PWM and current-limit control – Buck, Boost, Buck-Boost converters in continuous conduction – Design of power circuits- switch selection, inductor, and capacitor sizing. <br> MATLAB Simscape implementation of DC-DC converters. | **13** |

| | | |
|---|---|---|
| V | **Electric Drives and Applications**: Electric Drives: Block diagram, types of loads, classification of load torque<br>**DC Drives**: Single-phase converter-fed drives, dual converters (1-φ & 3-φ), simultaneous/non-simultaneous modes – Chopper-fed DC drives – Regenerative braking<br>**AC Drives:** 3-φ induction motor speed control: stator voltage control, frequency control, V/f control.<br>MATLAB Simscape-based simulation of converter fed DC drives. | **10** |
| | **Total hours** | **60** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL30B | SIGNALS AND SYSTEM ANALYSIS | PCC | 3 | 1 | 0 | 0 | 4 | 2023 |

**i) COURSE OVERVIEW**: This course introduces students to the fundamentals of signal and system analysis in both continuous and discrete domains. It emphasizes the mathematical modeling and analysis of linear time-invariant systems through time and frequency domain tools such as convolution, Fourier analysis, Laplace transforms, and Z-transforms. The course also covers essential aspects of digital signal processing, including DFT, FFT, and basic filter design, providing practical applications with the aim to develop analytical skills necessary for solving real-world problems in electrical engineering domains.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Identify various signals and systems and perform basic operations on signals. | Apply |
| CO2 | Model continuous-time and discrete-time systems using convolution and system properties. | Apply |
| CO3 | Apply Fourier and Laplace transforms to study system behaviour in the frequency domain. | Apply |
| CO4 | Make use of Z-transforms and DTFT for analysing discrete-time systems. | Apply |
| CO5 | Explain basic DSP operations like DFT, FFT, FIR and IIR filters for real-time applications. | Understand |

**iii) SYLLABUS**

Classification of signals and system properties, signal operations like time scaling, shifting, and reversal, impulse response and convolution using graphical and matrix methods, solution of differential and difference equations, Fourier Series, Fourier Transform, Laplace Transform and their applications, system stability, transfer functions, Z-transform and DTFT, discrete-time system analysis and sampling, and introduction to Digital Signal Processing including DFT, FFT, FIR and IIR filter design with applications in DSP.

**iv) (a) TEXT BOOKS**

1) Alan V. Oppenheim, *Signals and Systems*, Pearson Education, New Delhi, 2nd Edition, 1997.
2) Simon Haykin and Barry Van Veen, *Signals and Systems*, Wiley India, New Delhi, 2nd Edition, 2007.
3) John G. Proakis and Dimitris G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, Pearson Education, New Delhi, 4th Edition, 2007.

**(b) REFERENCES**

1) Michael J. Roberts, *Fundamentals of Signals and Systems*, Tata McGraw-Hill, New Delhi, 2nd Edition, 2010.

2) B.P. Lathi, *Principles of Linear Systems and Signals*, Oxford University Press, New Delhi, 2nd Edition, 2004.
3) A. Nagoor Kani, *Signals and Systems*, McGraw Hill Education India, New Delhi, 1st Edition, 2010.
4) Sanjit K. Mitra, *Digital Signal Processing: A Computer-Based Approach*, McGraw Hill, New York, 4th Edition, 2011.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Signals and Systems:** Classification of signals (Continuous/Discrete, periodic/aperiodic, energy/power, Odd/Even), basic signal operations - Time scaling, reversal and shifting, system properties (linearity, time-invariance, causality, stability, invertibility). | 12 |
| II | **Time-Domain Analysis:** Impulse response, Convolution and properties of LTI systems - Graphical and Matrix method, Differential and difference equations, System response. Solution of differential equations of linear time-invariant systems. | 12 |
| III | **Frequency domain Analysis:** Fourier Series and Fourier Transform for continuous-time signals, properties, frequency response of LTI systems, Laplace Transform and its application to system analysis, ROC, transfer function, poles, and zeros. Solution of difference equations (with initial conditions), Stability and Causality. | 12 |
| IV | **Discrete-Time Signal Processing:** Sampling theorem, aliasing, Z-transform and inverse Z-transform, discrete convolution, DTFS & DTFT, frequency response of discrete LTI systems. Solution of difference equation using Z-transforms, System characteristics, Properties of DTFT and Z-transforms. | 12 |
| V | **Digital Signal Processing and Filters**: Introduction to DSP and its significance in real-time systems. Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT): Simple Problems and Applications. Digital filter design: FIR and IIR filter basics. | 12 |
| | **Total hours** | **60** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL30C | SYNCHRONOUS AND INDUCTION MACHINES | PCC | 3 | 1 | 0 | 0 | 4 | 2023 |

**i) COURSE OVERVIEW**:

The goal of this course is to expose the students to the fundamental concepts of synchronous and induction machines including principle of operation, performance analysis and applications. It also introduces students to cognitive learning and develops problem solving skills with both theoretical and engineering-oriented problems.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Illustrate the principle and classification of synchronous and induction machines. | Understand |
| CO2 | Develop phasor diagrams and equivalent circuit of an alternator and synchronous motor. | Apply |
| CO3 | Apply various methods to determine the voltage regulation of alternators. | Apply |
| CO4 | Explain the process of synchronization and synchronization techniques. | Understand |
| CO5 | Develop the torque equations and performance parameters of synchronous and induction machines. | Apply |
| CO6 | Illustrate the various starting, braking and speed control methods of three phase induction motors. | Understand |

**iii) SYLLABUS**

Alternators - basic principle, constructional features, Armature windings, EMF Equation phasor diagram. Power Flow Equations - Direct Loading, EMF, MMF and ZPF methods.
Theory of salient pole machine – Blondel's two reaction theory -Analysis of phasor diagram under lagging power factor- slip test. Power Developed -Parallel operation of alternators.
Synchronous motor – construction and principle-torque and power relationship, phasor diagram, losses and efficiency.
Induction Motors–-constructional features-slip ring and cage types. Phasor diagram, power and torque relations, equivalent circuit. Circle diagrams.
Starting, speed control and braking of induction motors-Double cage induction motor – Synchronous induction motor -Single-phase induction motors.

**iv) (a) TEXT BOOKS**

1) Say M. G., *The Performance and Design of AC Machines*, CBS Publishers, New Delhi, 3rd Edition, 2002.
2) Bimbhra P. S., *Electric Machines*, Khanna Publishers, 2nd Edition, 2017.
3) D. P. Kothari, I. J. Nagrath, *Electric Machines*, Tata McGraw Hill, 5th Edition, 2019.
4) Langsdorf M. N., *Theory of Alternating Current Machinery*, Tata McGraw Hill, 2nd revised Edition, 2001.

5) Deshpande M. V., *Electrical Machines*, Prentice Hall India, New Delhi, Eastern Economy Edition, 2011.

**(b) REFERENCES**

1) Fitzgerald A. E., C. Kingsley and S. Umans, *Electric Machinery*, 6th Edition, McGraw Hill, 2003.
2) Charles I. Hubert, *Electric Machines*, Pearson, New Delhi, 2nd Edition, 2007.
3) J. B. Gupta, *Performance of Electrical Machines*, S K Kataria & Sons, 14th Edition, 2013.
4) Ashfaq Husain, Haroon Ashfaq, *Electric Machines*, Dhanpat Rai and Co., 3rd Edition, 2016.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| **I** | **Alternators** - basic principle, constructional features, Classification. Armature windings – types- single layer, double layer, full pitched and short pitched windings, Terminology, pitch factor and distribution factor – numerical problems. Effect of pitch factor on harmonics – advantages of short chorded winding, EMF Equation – numerical problems. Harmonics in generated EMF – suppression of harmonics.<br>**Performance of an alternator** – Causes for voltage drop in alternators – armature resistance, armature leakage reactance – armature reaction, synchronous reactance, and synchronous impedance– phasor diagram of a loaded alternator. | **12** |
| **II** | Power Flow Equations of a cylindrical rotor type alternator, Rating of Alternators.<br>**Voltage regulation** – Direct Loading, EMF, MMF and ZPF methods – Numerical problems.<br>**Theory of salient pole machine** – Blondel's two reaction theory – direct axis and quadrature axis synchronous reactances – Analysis of phasor diagram under lagging power factor- Determination of $X_d$ and $X_q$ by slip test. Power Developed in a salient pole alternator- numerical problems. | **14** |
| **III** | **Parallel operation of alternators** – necessity of parallel operation of alternators, methods of synchronization – dark lamp method and bright lamp method, synchroscope - Synchronising current, power and torque- Numerical Problems.<br>**Synchronous motor** – construction and principle of synchronous motor, methods of starting-Torque and power relationship, phasor diagram, losses and efficiency calculations of cylindrical rotor type motor; P- $\delta$ curve of a synchronous machine.<br>Effects of excitation on armature current and power factor- V and Inverted V Curves, Synchronous Condensers. | **10** |
| **IV** | **Induction Machines**– Three phase Induction Motors-constructional features-slip ring and cage types. Basic Principle-Concept of Rotating Magnetic Field-Phasor diagram, power & torque relations, equivalent circuit. Circle diagrams – tests on induction motors for determination of | **12** |

| | | |
|---|---|---|
| | equivalent circuit. Cogging, crawling and noise production in cage motors – remedial measures.<br>**Starting and braking** of induction motors.<br>**Speed control**- From stator side- V / f control or frequency control, Changing the number of stator poles, controlling supply voltage, adding rheostat in the stator circuit; From rotor side- Adding external resistance, Cascade control. | |
| **V** | **Double cage induction motor** – principle, torque-slip curves. Synchronous induction motor – principle of operation.<br>**Induction generator** – principle of operation, grid connected and self-excited operation, comparison of induction and synchronous machines.<br>**Single-phase induction motor** – double field revolving theory, equivalent circuit, torque-slip curve, types of single phase induction motors – split phase, capacitor start, capacitor start and run types-Applications. | **12** |
| | **Total hours** | **60** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23HSL30A | BUSINESS ECONOMICS AND ACCOUNTANCY | HSC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

To familiarize the prospective engineers with elementary Principles of Business Economics and Accountancy to analyse various business structures by using Economics principles and accounting tools at an elementary level.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the problem of scarcity of resources and consumer behaviour. | Understand |
| CO2 | Examine the production efficiency and profitability with the help of quantitative and qualitative methods. | Analyse |
| CO3 | Interpret the macro-economic policies, trends and issues of the economy. | Understand |
| CO4 | Analyse business viability with the help of business models and financial planning. | Analyse |
| CO5 | Develop an accurate and compliant balance sheet by classifying and recording financial transactions systematically. | Apply |

**iii) SYLLABUS**

**Introductory Micro-Economics**

Scarcity and choice - Basic economic problems- PPC – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.

**Microeconomic Foundations: Production, Cost, Market Structures & Pricing Strategies**

Production function – law of variable proportion – economies of scale – internal and external economies – Cobb-Douglas production function - Cost concepts - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point. Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly - Non-price competition – Product pricing strategies.

**Introductory Macro-Economics**

Circular flow of income-two sector and multi-sector models- National Income Concepts-Measurement Methods – Problems - Inflation, deflation - Fiscal Policy (Government spending & taxation) - Monetary Policy (Interest rates & money supply) - Wage Rigidity & Unemployment - Demand-Pull vs. Cost-Push Inflation.

**Business Models and Financial Planning**

Innovation and creativity in entrepreneurship - Business idea generation and feasibility analysis - Business planning (Lean Canvas, SWOT, PESTEL analysis) - Types of business structures (sole proprietorship, partnership, corporation) - Legal aspects and regulatory requirements - Sources of funding: Bootstrapping and personal savings, Venture capital and angel investors, Bank loans and government grants (Startup India, MSME financing), Crowdfunding and alternative finance - Financial planning and forecasting - Challenges in entrepreneurial finance (liquidity, risk management) - Exit strategies (IPO, mergers, acquisitions).

**Introduction to Accounting**

Book-Keeping and Accountancy - Elements of Double Entry – Book Keeping - rules for journalizing - Ledger accounts - Cash book - Banking transactions - Trial Balance - Method of Balancing accounts - the journal proper.

Final accounts: Preparation of trading and profit and loss Account - Balance sheet preparation and interpretation - Introduction to accounting packages.

**iv) (a) TEXT BOOKS**

1) Gregory N Mankiw, Principles of Macro Economics, Cengage Publications 2023.
2) Steven Rogers, Entrepreneurial Finance, McGraw-Hill, Fourth Edition, 2020.
3) Agrawal R and Srinivasan R, Accounting Made Easy, Tata McGraw-Hill 2010.

**(b) REFERENCES**

1) Dominick Salvatore, Theory and Problems of Micro Economic Theory. Tata Mac Graw- Hill, New Delhi, 2017.
2) Dwivedi D.N., Macroeconomics: Theory and Policy, Tata McGraw Hill, New Delhi 2018.
3) Dornbusch, Fischer and Startz, Macroeconomics, McGraw Hill, 12th edition, 2018.
4) Janet Kiholm Smith and Richard L Smith, Entrepreneurial Finance: Venture Capital, Deal Structure & Valuation, Stanford Business Books US, 2019.
5) M. Kasi Reddy and S. Saraswathi, Managerial Economics and Financial Accounting. Prentice Hall of India. New Delhi. 2008.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Scarcity and choice - Basic economic problems - PPC – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss. | 9 |
| II | Production function – law of variable proportion – economies of scale – internal and external economies – Cobb-Douglas production function - Cost concepts - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point. Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked | 8 |

| | | |
|---|---|---|
| | demand curve – Collusive oligopoly - Non-price competition – Product pricing strategies. | |
| **III** | Circular flow of income - two sector and multi-sector models - National Income Concepts - Measurement Methods – Problems - Inflation, deflation - Fiscal Policy (Government spending & taxation) - Monetary Policy (Interest rates & money supply) - Wage Rigidity & Unemployment - Demand-Pull vs. Cost-Push Inflation. | **9** |
| **IV** | Innovation and creativity in entrepreneurship - Business idea generation and feasibility analysis - Business planning (Lean Canvas, SWOT, PESTEL analysis) - Types of business structures (sole proprietorship, partnership, corporation) - Legal aspects and regulatory requirements - Sources of funding: Bootstrapping and personal savings, Venture capital and angel investors, Bank loans and government grants (Startup India, MSME financing), Crowdfunding and alternative finance - Financial planning and forecasting - Challenges in entrepreneurial finance (liquidity, risk management) - Exit strategies (IPO, mergers, acquisitions). | **9** |
| **V** | Book-Keeping and Accountancy - Elements of Double Entry - Book – Keeping - rules for journalizing - Ledger accounts - Cash book- Banking transactions - Trial Balance - Method of Balancing accounts - the journal proper.<br>Final accounts: Preparation of trading and profit and loss Account - Balance sheet preparation and interpretation - Introduction to accounting packages | **10** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEP30A | ELECTRICAL MACHINES LAB | PCC | 0 | 0 | 3 | 0 | 2 | 2023 |

**i) COURSE OVERVIEW**:

The course objective is to equip students with hands-on experience in testing AC and DC machines, enabling them to verify results and analyse performance using suitable tests.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Apply relevant tests on the given DC motor/generator to determine its performance characteristics. | Apply |
| CO2 | Develop the equivalent circuit of the given transformer by applying open-circuit and short-circuit tests. | Apply |
| CO3 | Experiment with the given induction motor to obtain its performance characteristics. | Apply |
| CO4 | Develop the equivalent circuit of the given single phase or three phase induction motor by conducting no load and blocked rotor tests. | Apply |
| CO5 | Apply direct loading, EMF, and MMF methods to calculate the regulation of the given three phase alternator. | Apply |
| CO6 | Experiment with the given three phase alternator/synchronous induction motor to develop V and inverted V curves using appropriate test procedures | Apply |

**iii) SYLLABUS**

- Familiarisation of meters, instruments and safety measures adopted in the laboratory; Study of starters of three phase Induction Motors
- Load Test on a DC Series Motor
- Load Test on a DC Shunt Motor
- OCC of a DC Shunt Generator
- Load Characteristics of a DC Shunt Generator
- OC and SC Tests on a single phase transformer
- OC and SC Tests on a three phase transformer
- Load Test on a single phase transformer
- Load Test on a three phase Slip ring Induction Motor
- No Load and Blocked Rotor tests on a three phase Squirrel cage Induction Motor
- Load Test on a single phase Capacitor start Induction Motor
- Regulation of a three phase Alternator by direct loading
- Regulation of a three phase Alternator by EMF and MMF methods
- Reactive power control in grid connected Alternators
- V and Inverted V curves of a Synchronous Induction Motor

## iv) REFERENCES


1) Bimbra P S, *Electric Machines*, Khanna Publishers, 2nd Edition, 2017.
2) D. P. Kothari, I. J. Nagrath, *Electric Machines*, Tata McGraw Hill, 5th Edition.
3) Say M G, *The Performance and Design of AC Machines*, CBS Publishers, New Delhi, 3rd Edition, 2002.
4) Langsdorf M. N., *Theory of Alternating Current Machinery*, Tata McGraw Hill, 2nd revised Edition, 2001.


## v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | a. Familiarization of meters and instruments used in Electrical Machines Lab<br>b. Study of safety measures to be taken while performing experiments in the lab<br>c. Study of starters of three phase Induction Motors | 3 |
| II | **Load Test on a DC Series Motor**<br>a. Plot the performance characteristics<br>b. Plot the electrical and mechanical characteristics | 3 |
| III | **Load Test on a DC Shunt Motor**<br>a. Plot the performance characteristics<br>b. Plot the electrical and mechanical characteristics | 3 |
| IV | **OCC of a DC Shunt Generator**<br>a. Plot the OCC at rated speed<br>b. Plot the OCC at a speed other than the rated<br>c. Determine critical resistance and critical speed<br>d. Determine the additional resistance required to just excite the machine | 3 |
| V | **Load Characteristics of a DC Shunt Generator**<br>Plot the internal and external characteristics | 3 |
| VI | **OC and SC Tests on a single-phase transformer**<br>a. Predetermination of efficiency<br>b. Predetermination of regulation<br>c. Develop the equivalent circuit | 3 |
| VII | **OC and SC Tests on a three-phase transformer**<br>a. Predetermination of efficiency<br>b. Predetermination of regulation<br>c. Develop the equivalent circuit | 3 |
| VIII | **Load Test on a single-phase transformer**<br>Calculate the regulation and efficiency at different loads | 3 |
| IX | **Load test on a three-phase slip ring Induction Motor**<br>a. Start the motor using autotransformer or rotor resistance starter and perform load test<br>b. Plot the performance characteristics | 3 |
| X | **No load and block rotor test on a three-phase squirrel cage Induction Motor**<br>a. Predetermination of performance parameters from circle diagram<br>b. Deduce the equivalent circuit | 3 |

| | | |
|---|---|---|
| **XI** | **Load Test on a single-phase capacitor start Induction Motor**<br>a. Perform load test on the motor<br>b. Plot the performance characteristics of the motor | **3** |
| **XII** | **Regulation of a three-phase Alternator by direct loading**<br>a. Determine the regulation of three phase alternator<br>b. Plot the regulation curve | **3** |
| **XIII** | **Regulation of a three phase Alternator by EMF and MMF methods**<br>Predetermine the regulation of alternator by EMF and MMF methods at 0.8pf lag, upf and 0.8pf lead. | **3** |
| **XIV** | **Reactive power control in grid connected Alternators**<br>a. Synchronize the alternator by bright lamp method<br>b. Control the reactive power and plot the V and inverted V curves for generator operation | **3** |
| **XV** | **V and inverted V curves of a synchronous Induction Motor**<br>Plot the V and inverted V curves of the Synchronous Induction Motor at no load and full load. | **3** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assessment of Lab Work<br>Continuous Assessment in Lab<br>(Lab work + Record + Viva - voce) -35 marks<br>and Internal Lab test -20 marks | : | 55 marks |
| Final Lab Assessment | : | 40 marks |
| **TOTAL** | **:** | **100 marks** |

**vii) FINAL LAB ASSESSMENT**

Final Lab Assessment – **2.5 hours/3 hours exam** for 40 marks

| | | | |
|---|---|---|---|
| (a) | Preliminary work | : | 15 marks |
| (b) | Implementing the work/Conducting the experiment | : | 10 marks |
| (c) | Result and inference | : | 10 marks |
| (d) | Viva voce | : | 5 marks |
| | **Total** | **:** | **40 marks** |

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEP30B | POWER ELECTRONICS LAB | PCC | 0 | 0 | 3 | 0 | 2 | 2023 |

**i) COURSE OVERVIEW**: The main objective of the course is to expose the students to the design and implementation of triggering circuits. It also includes design and implementation of converter circuits and simulation of converters fed drives using MATLAB Simulink/Simscape.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Develop the static characteristics and triggering methods of SCRs using hardware setups. | Apply |
| CO2 | Build and verify AC voltage controllers and gate driver circuits for MOSFETs/IGBTs. | Apply |
| CO3 | Develop and analyse SCR-based rectifier and inverter circuits in hardware and software. | Apply |
| CO4 | Develop and build DC-DC converters (buck, boost, buck-boost) and chopper-based motor control systems. | Apply |
| CO5 | Make use of MATLAB Simulink and Simscape to simulate power electronic converters and drives. | Apply |
| CO6 | Solve for harmonic analysis of inverter systems for power electronic applications | Apply |

**iii) SYLLABUS**

Comparative study of PWM and Square wave inverters.in MATLAB/SIMULINK. Study and characterization of power semiconductor devices including SCR, MOSFET, and IGBT. Implementation and testing of SCR triggering circuits using R, RC, and UJT methods. AC voltage control and gate driver circuit design. Experimental verification of controlled rectifiers, inverters, choppers, and DC motor drive systems. Design and set-up of buck, boost, and buck-boost DC-DC converters. Simulation and analysis of power electronic circuits including single-phase and three-phase converters, inverters, chopper-fed drives, and dual converters using MATLAB Simulink and Simscape. Advanced case studies on gate driver design, transformer/inductor design, and harmonic analysis of PWM inverters using FFT tools in MATLAB.

**iv) (a) TEXT BOOKS**

1) Rashid, M. H. *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson Education, 2013.
2) Mohan, N., Undeland, T. M., & Robbins, W. P. *Power Electronics: Converters, Applications and Design*, 3rd Edition, Wiley India, 2011.

**(b) REFERENCES**

1) Erickson, R. W., & Maksimovic, D. *Fundamentals of Power Electronics*, 2nd Edition, Springer, 2001.
2) Bimal K. Bose, *Modern Power Electronics and AC Drives*, Pearson Education, 2002.

3) Kassakian, J. G., Schlecht, M. F., & Verghese, G. C. *Principles of Power Electronics*, Addison-Wesley, 1991.
4) Billings, K., & Morey, T. *Switch Mode Power Supply Design*, 3rd Edition, McGraw-Hill Education, 2010.
5) MATLAB Documentation – *Simscape Electrical Toolbox*, MathWorks Inc.


**v) COURSE PLAN**

15 experiments are mandatory (10 Hardware & 5 Software)

| Experiment No. | List of exercises/experiments | No. of hours |
|---|---|---|
| **1** | Static characteristics of SCR | **3** |
| **2** | R and RC firing scheme for SCR control | **3** |
| **3** | Line Synchronised Triggering Circuits of SCR | **3** |
| **4** | AC Voltage Controller | **3** |
| **5** | Gate Driver Circuits for MOSFET/IGBT | **3** |
| **6** | Single Phase fully Controlled SCR bridge rectifier | **3** |
| **7** | Design and set-up buck/ boost / buck-boost converters | **3** |
| **8** | Design of Inductor/Transformer | **3** |
| **9** | Single-phase half bridge/full bridge inverter using power MOSFET/IGBT | **3** |
| **10** | Speed control of DC motor using chopper | **3** |
| **11** | Simulation of 1-phase fully-controlled and half-controlled rectifier fed separately excited DC motor | **3** |
| **12** | Simulation of buck/boost/buck-boost converters | **3** |
| **13** | Simulation of Dual Converter – 4 quadrant operation of separately excited DC motor | **3** |
| **14** | Simulation of single-phase & three-phase sine PWM inverters | **3** |
| **15** | Simulation of three-phase fully-controlled converter with R, and RL loads | **3** |
| **16** | Harmonic Analysis of PWM Inverters using FFT in MATLAB | **3** |
| **17** | Design of Inductor/Transformer/Gate Drivers and Protection Circuits for Power Electronic Applications (Case Study) | **3** |
| | **Total hours** | **45** |

## vi) ASSESSMENT PATTERN

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assessment of Lab Work | : | 55 marks |
| Continuous Assessment in Lab<br>(Lab work + Record + Viva - voce) -35 marks and Internal Lab test -20 marks | | |
| Final Lab Assessment | : | 40 marks |
| **TOTAL** | **:** | **100 marks** |

## vii) FINAL LAB ASSESSMENT

Final Lab Assessment – **2.5 hours/3 hours exam** for 40 marks

| | | | |
|---|---|---|---|
| (e) | Preliminary work | : | 15 marks |
| (f) | Implementing the work/Conducting the experiment | : | 10 marks |
| (g) | Result and inference | : | 10 marks |
| (h) | Viva voce | : | 5 marks |
| | **Total** | **:** | **40 marks** |

# PROGRAMME ELECTIVE I

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL31A | RENEWABLE ENERGY SYSTEMS | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: Goal of this course is to expose the students to the fundamental concepts of renewable energy sources available, its working principle and advantages**.** It illustrates the operating principles of wind, and ocean energy conversion systems and the features of biomass and small hydro energy resources. The course describes the concepts of fuel cell and hydrogen energy technologies.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Illustrate the use of various renewable energy-based power generation scheme. | Understand |
| CO2 | Explain the concepts of solar thermal and solar electric systems. | Understand |
| CO3 | Illustrate the operating principles of wind, and ocean energy conversion systems. | Understand |
| CO4 | Outline the features of biomass and small hydro energy resources. | Understand |
| CO5 | Explain the concepts of fuel cell and hydrogen energy technologies. | Understand |

**iii) SYLLABUS**

Introduction, Classification of Energy Resources- Conventional Energy Resources and Non-Conventional Energy Resources.

Principle of Conversion of Solar Radiation into Heat - Solar thermal collectors. - Flat plate collectors. Solar concentrators Solar Thermal Electric Power Generation, Solar Photovoltaic - Solar Cell fundamentals

Solar PV Systems - stand-alone and grid connected- Applications. Ocean Thermal Energy Conversion, Open Cycle (Claude cycle), Closed Cycle

Site-selection criteria- Biofouling - Wind Energy Conversion Systems wind speed Measurement-Classification of WECS- types of rotors. wind power equation -Betz limit. Electrical Power Output and Capacity Factor of WECS -Environmental impacts. Small

Hydro Power - Classification as micro, mini and small hydro projects. Basic concepts and types of turbines- selection considerations.

Fuel Cell-principle of operation- Hydrogen energy - hydrogen production, electrolysis - thermo chemical methods - hydrogen storage and utilization.

**iv) (a) TEXT BOOKS**

1) C.S. Solanki, *Solar Photovoltaic: Fundamentals Technologies and Applications*, Prentice-Hall of lndia Pvt. Limited, 3rd Edition, 2015.
2) Rai. G.D, *Non-conventional Energy Sources*, Khanna publishers, 6th Edition, 2017.
3) Rao S. and B. B. Parulekar, *Energy Technology*, Khanna Publishers, 1999.

**(b) REFERENCES**


1) G.N. Tiwari, *Solar Energy-Fundamentals, Design, Modelling and Applications*, Narosa Publishers, 2002.
2) Earnest J. and T. Wizelius, *Wind Power Plants and Project Development*, PHI Leaming, 2011.
3) Sab S. L., *Renewable and Novel Energy Sources*, MI. Publications, 1995.
4) Sawhney G. S., *Non-Conventional Energy Resources*, PHI Learning, 2012.
5) Tiwari G. N., *Solar Energy- Fundamentals, Design, Modelling and Applications*, CRC Press, 2002.
6) A.A.M. Saigh (Ed), *Solar Energy Engineering*, Academic Press, 1977.
7) Abbasi S. A. and N. Abbasi, *Renewable Energy Sources and Their Environmental Impact*, Prentice Hall of India, 2001.
8) Boyle G. (ed.), *Renewable Energy - Power for Sustainable Future*, Oxford University Press, 1996.
9) Earnest J. and T. Wizelius, *Wind Power Plants and Project Development*, PHI Leaming, 2011.
10) F. Kreith and J.F. Kreider: *Principles of Solar Engineering*, McGraw Hill, 1978.
11) Khan B.H, *Non-Conventional Energy resources*, Tata McGraw Hill, 2009.


**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction, Classification of Energy Resources- Conventional Energy Resources - Availability and their limitations- Non-Conventional Energy Resources - Classification, Advantages, Limitations; Comparison.<br>SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat - Solar thermal collectors. - Flat plate collectors. Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector.<br>SOLAR ELECTRIC SYSTEMS - Solar Thermal Electric Power Generation - Solar Photovoltaic - Solar Cell fundamentals - characteristics, classification, construction. Solar PV Systems - stand- alone and grid connected - Applications. | 10 |
| II | ENERGY FROM OCEAN - Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system - Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle. Site-selection criteria- Biofouling - Advantages & Limitations of OTEC.<br>TIDAL ENERGY - Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification-single basin - double basin types - Limitations - Environmental impacts. | 9 |
| III | WIND ENERGY - Introduction - Basic principles of Wind Energy Conversion Systems (WECS) wind speed Measurement- | 9 |

| | | |
|---|---|---|
| | Classification of WECS - types of rotors. wind power equation - Betz limit.<br>Electrical Power Output and Capacity Factor of WECS- Advantages and Disadvantages of WECS -Site selection criteria. | |
| **IV** | BIOMASS ENERGY - Introduction - Biomass fuels - Biomass conversion technologies - Urban waste to Energy Conversion-Biomass Gasification - Biomass to Ethanol Production- Biogas production from waste biomass - factors affecting biogas generation- types of biogas plants - KVIC and Janata model- Biomass program in India. | **9** |
| **V** | SMALL HYDRO POWER- Classification as micro, mini and small hydro projects - Basic concepts and types of turbines- selection considerations.<br>EMERGING TECHNOLOGIES: Fuel Cell-principle of operation - classification- conversion efficiency and losses - applications. Hydrogen energy - hydrogen production - electrolysis - Thermo chemical methods - hydrogen storage and utilization. | **8** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL31B | MATERIAL SCIENCE | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

This course introduces different types of materials used in electrical engineering such as conductors, semiconductors, insulators, solar energy materials, biomaterials, nanomaterials, superconducting materials and magnetic materials. The course gives a detailed explanation on dielectrics, polarization, modern techniques in material science and their applications.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Illustrate the characteristics of conductor, semiconductor and solar energy materials. | Understand |
| CO2 | Classify different insulating materials and describe polarization in dielectrics. | Understand |
| CO3 | Explain the mechanisms of breakdown in solids, liquids and gases. | Understand |
| CO4 | Classify various magnetic materials and superconducting materials. | Understand |
| CO5 | Summarize recent materials science developments, modern techniques, and their key applications. | Understand |

**iii) SYLLABUS**

Conducting materials- dependence of conductance on temperature and composition; Semiconductor materials-concepts, classifications and properties; Solar energy materials Solar selective coatings- Organic solar cells.

Dielectrics – Polarization – Classification - Clausius-Mossotti relation; Insulating materials classification-capacitor materials; Electronegative gases- Ferroelectricity.

Dielectric breakdown- Breakdown in solid, liquid and gaseous dielectrics- Vacuum insulation Testing and treatment of transformer oil.

Magnetic materials- Curie- Weiss laws- Iron and its alloys; Superconductor materials-types characteristics and application.

Biomaterials- Nanomaterials- Growth techniques; Modern techniques for material studies.

**iv) (a) TEXT BOOKS**

1) Dekker A.J., Electrical Engineering Materials, 1st Edition, Pearson Education India,2015.
2) K.K. Chattopadhyay, A. N. Banerjee, Introduction to Nanoscience and Nanotechnology, 1st Edition, PHI Learning Pvt Ltd., 2009.
3) G.K. Mithal, Electrical Engineering Materials, 2nd Edition, Khanna Publishers, 1991.
4) R K Shukla, Archana Singh, Electrical Engineering Materials, 1st Edition, McGraw Hill Education India, 2012.

**(b) REFERENCES**


1) Naidu M. S. and V. Kamaraju, High Voltage Engineering, 6th Edition, Tata McGraw Hill, 2020.
2) Indulkar C.S. & Thiruvegadam S., An Introduction to Electrical Engineering Materials,4th Edition, S.Chand, 2004.
3) Jeffrey O Hollinger, An Introduction to Biomaterials, 2nd Edition, CBC Press, 2012.
4) Amaresh Choudhury, Electrical Engineering Materials, 1st Edition, Notion Press, 2020.


**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Conducting Materials:** Conductivity- dependence on temperature and composition – Materials for electrical applications such as resistance, machines, solders etc.<br>**Semiconductor Materials**: Concept, materials and properties– Basic ideas of Compound semiconductors, amorphous and organic semiconductors applications.<br>**Solar Energy Materials**: Solar selective coatings for enhanced solar thermal energy collection. Solar cells -Silicon, Cadmium sulphide and Gallium arsenic, CIGS – Organic solar cells. | 8 |
| II | **Dielectrics:** Introduction to Dielectric polarization and classification– Clausius-Mossotti relation.<br>**Insulating materials:** classification- properties- common insulating materials used in electrical apparatus-Inorganic, organic, liquid and gaseous insulators- capacitor materials.<br>Electro-negative gases- properties and applications of SF6 gas and its mixtures with nitrogen. Ferro electricity. | 9 |
| III | **Dielectric Breakdown**: Mechanism of breakdown in gases, liquids and solids –basic theories including Townsend's criterion, Streamer mechanism.<br>Mechanism of breakdown in liquids and solids - suspended particle theory, Bubble theory, Stressed oil Volume Theory, intrinsic breakdown, electro mechanical breakdown, Thermal breakdown, Treeing and Tracking. Application of vacuum insulation-Breakdown in high vacuum.<br>Basics of treatment and testing of transformer oil. | 10 |
| IV | **Magnetic Materials**: Classification of magnetic materials -Curie-Weiss law -Application of iron and its alloys- Hard and soft magnetic materials– Ferrites- Magnetic materials used in electrical apparatus.<br>**Superconductor Materials**:- Basic Concept- types, characteristics and applications. | 9 |

| | | |
|---|---|---|
| V | **Novel materials**: Introduction to Biomaterials, Nano-materials and their significance. Growth techniques of nano-materials – Top-down and Bottom-up techniques, Lithographic and Non-lithographic processes (qualitative study only).<br>**Modern Techniques for materials studies**: Optical microscopy – Electron microscopy – Photo electron spectroscopy – Atomic absorption spectroscopy. | 9 |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL31C | EMBEDDED SYSTEMS | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: This course introduces the fundamentals of embedded systems, covering system design principles, firmware development, and RTOS-based applications. It includes study of ARM architecture and instruction sets, along with practical aspects of system programming, task management, and communication in embedded platforms.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the basic concepts of embedded systems and different phases in the embedded system design process/EDLC. | Understand |
| CO2 | Compare the firmware design approaches and programming languages used in embedded systems. | Understand |
| CO3 | Explain RTOS concepts, task scheduling, synchronization, and communication techniques in embedded system design | Understand |
| CO4 | Summarize the ARM architecture, core dataflow, and system-level features. | Understand |
| CO5 | Apply ARM instructions for data processing, memory, and control in embedded systems | Apply |

**iii) SYLLABUS**

Introduction to Embedded Systems**:** Classification, purpose, characteristics, design process, EDLC, Embedded Firmware Design: Super loop-based, OS-based approaches, Assembly and high-level language development,RTOS-Based Embedded System Design: Task scheduling, communication, synchronization, ARM Processor: RISC design, ARM core fundamentals, AMBA bus protocol, Pipeline, interrupts, core extensions, ARM Instruction Set: Data processing, load-store instructions, conditional execution

**iv) (a) TEXT BOOKS**

1) K.V. Shibu, Introduction to Embedded Systems, 2e, McGraw Hill Education India, 2016.
2) Raj Kamal, Embedded Systems Architecture, Programming and Design, TMH, 2003
3) Andrew N Sloss, Dominic System and Chris Wright, ARM System Developers Guide, Elsevier, Morgan Kaufman publisher, 1st Edition, 2008.
4) Steve Furber, ARM System-on-Chip Architecture, Second Edition, PEARSON, 2016.

**(b) REFERENCES**

1) Frank Vahid and Tony Givargis, Embedded Systems Design – A Unified Hardware/ Software Introduction, John Wiley, 2002.
2) Steve Heath, Embedded Systems Design, Newnes – Elsevier 2nd edition, 2002.
3) Lyla B. Das, Embedded Systems: An Integrated Approach, 1st edition, Cengage Learning India Pvt Ltd, 2012.
4) Seal, D. (2001). ARM Architecture Reference Manual. 2nd ed., Addison-Wesley.

## v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to embedded systems**: Classification of embedded systems based on generation and complexity, purpose of embedded systems, characteristics, quality attributes, design process, trends and challenges, Embedded product development cycle (EDLC) | 8 |
| II | **Embedded firmware design and development**: Embedded firmware design approaches-super loop-based approach, operating system-based approach; embedded firmware development languages-assembly language-based development, high level language-based development. | 8 |
| III | **RTOS based embedded system design:** Operating system basics, types of operating systems, tasks, process and threads, multiprocessing and multitasking, task scheduling: non-pre-emptive and pre-emptive scheduling; task communication-shared memory, message passing, Remote procedure call and sockets, Task Synchronization: Task Communication/ Synchronization issues, task synchronization techniques. | 10 |
| IV | **ARM Processor**: RISC design and ARM design philosophy, AMBA bus protocol, ARM bus technology, Memory, Peripherals, Embedded system software – Initialization (BOOT) code, Operating System, Applications. ARM Processor Fundamentals, ARM core dataflow model, registers, current program status register, Pipeline, Exceptions, Interrupts and Vector Table, Core extensions. | 9 |
| V | **Introduction to the ARM Instruction set:** Introduction, Data processing instructions, Load - Store instruction, Software interrupt instructions, Program status register instructions, Loading constants, ARMv5E extensions, Conditional Execution | 10 |
| | **Total hours** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL31D | SENSORS AND SENSING TECHNIQUES | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

The purpose of this course is to teach students about the fundamental principles and performance characteristics of essential sensors. This course covers the idea of smart sensors. Students will learn how to design interface circuits for various sensors, as well as how to create and evaluate measurement systems for industrial and scientific applications.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain various magnetic and electric field sensors. | Understand |
| CO2 | Explain the various types of mechanical and acoustic sensors. | Understand |
| CO3 | Explain the working of light-sensitive and thermal sensors. | Understand |
| CO4 | Summarize the working of light-sensitive and thermal sensors. | Understand |
| CO5 | Summarize the applications of smart sensors in different fields and recent developments. | Understand |

**iii) SYLLABUS**

Sensors-Types and characteristics, Magnetic and Electric Field Sensors-Sensors based on variable magnetic coupling, Hall-effect devices, integrated Hall devices, flux gate sensors, solid-state read and write heads, electrostatic sensors and applications. Mechanical and acoustic Sensors-Light-sensitive sensors, Photovoltaic diodes, photoconductors, photodiodes, phototransistors, positron-sensitive photo detectors, charge-coupled devices, fiber optic sensor technologies and applications - Thermal sensors: Platinum resistors, thermistors, silicon transistor thermometers, integrated temperature transducers. Smart Sensors.

**iv) (a) TEXT BOOKS**


1) Pallas-Areny Ramon, John G. Webster, *Sensors and Signal Conditioning*, Wiley, 2001.
2) Gerord C.M. Meijer, *Smart Sensor Systems*, John Wiley and Sons, 2008.
3) D. Patranabis, *Sensors and Transducers*, 2nd edition, Prentice Hall India, 2004.
4) Johnson, Curtis D, *Process Control Instrumentation Technology*, 8th edition, India, Pearson/Prentice Hall, 2006.


**(b) REFERENCES**


1) Barney G.C.V, *Intelligent Instrumentation*, Prentice Hall of India Pvt. Ltd., 2nd edition, 1988.
2) De Silva, Clarence W, *Sensors and Actuators: Engineering System Instrumentation*, CRC Press, 2nd edition, 2015.
3) Pavel Ripka, Alois Tipek, *Modern Sensors Handbook*, John Wiley & Sons, 2nd edition, 2013.

4) Khazan, Alexander D, *Transducers and Their Elements: Design and Application*, Prentice Hall, 1994.
5) Fraden Jacob, *Handbook of Modern Sensors: Physics, Designs, and Applications*, Springer Science & Business Media, 2004.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Sensor Fundamentals: Definition- basic principle- characteristics- types of sensors.** **Magnetic and Electric field sensors:** Sensors based on variable magnetic coupling, search coil, magneto resistors, Hall-effect devices, integrated Hall devices, flux-gate sensors, solid-state read and write heads, electrostatic sensors and applications. | 9 |
| II | **Mechanical and acoustic sensors:** metallic, thin-film and semiconductor strain gauges, silicon pressure sensors, accelerometer, displacement transducers, piezoelectric field-effect transducers, surface acoustic wave devices, ultrasonic based sensors, flow sensors. Potentiometers, Resistive temperature detector, LVDT | 9 |
| III | **Light-sensitive sensors:** photovoltaic diodes, photo conductors, photo diodes, photo transistors, positron-sensitive photo detectors, opto-isolators, photo diode arrays, charge-coupled devices, fiber-optic sensor technologies and applications. **Thermal sensors:** Platinum resistors, Thermistors, Thermocouples, pyroelectric sensors, electrochemical sensors, Magnetic Thermometer. | 10 |
| IV | **Smart Sensors: Components of smart sensor, general architecture of smart sensor,** integrated smart sensors, sensing elements, design of Interface electronics, parasitic effects, sensor linearization, Dynamic range, Universal Sensor Interface, front end circuits, DAQ, Design, Digital conversion, Micro-controllers and digital signal processors for smart sensors, selection criteria, Timer, Analog Comparator, ADC and DAC modules - Standards for smart sensor interface. | 9 |
| V | **Sensor systems and applications:** Integrated sensors, actuators, micro systems, sensor buses, multiple-sensor systems, sensor networks and automotive, consumer, power, medical measurement systems. | 8 |
| | **Total hours** | **45** |

**vii) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**viii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**ix) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL31E | BIOMEDICAL INSTRUMENTATION | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: Goal of this course is to provide an overview of instrumentation systems used in clinical medicine and biomedical research. The course is designed to give the basic concepts of Instrumentation involved in the medical field and human physiology.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Interpret the basics concepts of anatomy and physiology. | Understand |
| CO2 | Explain different techniques for the measurement of various physiological parameters. | Understand |
| CO3 | Illustrate modern imaging techniques for medical diagnosis. | Understand |
| CO4 | Summarize the various therapeutic equipment used in the biomedical field. | Understand |
| CO5 | Outline the patient safety measures and recent advancements in the medical field. | Understand |

**iii) SYLLABUS**

Introduction to biomedical instrumentation, Physiology and Anatomy of human body, Bioelectric potential, Bio potential Electrodes, Transducers for biomedical applications. Measurement of blood pressure, blood flow, cardiac output, Plethysmography, heart sounds. ECG, ECG and EMG block diagram, electrodes, waveforms and features, Measurements of respiratory parameters. Modern Imaging System, Therapeutic equipment, Test on blood cells. Physiological effects of electric current, Introduction to Tele- medicine - Introduction to medical robotics.

**iv) (a) TEXT BOOKS**

1) Leslie Cromwell and F.J. Weibell, E.A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice Hall India, 2nd edition, 1990.
2) Carr & Brown, Biomedical Equipment Technology, 4th edition, Pearson, 2002.
3) R.S. Khandpur, Handbook of Biomedical instrumentation, 3rd edition, Tata McGraw Hill Publishing Co Ltd., 2014.

**(b) REFERENCES**

1) John G Webster, Medical Instrumentation - Application and Design, 4th edition, John Wiley and Sons, 2007.
2) L.A. Geddes and L.E. Baker, Principles of Applied Biomedical Instrumentation, John Wiley & Sons, 1975.
3) Andrew G Webb, Principles of Biomedical Instrumentation, Cambridge university press, 2018.

## v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Biomedical Instrumentation:** Overview of Biomedical Instrumentation - Basic concepts of biomedical instrumentation. Man-Instrumentation System: Challenges in measuring living systems.<br>Human Physiological Systems (Brief Overview) - Cardiovascular system: Heart and circulation. Respiratory system: Basic physiology. Nervous and muscular systems.<br>Bioelectric Potentials - Generation and propagation of bioelectric potentials, Resting potential and action potential. Bio-potential electrodes: Surface electrodes, microelectrodes, and needle electrodes.<br>Transducers for Biomedical Applications - Overview of transducers used in biomedical instrumentation. Pressure, temperature, and respiration rate measurement systems. | 9 |
| II | **Measurement of Blood Pressure and Cardiac Measurements:** Blood Pressure Measurement - Direct vs. indirect measurement methods. Oscillometric method for blood pressure measurement. Ultrasonic method for non-invasive blood pressure measurement.<br>Cardiac Measurements - Electrocardiography (ECG): Working principles, electrodes, and leads. Einthoven's Triangle: Understanding ECG lead configuration. ECG machine and ECG read-out devices. ECG Block diagram.<br>Measurement of blood flow and cardiac output. Plethysmography: Photoelectric and impedance methods. Phonocardiography: Measurement of heart sounds | 9 |
| III | **Measurement of Nervous System and Respiratory Parameters**: Electroencephalography (EEG) - EEG: Basic waveforms and features. 10-20 electrode placement system for EEG measurement. Block diagram of EEG system.<br>Electromyography (EMG) - Measurement of muscle electrical activity. Block diagram of EMG system. Nerve conduction velocity (NCV) measurement techniques.<br>Respiratory Parameters - Spirometry: Measuring lung volumes and capacities. Pneumography: Respiratory rate and volume measurement. Finger-tip oximeter: Principle and working. | 9 |
| IV | **Modern Imaging Systems and Therapeutic Equipment:** Modern Imaging Systems - Basic X-ray machines: Working principle and components. Computed Tomography (CT) Scanner: Principles and components. Ultrasonic Imaging: Working principle and types of ultrasound imaging. Magnetic Resonance Imaging (MRI) - Basic principles. Positron Emission Tomography (PET) - Introduction to imaging principles.<br>Therapeutic Equipment - Cardiac pacemakers, Defibrillators, Haemodialysis machines and Artificial kidney. Lithotripsy, Shortwave and Microwave Diathermy, Ventilators, Heart-Lung Machine, and Infant Incubators. | 10 |

| | | |
|---|---|---|
| V | **Clinical Laboratory Instruments, Electrical Safety, and Emerging Technologies:** Clinical Laboratory Instruments - Instruments for blood tests. Chemical testing in clinical laboratories- Basic principles and applications.<br>Electrical Safety in Biomedical Equipment - Physiological effects of electric current on the human body. Shock hazards from electrical equipment in medical environments. Methods for preventing electrical accidents in healthcare settings.<br>Emerging Technologies: Introduction to telemedicine- Applications and technologies. Medical robotics - Introduction to robotic surgery and rehabilitation. Nano-robots - Principles and future applications in healthcare. Orthopedic prosthesis fixation - Modern techniques in biomedical instrumentation | **8** |
| | **Total hours** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

## vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

## viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL31F | OBJECT ORIENTED PROGRAMMING | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

This course introduces the fundamental concepts of object-oriented programming using Java. It covers core Java syntax, object-oriented principles, exception handling, multithreading, collections framework, and file handling. The course emphasizes practical implementation through hands-on coding exercises, enabling students to develop efficient and modular Java applications.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain object-oriented programming principles and core Java syntax. | Understand |
| CO2 | Apply object-oriented programming concepts such as inheritance, polymorphism, and abstraction in Java programs. | Apply |
| CO3 | Develop modular and reusable code using packages, interfaces, and exception handling techniques. | Understand |
| CO4 | Develop application programs in Java using collections framework and multithreading concepts for efficient program execution. | Apply |
| CO5 | Develop programs using file handling operations and advanced Java features like generics and lambda expressions in Java. | Apply |

**iii) SYLLABUS**

Basic concepts of Object-Oriented Programming, Application Programming interface, Simple Java Program, Java Virtual Machine, Primitive Data types. Core Java Fundamentals, Object Oriented Programming in Java, Introduction to Methods, Inheritance. Packages and Interfaces, Managing errors and Exceptions, Managing Input/Output Files. Java Library Array List class, Accessing a Collection via an Iterator, Event handling Multithreaded Programming.

**iv) (a) TEXT BOOKS**

1) Herbert Schildt, Java: The Complete Reference, 8th Edition, Tata McGraw Hill, 2011.
2) Balagurusamy E., Programming JAVA a Primer, 5th Edition, McGraw Hill, 2014.
3) Paul Deitel, Harvey Deitel, Java How to Program, Early Objects 11th Edition, Pearson, 2018.

**(b) REFERENCES**

1) Y. Daniel Liang, Introduction to Java Programming, 7th Edition, Pearson, 2013.
2) Nageswararao R., Core Java: An Integrated Approach, Dreamtech Press, 2008.
3) Flanagan D., Java in A Nutshell, 5th Edition, O'Reilly, 2005.
4) Barclay K., J. Savage, Object Oriented Design with UML and Java, Elsevier, 2004.
5) Sierra K., Head First Java, 2nd Edition, O'Reilly, 2005.

## v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | OOP Fundamentals: Classes, Objects, Inheritance, Encapsulation, Polymorphism, Java Basics: Java features (buzzwords), comparison with C++, JDK, API, Program Structure: Tokens, statements, compilation and execution, Data Types & Variables: Primitive types, literals, type casting, arrays, strings, vectors, Getting Started: JDK installation, writing and running simple Java programs. | 8 |
| II | Operators: Arithmetic, Bitwise, Relational, Logical, Assignment, Conditional, Operator Precedence, Control Flow: selection, Iteration, and jump statements, Core OOP in Java: Class structure, declaring objects, methods, Constructors, this keyword, method overloading and nesting, Method overriding, final keyword (variables, methods, classes), finalizer methods, Abstract classes and methods, methods with variable arguments (varargs) | 10 |
| III | Packages and Interfaces: defining and extending interfaces, implementing and accessing interfaces, Packages: using system Packages, creating and accessing user-defined packages, adding a class to a package, hiding classes, Exception handling: types of errors, mechanisms, multiple catch statements, using the finally statement, throwing exceptions. | 9 |
| IV | String Handling: string constructors, length, character extraction, modification, and valueOf(), Collections Framework: overview, collection and list interfaces, ArrayList, LinkedList, iterators, Multithreading: Java thread model, main thread, creating and managing threads, synchronization, and thread lifecycle operations. | 10 |
| V | Managing Input/Output Files: Concept of Streams, Stream Classes, File Handling in Java, Working with Text Files, Random Access Files, Buffered Streams, Character Streams, Interactive Input and Output. Advanced Java Concepts: Lambda Expressions, Functional Interfaces, Introduction to Streams API, Introduction to Generics. | 8 |
| | **Total hours** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

### vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

### viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL31G | DATA STRUCTURES | PEC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

This course aims to introduce the various data structures, their organization, and operations. It covers abstract concepts for data organization and manipulation using data structures such as stacks, queues, linked lists, binary trees, heaps, and graphs. It helps the learner to apply appropriate data structures and associated algorithms for solving real world problems efficiently.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the fundamental concepts of data structures, algorithms, and performance analysis, alongside demonstrating the ability to articulate arrays, searching techniques, linked lists, memory management, trees, and graphs. | Apply |
| CO2 | Apply arrays, stacks, queues, and searching algorithms effectively to solve real-world problems, demonstrating proficiency in algorithmic problem-solving. | Apply |
| CO3 | Apply a linked list to represent a data item required to be processed to solve a given computational problem and write an algorithm to find the solution of the computational problem. | Apply |
| CO4 | Apply comprehensive understanding and practical skills in trees, binary trees, binary search trees, and graph algorithms | Apply |
| CO5 | Explain the sorting algorithms and different hashing techniques used. | Understand |

**iii) SYLLABUS**

Introduction: Basic Concepts of Data Structures, Algorithms, Performance Analysis, Asymptotic Notation, Complexity Calculation of Simple Algorithms.

Arrays and Searching: Sparse matrix, Stacks and Queues, Linear Search and Binary Search.

Linked List: Operations on Linked List, Types of Linked Lists, Stacks and Queues.

Trees and Graphs: Binary Trees, Binary Search Trees, Graph Representations, Depth First Search and Breadth First Search, Applications of Graphs.

Sorting and Hashing: Selection Sort, Insertion Sort, Quick Sort, Hashing Techniques, Collision Resolution, Overflow handling, Hashing functions.

**v) (a) TEXT BOOKS**

1) Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed, "Fundamentals of Data Structures in C", 2nd Edition, Universities Press, 2007.

**(b) REFERENCES**

1) Samanta D., "Classic Data Structures", 2nd Edition, Prentice Hall India Learning Private Limited, 2009.
2) Richard F. Gilberg, Behrouz A. Forouzan, "Data Structures: A Pseudocode Approach with C", 2nd Edition, Cengage Learning, 2005.
3) Aho A. V., J. E. Hopcroft and J. D. Ullman, "Data Structures and Algorithms", Pearson Publication, 1982.
4) Tremblay J. P. and P. G. Sorenson, "Introduction to Data Structures with Applications", Tata McGraw Hill, 1984.

**vi) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction: Basic Concepts of Data Structures, System Life Cycle, Algorithms, Performance Analysis, Space Complexity, Time Complexity, Asymptotic Notation, Complexity Calculation of Simple Algorithms. | 8 |
| II | Arrays and Searching: Polynomial representation using Arrays, Sparse matrix, Stacks, Queues-Circular Queues, Priority Queues, Double Ended Queues, Evaluation of Expressions, Linear Search and Binary Search. | 9 |
| III | Linked List: Self-Referential Structures, Dynamic Memory Allocation, Operations on Linked List - Singly Linked List, Doubly Linked List. Stacks and Queues using Linked List, Polynomial representation using Linked List. | 10 |
| IV | Trees and Graphs: Trees, Binary Trees-Tree Operations, Binary Tree Representation, Tree Traversals, Binary Search Trees- Binary Search Tree Operations, Graphs, Representation of Graphs, Depth First Search and Breadth First Search on Graphs, Applications of Graphs. | 9 |
| V | Sorting and Hashing: Sorting Techniques – Selection Sort, Insertion Sort, Quick Sort. Hashing, Hashing Techniques, Collision Resolution, Overflow handling, Hashing functions – Mid square, Division, Folding, Digit Analysis. | 9 |
| | **Total hours** | **45** |

### vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

### vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

### viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

# MINORS/HONOUR

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3MA | RASPBERRY PI-PYTHON INTERFACE FOR ELECTRICAL ENGINEERING | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

This course covers the fundamentals of Raspberry Pi and Python for creating interactive and automated systems. Students will explore hardware interfacing, including GPIO control, sensor integration, and relay modules. They will gain practical experience with analog sensors, PWM, and communication protocols (UART, I2C, SPI). The course also delves into IoT applications, data logging, real-time visualization, and wireless communication. Additionally, students will learn to build home automation systems, integrate smart devices, and develop basic web-based dashboards for remote monitoring.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the hardware features of Raspberry Pi and basic Python programming for GPIO-based interfacing. | Understand |
| CO2 | Explain sensor and output device interfacing, and communication protocols using Raspberry Pi. | Understand |
| CO3 | Develop Python-based solutions using PWM control and implement home automation applications with Raspberry Pi. | Apply |
| CO4 | Explain data logging, real-time visualization, wireless communication, and cloud integration techniques using Raspberry Pi. | Understand |
| CO5 | Apply Raspberry Pi and Python to develop basic home automation systems using multiple sensors, relays, and smart devices | Apply |

**iii) SYLLABUS**

Introduction to Raspberry Pi and OS setup, Python programming basics for hardware control, GPIO interfacing: LEDs, buttons, relays, Sensor interfacing: analog (LM35), proximity, current sensors, Data acquisition and plotting using Python, PWM for motor and LED control, Communication protocols: UART, I2C, SPI, IoT applications: MQTT, cloud integration (ThingSpeak, Blynk),Wireless communication: Bluetooth (HC-05), Wi-Fi (ESP8266), Home automation: multiple sensors, smart devices, dashboards, voice control

**iv) (a) TEXT BOOKS**

1) Simon Monk., Programming the Raspberry Pi: getting started with Python, McGraw-Hill, 2013.
2) Shawn Wallace, Matt Richardson, Wolfram Donat, Getting Started With Raspberry Pi, 4th Edition, O'Reilly, 2021.
3) Tim Cox., Raspberry Pi Cookbook for Python Programmers, Packt Pub Ltd, 2014.

**(b) REFERENCES**

1) Herb Norbom, Raspberry Pi Python Projects, Createspace Independent Publishers, first edition 2017.
2) Colin Dow, Internet of Things Programming Projects: Build modern IoT solutions with the Raspberry Pi 3 and Python, Packt Publishing Limited, 2018.
3) Joe Grant, Raspberry Pi: A Comprehensive Beginner's Guide to Setup, Programming (Concepts and techniques) and Developing Cool Raspberry Pi Projects, Independently Published, 2019.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction to Raspberry Pi: Hardware overview (GPIO, peripherals). Setting up Raspberry Pi OS (Raspbian). Python Programming Basics: Syntax, data types, loops, functions. Libraries for EE applications, Interfacing with Raspberry Pi: Basic GPIO control (LED blinking, button input), using Python scripts for hardware interaction, setting up Raspberry Pi, writing a Python script to blink an LED | 8 |
| II | Interfacing output devices: Relay module for switching applications, Introduction to analog sensor interfacing: LM35 temperature sensor with MCP3008 ADC, Basic data acquisition and plotting using Python and Matplotlib, Introduction to Pulse Width Modulation (PWM): LED brightness control using software PWM, Overview of communication protocols: UART, I2C, SPI | 10 |
| III | Raspberry Pi in Control Systems: Motor speed control using PWM, Home Automation Applications: Relay control for appliances. IoT-based control using Python scripts. Interfacing with Industrial Sensors-Proximity sensors, current sensors (ACS712). | 9 |
| IV | Data Logging & Visualization: storing sensor data in CSV/MySQL. Real-time plotting with Matplotlib/Plotly, IoT with Raspberry Pi. MQTT protocol for remote monitoring, sending data to cloud (ThingSpeak, Blynk). wireless communication, Bluetooth/Wi-Fi modules (HC-05, ESP8266), creating a web-based dashboard to monitor sensor data. | 10 |
| V | Setting up a basic home automation system with sensors and relays, connecting multiple sensors, interfacing multiple sensors with Raspberry Pi, Collecting and displaying data from multiple sensors on the same dashboard, Voice-Controlled Automation, Integrating Raspberry Pi with smart home devices (e.g., smart lights, smart plugs) using Python | 8 |
| | **Total hours** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

## vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

## viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3MC | ENERGY EFFICIENCY IN BUILDINGS | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

Goal is to expose students to the fundamental concepts of energy efficient design of buildings such as lighting, heating, ventilation etc. This course also intends to make students aware of ECBS, LEEB, GRIHA etc.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Identify building services and factors for optimum design of energy efficient buildings. | Apply |
| CO2 | Explain the concepts of energy efficient heating and ventilation | Understand |
| CO3 | Explain the energy efficiency in pumps, blowers, fans, air conditioning etc. | Understand |
| CO4 | Explain the concepts of energy efficient design of buildings. | Understand |
| CO5 | Identify different energy codes and ratings. | Apply |

**iii) SYLLABUS**

Building Services- Climate adapted and climate rejecting buildings — Bioclimatic zones -Heat Transfer - Thermal Storage- Environmental Factors, Site Planning and Development

Energy efficient heating and ventilation— Terminology — Requirements Thermal performance of Building sections- Natural Ventilation — Purpose of ventilation- Design for Natural Ventilation

Energy efficient Lighting-Day Lighting- Lighting principles and fundamentals- Lighting control for day lighted buildings — Switching controls- Power Adjustment Factors

Energy efficiency in pumps, blowers, fans, compressed air system, refrigeration and air conditioning System-Cooling towers- DG Sets-Energy efficient HVAC systems

Energy Efficient Design of Buildings - Green Buildings - Energy efficient materials for buildings — Design - Operational energy reduction and net zero building

Energy codes ECBC (ECBC 2007) requirement, Concepts of OTTV etc., Green Performance rating, requirements of LEED, GRIHA etc.

**iv) (a) TEXT BOOKS**

1) Givoni B., Givoni B., Passive and Low Energy Cooling of Buildings, John Wiley & Sons, Inc, 1994.
2) Callaghn P.W., Design and Management for Energy Conservation, Pergamon Press, John Wiley and Sons Inc, Oxford, 2001.
3) Energy Conservation Building Code, Bureau of Energy Efficiency, New Delhi, Bureau of Energy Efficiency Publications-Rating System, TERI Publications- GRIHA Rating System.

**(b) REFERENCES**


1) Part 1 to 4 SP: 41,1987, Handbook on Functional Requirements of Buildings, Bureau of Indian Standards Publication, 1st reprint, 1995.
2) Majumdar M., Energy - Efficient Buildings in India, Tata Energy Research Institute, Ministry of Non-Conventional Energy Sources, 2002.
3) Moore, F., Environmental Control System, McGraw Hill Inc. 2002
4) Tyagi, A. K., Handbook on Energy Audits and Management, Tata Energy Research Institute, 2000.


**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction- Building Services- Climate adapted and climate rejecting buildings — Heat Transfer — Measuring Conduction — Thermal Storage — Measurement of Radiation —Greenhouse Effect — Convection — Measuring latent and sensible heat — Thermal Comfort — Microclimate, Environmental Factors, Site Planning and Development — Temperature — Humidity — Wind — Steady and Periodic Heat Transfer-Optimum Site Locations. | 9 |
| II | Energy efficient heating and ventilation- Hourly Solar radiation — Heat insulation — Terminology — Requirements — Heat transmission through building sections — Thermal performance of Building sections — Orientation of buildings — Building characteristics for various climates — Thermal Design of buildings —Influence of Design Parameters — Mechanical controls — Examples. Natural Ventilation — Purpose of ventilation — Minimum standards for ventilation — Ventilation Design — Mechanisms-Energy Conservation in Ventilating systems — Design for Natural Ventilation. | 9 |
| III | Energy efficient lighting- Day Lighting- Lighting principles and fundamentals- Daylight Factor - Daylight Analysis - Daylight and Shading Devices- Materials, components and details — Insulation — Optical materials — Radiant Barriers — Glazing materials — Glazing Spectral Response-Electric Lighting — Light Distribution — Electric Lighting control for day lighted buildings — Switching controls — Coefficient of utilization — Electric Task Lighting — Electric Light Zones — Power Adjustment Factors. | 9 |
| IV | Energy efficiency in pumps, blowers, fans, compressed air system, refrigeration and air conditioning system-Cooling towers- DG sets-Energy efficient HVAC systems | 8 |
| V | Energy Efficient Design of Buildings-Green Buildings-Design-Operational energy reduction and net zero building, Optimization for design of building for energy efficiency and example of optimization through use of Evolutionary genetic algorithm- Effects of trees and | 10 |

| | | |
|---|---|---|
| | microclimatic modification through greening, Use of Building Integrated Photo Voltaic (BIPV) and other renewable energy in buildings, basic concepts and efficiency. Energy codes ECBC (ECBC 2007) requirement, Concepts of OTTV etc, Green Performance rating, requirements of LEED, GRIHA etc. | |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3ME | SOLAR AND WIND ENERGY CONVERSION SYSTEMS | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: This course aims to impart the knowledge of renewable energy sources as sustainable development. The students will be familiarised with the major aspects of solar and wind energy conversion systems. This course also aims at providing the fundamental information in modelling the energy conversion systems.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the basics of solar energy conversion systems. | Understand |
| CO2 | Explain the principle behind solar thermal systems and its applications. | Understand |
| CO3 | Apply the design aspects of solar photovoltaic systems in sizing its components. | Apply |
| CO4 | Outline the concepts involved in wind energy systems. | Understand |
| CO5 | Classify various Wind Energy Conversion and Wind Electric Generation Systems and discuss the issues with hybrid energy conversion systems. | Understand |

**iii) SYLLABUS**

Solar Energy - Solar radiation – Solar Radiation on an Inclined/Tilted Surface.
Solar Thermal Systems – Solar Concentrators – Applications.
Solar photovoltaic systems - Characteristics - Types of solar cells - PV Module - Block diagram of SPV system – MPPT – Design of SPV - Modelling of SPV.
Wind Energy **-** Wind power and its sources - Modes of wind power generation.
Wind Energy Conversion Systems WECS – Principles - Classification of WECS - Wind Electric Generation Systems - Effects of Wind Speed and Grid Condition.

**iv) (a) TEXT BOOKS**


1) Earnest J. and T. Wizelius, Wind Power Plants and Project Development, Prentice Hall of India, Learning Private Limited, 2$^{nd}$ edition, 2015.
2) Godfrey Boyle, Renewable Energy: Power for a sustainable future, Oxford University Press, 2012.
3) Rai. G.D, Non-conventional Energy Sources, Khanna publishers, 2011.
4) A.A.M. Saigh (Ed): Solar Energy Engineering, Academic Press, 1977.
5) G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers,2002.


**(b) REFERENCES**


1) Gary, L. Johnson, Wind Energy System, Prentice Hall, 1985.

2) C. S. Solanki, Solar Photovoltaics: Fundamentals Technologies and Applications, Prentice-Hall of India Pvt. Limited, 3rd edition, 2015.
3) Rai. G.D, Solar Energy Utilization, Khanna Publishers, 1995.
4) Kastha D, Banerjee S and Bhadra S N, Wind Electrical Systems, Oxford University Press, New Delhi, 2005.
5) Rashid M.H., Power Electronics Circuits, Devices and Applications, 4th edition, Pearson Education, 2017.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction** - Basic Concept of Energy - Source of Solar Energy - Formation of the Atmosphere - Solar Spectrum. Solar Constant - Air Mass - Solar Time-Sun – Earth Angles - Solar Radiation - Instruments to Measure Solar Radiation - Pyrheliometer – Pyranometer - Sunshine Recorder -Solar Radiation on a Horizontal Surface - Extra-terrestrial Region - Terrestrial Region - Solar Radiation on an Inclined Surface - Conversion Factors - Total Solar Radiation on an Inclined/Tilted Surface - Monthly Average Daily Solar Radiation on Inclined Surfaces. | 9 |
| II | **Solar Thermal System** - Principle of Conversion of Solar Radiation into Heat, – Solar thermal collectors – General description and characteristics – Flat plate collectors – Heat transfer processes – Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – performance evaluation. Applications - Solar heating system, Air conditioning and Refrigeration system, Pumping system, solar cooker, Solar Furnace, Solar Greenhouse -Design of solar water heater. | 9 |
| III | **Solar PV Systems** - Introduction - Fundamentals of Semiconductor and Solar Cells - Photovoltaic Effect - Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell - Generation of Solar Cell (Photovoltaic) Materials-.Photovoltaic (PV) Module and PV Array - Single-Crystal Solar Cell Module, Thin-Film PV Modules, III- V Single Junction and Multijunction PV Modules - Emerging and New PV Systems - Packing Factor of the PV Module - Efficiency of the PV Module - Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules - Effect of shadowing-Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems – stand-alone and grid connected - Design steps for a Stand-Alone system, Control scheme used for single stage grid connected PV system – Storage batteries and Ultracapacitors. | 9 |
| IV | **Wind Turbines** – Introduction - Origin of Winds - Nature of Winds – Classification of Wind Turbines - Wind Turbine Aerodynamics - Basic principles of wind energy extraction – Extraction of wind turbine power (Numerical problems) - Weibull distribution - Wind | 9 |

| | | |
|---|---|---|
| | power generation curve-Betz's Law - Modes of wind power generation. | |
| V | **Wind Energy Conversion Systems** – Introduction - Components of WECS - Fixed speed drive scheme - Variable speed drive scheme - Wind–Diesel Hybrid System – Induction generators - Doubly Fed Induction Generator (DFIG) - Squirrel Cage Induction Generator (SCIG) - Synchronous Generators, Permanent Magnet Synchronous Generators. Power converters in renewable energy system - AC-DC Converters, DC-DC Converters, DC-AC Converters (Block Diagram Only) - Effects of Wind Speed and Grid Condition (System Integration) - Environmental Aspects - Wind Energy Program in India. | 9 |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3MG | HYBRID AND ELECTRIC VEHICLES | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

This course aims to equip students with a foundational understanding of electric and hybrid vehicles, including their key concepts and evolving trends. Students will learn about drive systems, battery management, energy sources, and essential communication protocols relevant to electric vehicles.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Illustrate the basic concepts of electric and hybrid electric vehicles. | Understand |
| CO2 | Classify the various configurations of electric and hybrid electric drive trains. | Understand |
| CO3 | Outline the propulsion unit for electric and hybrid vehicles | Understand |
| CO4 | Summarise various energy storage systems for vehicle applications. | Understand |
| CO5 | Compare various communication protocols and technologies used in vehicle networks. | Understand |

**iii) SYLLABUS**

Conventional Vehicles, Basics of vehicle performance

Hybrid and Electric drive trains- Basic Architecture of hybrid traction, Power flow control.

Electric Propulsion unit, Configuration and control of DC motor and Induction Motor drives.

Energy Storage Requirements in Hybrid and Electric Vehicles, Battery, fuel cell and supercapacitor-based energy storage, Type of charging stations.

Communication Systems, Energy Management Strategies.

**iv) (a) TEXT BOOKS**

1) Iqbal Husain: *Electric and Hybrid vehicles: Design Fundamentals,* CRC press, 3rd Edition 2021.
2) Ehsani M., *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2005.
3) Gianfranco Pistoia, *Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market,* Elsevier,2010.
4) Chan C. C. and Chau K. T., *Modern Electric Vehicle Technology,* OXFORD University Press, 2001.

**(b) REFERENCES**

1) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, 2nd Edition Wiley 2003.
2) Fuhs A. E., *Hybrid Vehicles and the Future of Personal Transportation,* CRC Press, 2009.
3) Chris Mi , Abul Masrur M., *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives,* 2nd Edition, John Wiley & Sons Ltd, 2017.
4) Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer, 2013.


**(c) ONLINE RESOURCES**

1) NPTEL courses/Materials (IITG, IITM, IITD) – Electric and Hybrid vehicles
   https://nptel.ac.in/courses/108/103/108103009/ (IIT Guwahati)
   https://nptel.ac.in/courses/108/102/108102121/ (IIT Delhi)
   https://nptel.ac.in/courses/108/106/108106170/ (IIT Madras)
2) FOC Control - video lecture by Texas Instruments
   https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors
3) Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
   https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
   https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html
4) Electric Vehicle Conductive AC Charging System
   https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf Electric Vehicle Conductive AC Charging System

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Hybrid Electric Vehicles**: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles.<br>**Basics of vehicle performance**, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance. | 9 |
| II | **Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies.<br>**Electric Drive-trains:** Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies. | 9 |

| | | |
|---|---|---|
| III | **Electric Propulsion unit:** Introduction to electric components used in hybrid and electric vehicles. Configuration and control of separately excited DC motors, Induction Motors (block diagram representation of FOC). | 9 |
| IV | **Energy Storage**: Introduction to energy storage requirements in Hybrid and Electric Vehicles- Battery based energy storage systems - Fuel Cell based energy storage systems- Introduction to Supercapacitors - Hybridization of different energy storage devices<br>**Types of charging stations** - AC Level 1 & 2, DC - Level 3 –V2G concept. | 10 |
| V | **Communications**, supporting subsystems: In vehicle networks- Communication Protocols - CAN, LIN, FLEXRAY (Basics only)<br>**Introduction to energy management strategies in EVs**: Classification of different energy management strategies, comparison of different energy management strategies. | 8 |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3HA | RENEWABLE ENERGY RESOURCES AND DISTRIBUTED GENERATION | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

This course offers an introduction to renewable energy technologies and distributed power generation. It covers the fundamentals of solar photovoltaics, including solar resource assessment, PV cell characteristics, and power optimization. Wind power systems are discussed with emphasis on turbine technology, energy estimation, and environmental impacts. The course also explores electricity storage technologies, particularly batteries and supercapacitors, along with the basics of fuel cell operation and efficiency. Finally, it introduces reciprocating engine and gas turbine-based distributed generation systems, highlighting their role in modern decentralized energy networks.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Illustrate various parameters required for functioning of Solar PV systems. | Understanding |
| CO2 | Explain energy production from Wind energy systems. | Understanding |
| CO3 | Demonstrate the working of batteries, super capacitors and fuel cells. | Understanding |
| CO4 | Explain the working of Reciprocating engine based Distributed Generation. | Understanding |
| CO5 | Explain the working of Gas Turbine based Distributed Generation. | Understanding |

**iii) SYLLABUS**

Introduction-Solar Resource –Solar Spectrum, Earth's orbit, Altitude angle of the Sun at Solar Noon, Solar Position at any time of the day, Clear-sky direct beam radiation.

Historical Development of Wind Power, Wind Turbine Technology – Rotors and Generators; Power in the wind; Wind Turbine Power Curves; Average Power in the Wind.

Stationary Battery Storage – Basics of Lead-Acid batteries, Battery Storage Capacity, Coulomb efficiency instead of energy efficiency, Battery Sizing.

Fuel Cell – Historical Development-Basic Operation, Fuel Cell Thermodynamics, Entropy and the theoretical efficiency.

Introduction, Distributed Versus Central Station Generation, Traditional Power Systems. Reciprocating Piston Engine Distributed Generation

Introduction, Three Types of Turbine DG: Utility, Mini and Micro Turbine; Basic Turbine Generator Concepts.

**iv) (a) TEXT BOOKS**

1) 1. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", Second Edition, IEEE Press, Wiley, 2013.
2) H. Lee Willis and Walter G. Scott, Marcel Dekker, "Distributed Power Generation – Planning and Evaluation", 2000.

**(b) REFERENCES**

1) Mukund R. Patel, "Wind and Solar Power Systems – Design, Analysis and Operation", 2nd Edition, Taylor & Francis, 2006.
2) N. Jenkins, J.B. Ekanayake and G. Strbac, "Distributed Generation", 1st Edition, The Institution of Engineering and Technology, London, 2010.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **INTRODUCTION TO SOLAR PHOTOVOLTAICS:**<br>Solar Resource –Solar Spectrum, Earth's orbit, Altitude angle of the Sun at Solar Noon, Solar Position at any time of the day, Clear-sky direct beam radiation, Total clear-sky direct beam radiation on a collecting surface, Tracking Systems, Average Monthly Insolation.<br>PV Cell, PV Materials, Equivalent Circuits for PV Cells, Modules and Arrays; PV I-V Curve under Standard Testing Conditions; Impact of Temperature and Insolation on I-V curves; Shading Impacts on I-V curves; Maximum Power Point Trackers (MPPT). | **10** |
| II | **WIND POWER SYSTEMS**<br>Historical Development of Wind Power, Wind Turbine Technology – Rotors and Generators; Power in the wind; Wind Turbine Power Curves; Average Power in the Wind; Estimating Wind Turbine Energy Production; Wind Turbine Economics; Environmental impacts of Wind Turbines. | **8** |
| III | **ELECTRICITY STORAGE & FUEL CELLS**<br>Stationary Battery Storage – Basics of Lead-Acid batteries, Battery Storage Capacity, Coulomb efficiency instead of energy efficiency, Battery Sizing. Different Battery storage technologies and comparison of their performance. Introduction to Super capacitors.<br>Fuel Cell – Historical Development-Basic Operation, Fuel Cell Thermodynamics, Entropy and the theoretical efficiency of Fuel Cells, Gibbs Free Energy and Fuel Cell efficiency, Electrical output of an Ideal Cell, Electrical Characteristics of Real Fuel Cells, Types of Fuel Cells, Hydrogen Production. | **10** |
| IV | **RECIPROCATING ENGINE DISTRIBUTED GENERATION**<br>Introduction, Distributed Versus Central Station Generation, Traditional Power Systems. Reciprocating Piston Engine Distributed Generation – Introduction, Basics of Reciprocating Piston Engines, Important Design Characteristics, Conversion to Electric Power, Salient aspects of Piston-DG systems. | **8** |

| | | |
|---|---|---|
| V | **GAS TURBINE POWERED DISTRIBUTED GENERATION**<br>Introduction, Three Types of Turbine DG: Utility, Mini and Micro Turbine; Basic Turbine Generator Concepts, Utility System Turbine Generators, Mini Gas Turbine Generators; Micro Gas Turbine Generators. | 9 |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3HC | ELEMENTS OF SOLAR ENERGY CONVERSION | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: This course provides students with a comprehensive understanding of solar energy conversion systems. The course covers the fundamental principles of solar energy, with a focus on photovoltaic (PV) systems, solar thermal systems, and their applications in both residential and industrial settings.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Understand the fundamental principles of solar radiation and energy conversion technologies. | Understand |
| CO2 | Understand the working principles of photovoltaic cells and the MPPT methods | Understand |
| CO3 | Develop photovoltaic systems considering energy demand, efficiency, and safety aspects | Apply |
| CO4 | Explain the components, working and applications of solar thermal systems | Understand |
| CO5 | Understand the integration of solar energy with storage systems, grid interaction and emerging trends in solar technology | Understand |

**iii) SYLLABUS**

Overview of Solar Energy. Photovoltaic (PV) Systems – Fundamentals, PV Cell Materials. Components of a PV system, Grid-connected vs. off-grid systems, DC vs. AC power conversion. Design and Performance of Photovoltaic Systems. Performance Evaluation and Safety. Maintenance and safety protocols for PV installations. Introduction to Solar Thermal Energy. Integration, Storage, and Future of Solar Energy. Future Trends and Innovations in Solar Energy.

**iv) (a) TEXT BOOKS**


1) G.D. Rai, "Non-Conventional Energy Sources" Khanna publishers, 5th edition,2014.
2) Chetan Singh Solanki, "Solar Photo Voltaics Fundamentals, Technology and application", publisher PHI learning Pvt Ltd, 3rd edition,2019.
3) Sukhatme, S. and Nayak, J, 'Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw Hill, New York, 3rd Edition, 2009.
4) Garg, H.P. and Prakash, J., "Solar Energy: Fundamentals and Applications", Tata McGraw Hill Publishers, New Delhi, 1st Revised Edition, 2000.
5) Siraj Ahmed," Wind Energy Theory and Practice" publisher PHI learning Pvt Ltd ,3rd edition, 2016.
6) D.P Kothari, K.C Singal, Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", PHI learning Pvt Ltd, 2nd edition, 2012.


**(b) REFERENCES**


1) Tiwari and Ghosal, "Renewable Energy resources", publisher Narosa, 2005.
2) John Twidell and Tony Weir, "Renewable Energy Resources", publisher Taylor and Francis, 2nd edition, 2006.

## v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Solar Energy:** Overview of Solar Energy -Importance of solar energy as a renewable resource, Sun earth angles, Global energy demands and the role of solar energy in reducing carbon footprints, Solar radiation and its distribution across the Earth. Factors affecting solar energy availability: location, time of year, atmospheric conditions, and geographic features; Solar irradiance and solar constant, Solar radiation data and forecasting. Total solar radiation on an inclined/tilted surface, monthly average daily solar radiation on inclined surfaces. | 9 |
| II | **Photovoltaic (PV) Systems – Fundamentals:** Working Principle of Photovoltaic Cells - Semiconductor physics: p-n junction, the photoelectric effect, Light absorption and electron excitation in photovoltaic materials, Current-voltage characteristics of a solar cell. PV Cell Materials - Silicon-based solar cells (monocrystalline, polycrystalline, and amorphous silicon), Emerging PV materials - thin-film, perovskite, and organic solar cells. MPPT – P&O, Incremental conductance. | 9 |
| III | **Design and Performance of Photovoltaic Systems:** Components of a PV system - Solar panels, inverters, charge controllers, batteries.<br>Sizing a PV System - Calculating energy demand and system sizing, Determining the required number of panels, inverters, and batteries, Estimating system efficiency and losses. PV System Design Considerations - Factors influencing system performance: tilt angle, shading, orientation, and temperature, Choosing the right components based on the load, location, and budget. | 9 |
| IV | **Solar Thermal Systems:** Introduction to Solar Thermal Energy - Working principle of solar thermal systems: conversion of sunlight into heat, Types of solar thermal systems: active vs. passive systems. Types of Solar Thermal Collectors - Flat-plate collectors., Evacuated tube collectors, Concentrated solar thermal (CST) collectors. Applications of Solar Thermal Systems - Domestic hot water systems, Solar space heating and cooling, Industrial process heating, Solar thermal power generation, Solar furnace, Solar cooker, Solar green house. | 9 |
| V | **Integration, Storage, and Future of Solar Energy:** Energy Storage for Solar Systems - Importance of storage for solar energy, Battery storage technologies: Lead-acid, lithium-ion, and flow batteries, Thermal storage systems: Sensible and latent heat storage. Integration of Solar Energy with the Grid - Challenges in grid integration, Grid-connected vs off-grid systems. Hybrid Solar Systems - Combining solar with other renewable sources (wind, hydro), Hybrid off-grid systems and their applications in rural areas.<br>**Future Trends and Innovations in Solar Energy**: Emerging PV technologies - Bifacial PV, tandem cells, and perovskites, Building-integrated photovoltaics (BIPV), Solar power in transportation (solar cars, solar-powered vehicles). | 9 |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3HE | SOLAR PHOTOVOLTAICS FUNDAMENTALS | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: This course aims to impart the knowledge of photovoltaic systems, various technologies of solar PV cells, details about manufacture, sizing, operating techniques and design considerations. The students will be familiarized with the major aspects of solar energy conversion systems.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the basics of solar energy conversion systems. | Understand |
| CO2 | Explain the principle behind the design of solar cells. | Understand |
| CO3 | Explain various protection and performance measurement methods in solar PV systems. | Understand |
| CO4 | Apply design principles to size components for solar photovoltaic systems. | Apply |
| CO5 | Illustrate the various maximum power point tracking methods. | Understand |

**iii) SYLLABUS**

Solar Energy - Solar radiation — Solar Radiation on an Inclined/Tilted Surface. Manufacture of Solar Cells-Technologies. Flat plate arrays, Support structures, Module interconnection and cabling, Lightning protection, Solar photovoltaic systems - Characteristics - Types of solar cells - PV Module - Block diagram of SPV system — MPPT — Design of SPV - Modelling of SPV.

**iv) (a) TEXT BOOKS**

1) F C. Treble, “Generating electricity from Sun”, Pergamon Press.
2) A. K. Mukherjee, Nivedita Thakur, “Photovoltaic systems: Analysis and design”, PHI, 2011.
3) Rai. G.D, Non-conventional Energy Sources, Khanna publishers, 2011.
4) A.A.M. Saigh (Ed): Solar Energy Engineering, Academic Press, 1977.
5) G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers,2002.

**(b) REFERENCES**

1) C. S. Solanki, Solar Photovoltaics: Fundamentals Technologies and Applications, Prentice-Hall of India Pvt. Limited, 3rd edition, 2015.
2) Rai. G.D, Solar Energy Utilization, Khanna Publishers, 1995.
3) Rashid M.H., Power Electronics Circuits, Devices and Applications, 4th edition, Pearson Education, 2017.

### v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | **Solar Energy** - Sun and Earth, Solar energy potential - Global and Indian scenario Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation, Solar cell, Equivalent circuit, V-I characteristics, Performance improvement. | 9 |
| II | **Solar Cells -**Manufacture of Solar Cells-Technologies, Design of Solar cells, Photovoltaic modules, Design requirements, Encapsulation systems, Manufacture, Power rating, Hotspot effect, Design qualifications. | 9 |
| III | **Protection and Measurements -** Flat plate arrays, Support structures, Module interconnection and cabling, Lightning protection. Protection devices: Fuses, circuit breakers, surge protectors.<br>Measurement instruments: Pyranometer, Pyrheliometer, Sunshine Recorder**.** Performance measurement using natural sunlight and simulator, Determination of temperature coefficients, Internal series resistance, Curve correction factor. | 9 |
| IV | **Photovoltaic Systems** — Photovoltaic systems, Types, General design considerations, System sizing, Battery sizing, Inverter sizing, Design examples, Balance of PV systems. | 9 |
| V | **Maximum Power Point Trackers** — Maximum power point trackers, Perturb and observe, Incremental conductance method, Hill climbing method, Hybrid and complex methods, Data based and other approximate methods, Instrument design, Other MPP techniques, Grid interactive PV system.<br>Inverters: Grid-tied, off-grid, hybrid inverters. | 9 |
| | **Total hours** | **45** |

### vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3HG | ELECTRIC VEHICLE TECHNOLOGY | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: The main goal of this course is to expose the students to the fundamental concepts and trends in electric vehicles and hybrid electric vehicles and it also discusses how to choose proper energy storage systems for vehicle applications. It gives an insight into the electric propulsion unit and its control for application of electric vehicles.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Apply hybrid electric vehicle principle to determine the vehicle performance. | Apply |
| CO2 | Illustrate the basic concepts of electric and hybrid electric drive trains and the control of motors in electric propulsion. | Understand |
| CO3 | Identify the suitable system components for designing electric and hybrid vehicles. | Apply |
| CO4 | Compare the proper energy storage systems for vehicle applications. | Understand |
| CO5 | Explain various communication protocols and technologies used in hybrid and electric vehicles. | Understand |

**iii) SYLLABUS**

Conventional Vehicles, Basics of vehicle performance, Basic Architecture of hybrid traction, Power flow control.

Electric Propulsion unit, Configuration and control of DC, Induction Motor, PMSM and BLDC motor drives.

Design of electric and hybrid electric vehicles-sizing of power electronics and motor.

Energy Storage Requirements in Hybrid and Electric Vehicles, Battery, fuel cell, flywheel and supercapacitor.

Communication Systems, Energy Management Strategies, EV charging technologies and policies.

**iv) (a) TEXT BOOKS**

1) Iqbal Husain: *Electric and Hybrid vehicles: Design Fundamentals,* CRC press, 3$^{rd}$ Edition 2021.
2) Ehsani M., *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2005.
3) Gianfranco Pistoia, *Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market,* Elsevier,2010.
4) Chan C. C. and Chau K. T., *Modern Electric Vehicle Technology,* OXFORD University Press, 2001.

### (b) REFERENCES

1) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, 2nd Edition Wiley 2003.
2) Fuhs A. E., *Hybrid Vehicles and the Future of Personal Transportation,* CRC Press, 2009.
3) Chris Mi , Abul Masrur M., *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives,* 2nd Edition, John Wiley & Sons Ltd, 2017.
4) Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles*, Springer, 2013.

### (c) ONLINE RESOURCES

1) NPTEL courses/Materials (IITG, IITM, IITD) – Electric and Hybrid vehicles
https://nptel.ac.in/courses/108/103/108103009/ (IIT Guwahati)
https://nptel.ac.in/courses/108/102/108102121/ (IIT Delhi)
https://nptel.ac.in/courses/108/106/108106170/ (IIT Madras)
2) FOC Control - video lecture by Texas Instruments
https://training.ti.com/kr/field-oriented-control-permanent-magnet-motors
3) Sensored and sensorless FOC control of PMSM motors – Application notes (TI, MATLAB)
https://www.ti.com/lit/an/sprabz0/sprabz0.pdf?ts=1620018267996&ref_url=https%253A%252F%252Fwww.google.com%252F
https://in.mathworks.com/help/physmod/sps/ref/pmsmfieldorientedcontrol.html
4) Electric Vehicle Conductive AC Charging System
https://dhi.nic.in/writereaddata/UploadFile/REPORT%20OF%20COMMITTEE636469551875975520.pdf
Electric Vehicle Conductive AC Charging System.

### v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Electric and Hybrid Electric Vehicles**: Hybrid and Electric Vehicles Components, Power transmission path. **Basics of Vehicle Propulsion**: Dynamic equation, Maximum tractive effort, Vehicle Power Plant and Transmission characteristics. **Hybrid Electric Drive-trains:** Architecture of Hybrid Electric Drive Trains, various topologies, Power flow control in Series Hybrid Electric Drive Trains and Parallel hybrid electric drive trains. | 9 |
| II | **Electric propulsion:** Electric components used in electric and hybrid drives, Classification of Electric Motors in EV, DC motor drives and speed control, Induction motor drives, Permanent Magnet Motor Drives, BLDC Drive: Configuration, and control of Drives. | 9 |
| III | **Design of Electric and Hybrid Electric Vehicles:** Sizing of major components - Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology. Design of Battery Electric Vehicle. | 9 |

| | | |
|---|---|---|
| IV | **Energy Storage for EV and HEV:** Energy storage requirements, Battery parameters, Battery based energy storage and its analysis, Li-ion batteries, Battery Management System, Fuel Cell based energy storage and its analysis, Supercapacitors and Flywheel based energy storage (Analysis not required), Hybridization of different energy storage devices. | 10 |
| V | **Communications:** In vehicle networks – CAN- Block diagram.<br>**Energy management strategies:** Energy Management Strategies used in Electric and Hybrid Vehicles, Concept of V2G, G2V, V2B, V2V.<br>**EV Charging Technologies:** Standards, Conductive and Inductive charging methods, EV Charging infrastructure, Impacts of integration of EVs in Smart Grid. | 8 |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

# SEMESTER VI

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL30D | LINEAR CONTROL SYSTEMS | PCC | 3 | 1 | 0 | 0 | 4 | 2023 |

**i) COURSE OVERVIEW**:

This course introduces the modeling, analysis, and design of linear time-invariant control systems using classical techniques. Students will learn to derive system transfer functions, analyze system performance in both time and frequency domains, assess system stability, and design basic compensators. Emphasis is placed on understanding system behavior, feedback control, and practical applications in electrical and electronics engineering.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain open-loop and closed-loop linear control systems and their applications. | Understand |
| CO2 | Apply transfer function techniques to analyse time response and compute steady-state errors. | Apply |
| CO3 | Make use of Routh-Hurwitz criterion to assess system stability and apply root locus techniques to study system behaviour. | Apply |
| CO4 | Construct Bode, Polar, and Nyquist plots to evaluate the frequency response and stability margins of control systems. | Apply |
| CO5 | Apply classical control strategies and compensator design concepts to basic engineering systems. | Apply |

**iii) SYLLABUS**

Introduction to linear control systems, classification of control systems, mathematical modeling of electrical and mechanical systems using differential equations, derivation of transfer functions, block diagram representation and reduction, signal flow graphs and Mason's gain formula.

Time domain analysis of first and second order systems, standard test signals, time domain specifications, steady-state error analysis using error constants, dominant pole approximation, introduction to P, PI, PD, and PID controllers.

Concepts of stability, Routh-Hurwitz criterion, root locus technique and its application to stability and system behavior.

Frequency response analysis of control systems using Bode plots, determination of gain and phase margins, polar plots and Nyquist stability criterion.

Classical controller design using lag and lead compensators with Bode plots, PID tuning using Ziegler-Nichols method, brief introduction to lag-lead compensator, conceptual case studies in motor control and renewable energy systems.

**iv) (a) TEXT BOOKS**

1) Benjamin C. Kuo, *Automatic Control Systems*, McGraw-Hill Education, 8th Edition, 2003.

2) I.J. Nagrath and M. Gopal, *Control Systems Engineering*, New Age International Publishers, 6th Edition, 2018.
3) Norman S. Nise, *Control Systems Engineering*, Wiley, 7th Edition, 2015

**(b) REFERENCES**

1) Ogata Katsuhiko, *Modern Control Engineering*, Pearson Education, 5th Edition, 2010.
2) R.T. Stefani, B. Shahian, C.J. Savant Jr., and G.H. Hostetter, *Design of Feedback Control Systems*, Oxford University Press, 4th Edition, 2002.
3) Richard C. Dorf and Robert H. Bishop, *Modern Control Systems*, Pearson, 13th Edition, 2016.
4) Gopal M., *Control Systems: Principles and Design*, McGraw-Hill Education, 4th Edition, 2012.

**i) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Linear Control Systems**<br>Basic structure of control systems – open-loop and closed-loop systems, Block diagram, effect of feedback on sensitivity and stability, Mathematical modeling of simple electrical and mechanical systems, Transfer function derivation from differential equations, Block diagram representation and reduction techniques, Signal Flow Graphs – Mason's Gain Formula – Application to system modeling and transfer function determination. | 12 |
| II | **Control System Components:** AC servomotor, DC servomotor, Synchro, Gyroscope.<br>**Time Domain Analysis**<br>Standard test signals, Time response of first and second order systems, Time domain specifications, Steady-state error analysis, Concept of dominant poles and approximations, Introduction to P, PI, PD, and PID controllers. | 12 |
| III | **Stability and Root Locus Method**<br>Concepts of stability – BIBO and asymptotic stability, Routh-Hurwitz stability criterion – formulation and special cases, Root locus technique – construction rules, root locus sketches for standard systems, Effect of adding poles and zeros on system behavior. | 12 |
| IV | **Frequency Domain Analysis**<br>Frequency response and specifications – bandwidth, resonant frequency, phase margin, gain margin, Bode plot – construction, phase and gain margin calculations, Introduction to Nyquist criterion – graphical interpretation only, Polar plots and stability analysis using Nyquist plot. | 15 |
| V | **Controller Design**<br>Lag and lead compensator design using Bode plot techniques, PID controllers – tuning basics using Ziegler-Nichols method, Brief introduction to lag-lead compensator – concept only. | 9 |
| | **Total hours** | **60** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL30E | POWER SYSTEMS I | PCC | 3 | 1 | 0 | 0 | 4 | 2023 |

**i) COURSE OVERVIEW**:

The goal of this course is to expose the students to the fundamental concepts of generation, transmission and distribution of electric power. The course also intends to deliver the basic concepts of power system protection including the different types of relays and circuit breakers.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the various types of power generation, protection and HVDC transmission schemes | Understand |
| CO2 | Solve for the various parameters related to economics of power generation and power factor improvement | Apply |
| CO2 | Solve for the inductance, capacitance, ABCD parameters and volume of conductor material required for the various types of power transmission schemes | Apply |
| CO4 | Solve for the various parameters related to overhead transmission lines and cables | Apply |
| CO5 | Solve current distribution problems related to various power distribution systems | Apply |

**iii) SYLLABUS**

Introduction - Generation of Electric Power - Overview of conventional generation schemes, Economics of Generation – Terminology - Power Factor Improvement using capacitors.

Power Transmission - Transmission Line Parameters: Resistance, inductance and capacitance of single phase, two wire and three phase lines, Modelling of Transmission Lines.

Introduction of Overhead transmission and underground transmission – Volume of conductor material required - Mechanical Characteristics of transmission lines – Insulators, Cables – Corona.

HVDC Transmission – Comparison, Types of DC Links - Power distribution systems – DC and AC distribution - Types.

Basics of power system protection – Circuit Breakers - Protective Relays – Principle and types.

**iv) (a) TEXT BOOKS**

1) B. R. Gupta, *Power System Analysis and Design*, Wheeler Publishers, 7th revised edition, 2005.
2) J. B. Gupta, *A course in Electrical Power*, Kataria and Sons, 2013 edition.
3) C. L. Wadhwa, *Electrical Power System*, New Age International Publishers, 1st edition, 2016.
4) Grainer J.G., Stevenson W.D., *Power System Analysis*, Tata McGraw Hill, 1st edition, 2017.
5) Badri Ram, D. N. Vishwakarma, *Power System Protection and Switchgear*, Tata McGraw Hill, 2nd edition, 1994.

**(b) REFERENCES**

1) A. Chakrabarti, M. L. Soni, P. V. Gupta, U. S. Bhatnagar, A *text book on Power System Engineering*, Dhanpat Rai and Co., 2016 edition.
2) I. J. Nagarath & D. P. Kothari, *Modern Power System Analysis*, Tata McGraw Hill, 4th edition, 2011.
3) K. R. Padiyar, *FACTS Controllers in Power Transmission and Distribution*, New Age International, New Delhi, 2nd edition, 2016.
4) William D. Stevenson Jr, *Elements of Power System Analysis*, Tata McGraw Hill, 4th edition, 1982.
5) Sunil S. Rao, *Switchgear and Protection*, Khanna Publishers, 2nd edition, 2012.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| **I** | **Introduction:** Typical layout of Power system Network.<br>**Generation of Electric Power:** Overview of conventional generation schemes-Hydro, Thermal and Nuclear; Non-Conventional Sources-Solar and Wind.<br>Economics of Generation: Terminology-Load factor, diversity factor, Load curve; Numerical Problems.<br>Causes of low lagging power factor, Importance of power factor improvement, Power Factor Improvement using capacitors - Numerical Problems. | **10** |
| **II** | **Power Transmission:** Transmission Line Parameters: Resistance, inductance and capacitance of 1Φ, 2 wire lines-composite conductors.<br>Inductance and capacitance of 3Φ lines. Symmetrical and unsymmetrical spacing-transposition-double circuit lines-bundled conductors - Numerical Problems.<br>Modelling of Transmission Lines: Classification of lines-short lines-voltage regulation and efficiency-medium lines-nominal T and Π configurations-ABCD constants- Numerical Problems-Ferranti effect. | **14** |

| | | |
|---|---|---|
| **III** | **Introduction of Overhead transmission and underground transmission:** Conductors -types of conductors - copper, aluminium and ACSR conductors -Volume of conductor required for various systems of transmission.<br>Mechanical Characteristics of transmission lines – Calculation of sag and tension-supports at equal and unequal heights -effect of wind and ice- Numerical Problems.<br>Insulators - Different types - Voltage distribution, grading and string efficiency of suspension insulators- Numerical Problems.<br>Corona – disruptive critical voltage - visual critical voltage -power loss due to corona - Factors affecting corona.<br>Underground Cables - types of cables -insulation resistance - voltage stress - grading of cables- Numerical Problems. | **14** |
| **IV** | **HVDC Transmission:** Comparison between AC & DC Transmission, Power flow equations and control, Types of DC links.<br>**Power Distribution systems:** Radial and Ring Main Systems - DC and AC distribution: Types of distributors- bus bar arrangement - Concentrated loading - Methods of solving distribution problems. | **10** |
| **V** | **Power System Protection:** Nature, causes and consequences of faults - Fault statistics - Need for protection - Essential qualities of protection - Types of protection – Primary and back up protection.<br>**Circuit breakers:** principle of operation - formation of arc - Arc quenching theory - Restriking Voltage - Recovery Voltage, RRRV<br>Types of Circuit Breakers: Air blast CB – Oil CB – SF6 CB – Vacuum CB –CB ratings.<br>**Protective Relays:** Zones of Protection, Essential Qualities - Classification of Relays - Electro mechanical, Static Relays, Microprocessor Based Relays; Buchholz relay for transformer protection. | **12** |
| | **Total hours** | **60** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL30F | ELECTROMAGNETIC THEORY AND COMPATIBILITY | PCC | 3 | 1 | 0 | 0 | 4 | 2023 |

**i) COURSE OVERVIEW**:

The objective of the course is to familiarize the students with a foundational understanding of electrostatics, magnetostatics and electromagnetic fields enabling them to apply this knowledge in the determination of electric and magnetic fields and to summarize Maxwell's equations. The course also provides to grasp the principles of electromagnetic wave propagation, transmission lines, and electromagnetic compatibility.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO 1 | Apply principles of vector analysis and coordinate systems to determine solutions for static electric and magnetic field scenarios | Apply |
| CO 2 | Apply Gauss's and Coulomb's laws to solve for electric fields and potentials in problems involving various charge distributions and capacitors. | Apply |
| CO 3 | Make use of Biot-Savart's and Ampere's Circuital laws to determine magnetic fields due to various current distributions. | Apply |
| CO 4 | Develop wave equations from Maxwell's equations for time-varying fields and explain the wave propagation through various media. | Apply |
| CO 5 | Summarize transmission line equations and parameters, identify electromagnetic interference sources and explain EMI control techniques. | Understand |

**iii) SYLLABUS**

Introduction to Co-ordinate Systems; Del, Curl, Gradient operations; Divergence Theorem; Stokes' Theorem.
Coulomb's law; Electric field intensity; Flux Density; Gauss's law; Potential-Potential Gradient; Poisson's and Laplace's equations; Capacitance and Inductance.
Biot-Savart's l
aw; Magnetic Field intensity; Magnetic Flux Density; Ampere's circuital law; Force between current carrying conductors; Magnetic potential.
Conductors and dielectrics; Continuity equation; Boundary conditions; Maxwell's Equations; Polarization.
Electromagnetic Wave Equations; Uniform Plane Waves; Poynting Theorem; Transmission Lines. Electromagnetic compatibility; Electromagnetic Interference; Introduction to Ansys Maxwell Software.

**iv) (a) TEXT BOOKS**

1) Matthew N.O. Sadiku, *Principles of Electromagnetics*, Oxford university Press, $6^{th}$ Edition, 2015.

2) Bakshi A.V. and Bakshi U.A., *Electromagnetic Theory*, Technical Publications, 2020.
3) John Kraus and Daniel Fleisch, *Electromagnetics with Applications*, McGraw-Hill Education, 5th Edition, 2015.


**(b) REFERENCES**


1) William, H. Hayt. and John A. Buck, *Engineering Electromagnetics*, McGraw-Hill Education, 8th Edition, 2017.
2) William, H. Hayt and John A. Buck, *Problems and Solutions in Electromagnetics,* McGraw- Hill Education, 2017.
3) Joseph A. Edminister, *Electromagnetics, Schaum's Outline Series*, McGraw-Hill Education, 2013.


**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Co-ordinate Systems:** Introduction to vector calculus and different co-ordinate systems- Rectangular, Cylindrical and Spherical co-ordinate systems; Representation of a point, base vectors, vector representation, Transformation of points and vectors among the three coordinate systems - Transformation matrices. Del operator - Gradient of a Scalar field, Divergence of a Vector field and Curl of a Vector field in different co-ordinate systems and their physical interpretation, Divergence Theorem, Stokes' Theorem. | 12 |
| II | **Electrostatics:** Coulomb's Law, Electric field intensity, Types of charge distributions, Electric field due to a line charge, Electric Flux and Flux Density; Gauss's law and its application to determine the field due to an infinite sheet charge; Electric Potential-Potential Gradient, Conservative property of electric field, Equipotential surfaces; concept of Electric Dipole; Poisson's and Laplace's equations; Boundary Conditions; Capacitance of a two-wire transmission line. | 12 |
| III | **Magnetostatics:** Biot-Savart's Law, Magnetic Field intensity due to finite and infinite current carrying conductors; Magnetic field intensity on the axis of a circular and rectangular current carrying loop; Magnetic flux Density; Ampere's circuital Law and its application to find the magnetic field due to an infinite current carrying conductor; Force between current carrying conductors; Magnetic boundary conditions. | 12 |
| IV | **Electric and Magnetic fields in materials:** Conduction current and displacement current; Equation of continuity; Relationship between current density and charge density; Dielectric polarization; Expressions for energy and energy density in electrostatic and magnetostatic fields; Maxwell's Equations in | 12 |

| | | |
|---|---|---|
| | Differential and Integral form for time-varying fields. **Electromagnetic Waves:** Wave Equations from Maxwell's Equations in point form and Phasor form. **Uniform Plane Waves** -Properties of uniform plane waves, propagation of Uniform Plane waves in free space. | |
| V | Propagation of Uniform Plane waves in loss-less and lossy dielectric medium, good conductors; properties in different medium-attenuation constant, phase constant, propagation constant, intrinsic impedance; Skin effect and Skin depth; Poynting Vector and Poynting Theorem. **Transmission lines**- Uniform lossless transmission lines-Transmission line equations, line parameters; Standing waves and VSWR; Impedance matching; Electromagnetic compatibility; Electromagnetic Interference-types, sources, effects, and control techniques. **Familiarization of Ansys Maxwell software** – solution of simple electric and magnetic fields using Ansys Maxwell software. | **12** |
| | **Total hours** | **60** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEP30C | CONTROL SYSTEMS LAB | PCC | 0 | 0 | 3 | 0 | 2 | 2023 |

## i) COURSE OVERVIEW:

Objective of the course is to impart practical experience to students to develop mathematical models for electrical systems. The course deals with the time and frequency analysis of the systems and implementation of compensators for systems based on system performance. The course is also designed to familiarise the students with different simulation tools used in control engineering.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Apply modeling and simulation tools, along with hardware experiments, to study the time-domain response of basic electrical systems. | Apply |
| CO2 | Apply experimental methods to determine the transfer functions of AC and DC motors and validate system behaviour. | Apply |
| CO3 | Apply experimental methods to plot and study the performance characteristics of synchro transmitter-receiver units. | Apply |
| CO4 | Analyse the stability and frequency response of second-order systems using root locus and frequency domain techniques. | Analyse |
| CO5 | Apply compensator and PID controller design techniques using passive and active components to meet control system performance requirements. | Apply |

## iii) SYLLABUS

- System Modeling and Simulation of Electrical System
- Transfer function of AC Servo motor
- Transfer function of DC Servo motor
- Synchro Transmitter and Receiver
- Step response of a second order system
- Performance Analysis using Root-Locus Method
- Stability Analysis by Frequency Response Methods.
- Realisation of lead compensator.
- Realisation of lag compensator.
- Design of compensator in frequency domain.
- Study of PID Controller
- Performance of a typical process control system

## iv) REFERENCES


1) Ogata K., Modern Control Engineering, Pearson Prentice Hall, 2006.
2) Gopal M., Control Systems, Tata McGraw-Hill, 3rd Edition, 2006.
3) Franklin G. F., Powell J. D. and Naeini A. E., Feedback Control of Dynamic Systems, Pearson Education Asia, 7th Edition., 2014.

4) Goodwin G. C., Graebe S. F. and Salgado M. E., Control System Design, Prentice Hall India, 2003.
5) D'Azzo J. J., Houpis C. H., Sheldon S. N., Linear Control System Analysis & Design with MATLAB, 5th Edition, Marcel Dekker, 2003.

### v) COURSE PLAN

Any **12 experiments** are mandatory.

| Module | Contents | No. of hours |
|---|---|---|
| I | **System Modeling and Simulation of Electrical System**<br>**Objective:** Model basic RLC system and determine transfer functions.<br>Simulation of time response using M-File and Simulink.<br>Comparison with theoretical time response. | 3 |
| II | **Transfer function of AC Servo motor**<br>Objective: Obtain the open loop transfer function of AC Servo motor by experiment. | 3 |
| III | **Transfer Function of DC Servo motor**<br>Objective: Obtain the transfer function of DC Servo motor by experiment. | 3 |
| IV | **Synchro Transmitter and Receiver**<br>Objective: Plot and study the different performance characteristics of Synchro transmitter-receiver units. | 3 |
| V | **Step response of a second order system**<br>Objective: Design a second order system (eg: RLC network) to analyse the following:<br>A. The effect of damping factor (ξ: 0, <1, =1, >1) on the unit step response using simulation study (M-File and SIMULINK).<br>B. Verification of the delay time, rise time, peak overshoot and settling time with the theoretical values.<br>C. Performance analysis of hardware setup and comparison with the simulation results. | 3 |
| VI | **Performance Analysis using Root-Locus Method**<br>Objective: Plot the root locus of the given transfer function to analyse the following using simulation:<br>A. Verification of the critical gain, with the theoretical values.<br>B. The effect of the controller gains K on the stability.<br>C. The sensitivity analysis by giving small perturbations in given poles and zeros.<br>D. The effect of the addition of poles and zeros on the given system. | 3 |
| VII | **Frequency response of a second order system**<br>Objective: Design a second order system (eg: RLC network) to analyse the following:<br>A. The effect of damping factor (ξ = 0.6, 0.8 and 1) on the frequency response using simulation study (M-File and SIMULINK).<br>B. Verification of the resonant peak, resonant frequency and bandwidth with the theoretical values.<br>C. Performance analysis of hardware setup and comparison with the simulation results. | 3 |
| VIII | **Stability Analysis by Frequency Response Methods.**<br>Objective: Plot the i) Bode plot and ii) Nyquist plot of the given transfer functions to analyse the following using simulation: | 3 |

| | | |
|---|---|---|
| | Determination of Gain Margin and Phase Margin.<br>Verification of GM and PM with theoretical values.<br>The effect of the controller gains K on the stability.<br>The effect of the addition of poles and zeros on the given system (especially the poles at origin). | |
| **IX** | **Realisation of lead compensator.**<br>Objective: Design, set up and analyse the gain and phase plots of a lead compensator by hardware experimentation using passive elements. | **3** |
| **X** | **Realisation of lag compensator.**<br>Objective: Design, set up and analyse the gain and phase plots of a lag compensator by hardware experimentation using passive elements. | **3** |
| **XI** | **Realisation of lead compensator.**<br>Objective: Design, set up and analyse the gain and phase plots of a lead compensator by hardware experimentation using active components. | **3** |
| **XII** | **Realisation of lag compensator.**<br>Objective: Design, set up and analyse the gain and phase plots of a lag compensator by hardware experimentation using active components. | **3** |
| **XIII** | **Design of compensator in frequency domain.**<br>Objective: Design a compensator for the given system to satisfy the given frequency domain specifications using MATLAB. | **3** |
| **XIV** | **PID Controller Design**<br>Objective: Study of effect of PID controller on the step response of a second order system. | **3** |
| **XV** | **Performance of a typical process control system**<br>Objective: Study of performance characteristics and response analysis of a typical temperature/Flow/ Level control system. | **3** |
| | **Total hours** | **45** |

### vi) ASSESSMENT PATTERN

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assessment of Lab Work | : | 55 marks |
| Continuous Assessment in Lab<br>(Lab work + Record + Viva - voce) -35 marks<br>and Internal Lab test -20 marks | | |
| Final Lab Assessment | : | 40 marks |
| **TOTAL** | **:** | **100 marks** |

### vii) FINAL LAB ASSESSMENT

Final Lab Assessment – **2.5 hours/3 hours exam** for 40 marks

| | | | |
|---|---|---|---|
| (a) | Preliminary work | : | 15 marks |
| (b) | Implementing the work/Conducting the experiment | : | 10 marks |
| (c) | Result and inference | : | 10 marks |
| (d) | Viva voce | : | 5 marks |
| | **Total** | **:** | **40 marks** |

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EES38A | SEMINAR | PWS | 0 | 0 | 4 | 0 | 2 | 2023 |

## i) COURSE OVERVIEW

The course involves exploring academic literature to select a relevant document in the student's area of interest and, under a seminar guide's supervision, develop skills in presenting and preparing technical reports. The course aims to enhance students' ability to engage critically with scholarly work and communicate technical information effectively.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Investigate and synthesize information from diverse sources to gain a comprehensive understanding of a chosen technical topic. | Apply |
| CO2 | Interpret technical content to explore the practical implications and applications of emerging technologies in the field of engineering. | Apply |
| CO3 | Utilize communication skills to articulate complex technical information through oral presentations and written report. | Apply |
| CO4 | Engage in constructive discussions and respond to questions and feedback. | Apply |

## iii) GENERAL GUIDELINES

- An Internal Evaluation Committee (IEC) shall be constituted by the department, comprising the program's HoD / Senior Faculty as Chairperson, along with the seminar coordinator and the student's seminar guide as members. All IEC members must be present during each student's seminar presentation.
- Formation of IEC and guide allotment shall be completed within a week after the End Semester Examination (or last working day) of the previous semester.
- Guide shall provide required input to their students regarding the selection of topic/ paper.
- A topic/paper relevant to the discipline shall be selected by the student during the semester break.
- The seminar topic should be current and broad-based/narrowly focused on specific research. Ideally, it should be closely related to the student's final year project area. Team members may select or be assigned seminar topics that cover different aspects of their common project theme.
- Topic/Paper shall be finalized in the first week of the semester and shall be submitted to the IEC.
- The IEC shall approve the selected topic/paper by the second week of the semester.
- Accurate references from genuine peer reviewed published material to be given in the report and to be verified.

**iv) EVALUATION PATTERN**

| Total Marks | CIE Marks |
|---|---|
| 100 | 100 |

**CONTINOUS ASSESSMENT EVALUATION PATTERN**

**Seminar Guide (20 Marks):**

Background Knowledge – 10 marks (based on the student's understanding of the selected topic).
Relevance of Topic – 10 marks (based on the suitability and significance of the selected paper/topic).

**Seminar Coordinator (15 Marks):**

Seminar Diary – 10 marks (weekly progress tracked and approved by the guide).
Attendance – 5 marks.

**Presentation by IEC (45 Marks):**

Clarity of Presentation – 10 marks.
Interaction – 10 marks (ability to answer questions).
Overall Participation – 10 marks (engagement during others' presentations).
Quality of the content – 15 marks.

**Marks awarded by IEC for report (20 Marks)**

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEJ38B | MINI PROJECT | PWS | 0 | 0 | 4 | 0 | 2 | 2023 |

## i) COURSE OVERVIEW:

The objective of this course is to enable students to apply the fundamental principles of Electrical Engineering in the effective development of an application or research-oriented project. It guides learners through the essential phases of the problem identification, literature review, determination of methodology and its implementation for design and development of appropriate solution.

## ii) COURSE OUTCOMES:

After the completion of the course the student will be able to

| | | |
|---|---|---|
| CO1 | Identify problems that are socially relevant, technically feasible and economically viable. | Apply |
| CO2 | Make use of relevant literature to explore existing solutions and established processes. | Apply |
| CO3 | Identify appropriate design approaches, using modern tools with a strong commitment to professional ethics. | Apply |
| CO4 | Deduce innovative interpretation of the study outcomes, using engineering and management principles to generate novel insights or improvements. | Evaluate |
| CO5 | Apply appropriate communication techniques to prepare presentations and reports that convey project outcomes effectively. | Apply |
| CO 6 | Develop the ability to manage tasks independently and engage collaboratively in team environments to achieve shared goals. | Apply |

## iii) GUIDELINES:

Student groups consisting of three to four members are required to select a topic of interest in consultation with their Project Supervisor. They should conduct a thorough literature review and identify a problem to address the gaps identified, related to the chosen topic. Clear objectives must be defined, and a suitable methodology should be developed to achieve them. The project should incorporate innovative design concepts, while considering important factors such as performance, scalability, reliability, aesthetics, ergonomics, user experience, and security.

The progress of the mini project is evaluated based on three reviews. The first review is to check the feasibility in implementation of the project. The second review is to evaluate the progress of the work. The third review will evaluate the completed work. The review committee will be constituted by the Head of the Department comprising of HoD or a senior faculty member, Mini Project coordinator and project supervisor. The evaluation shall be made based on the progress/outcome of the project, reports and a viva-voce examination, conducted internally by the review committee. A project report is required at the end of the semester. The project has to be demonstrated for its full design specifications.

**iv) MARK DISTRIBUTION**

| Total Marks | CIE Marks | ESE Marks |
|---|---|---|
| 100 | 60 | 40 |

**v) CONTINOUS ASSESSMENT EVALUATION PATTERN**

**First Review and Second Review** **60 marks**

Attendance 5 marks
Marks awarded by Project Supervisor 10 marks
Marks awarded by Review Committee 45 marks

**Final Review** **40 marks**

Project Report 10 marks
Marks awarded by Review Committee 30 marks

<table>
<tr><th colspan="25">Marks awarded by Review Committee - First and Second Review</th></tr>
<tr><td colspan="4">Problem identification considering social relevance, feasibility and economics.<br>CO 1</td><td colspan="4">Review of relevant literature, identification of gaps in existing literature, framing objectives.<br>CO 2</td><td colspan="4">Framing of methodology, usage of modern tools and display of professional ethics.<br>CO 3</td><td colspan="4">Quality of results, conclusions, solutions including innovation and novelty<br>CO 4</td><td colspan="4">Preparation of technical presentation.<br>CO 5</td><td colspan="4">Individual contribution to the project<br>CO 6</td><td>Total Marks</td></tr>
<tr><td colspan="4">(10)</td><td colspan="4">(5)</td><td colspan="4">(10)</td><td colspan="4">(5)</td><td colspan="4">(5)</td><td colspan="4">(10)</td><td>(45)</td></tr>
<tr><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td rowspan="2"></td></tr>
<tr><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td></tr>
</table>

<table>
<tr><th colspan="25">Marks awarded by Project Supervisor - First and Second Review</th></tr>
<tr><td colspan="20" rowspan="4"></td><td colspan="4">Display of sound knowledge at individual level in various phases of the project<br>CO 6</td><td>Total Marks</td></tr>
<tr><td colspan="4">(10)</td><td>(10)</td></tr>
<tr><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td rowspan="2"></td></tr>
<tr><td>P</td><td>F</td><td>VG</td><td>O</td></tr>
</table>

<table>
<tr><th colspan="22">Marks awarded by Review Committee - Final Review</th></tr>
<tr><td colspan="4">Quality of Technical Report<br>CO5</td><td colspan="4">Framing of methodology, usage of modern tools and display of professional ethics.<br>CO 3</td><td colspan="4">Preparation of technical presentation.<br>CO 5</td><td colspan="4">Quality of results, conclusions, solutions displaying innovation and creativity<br>CO 4</td><td colspan="4">Individual contribution displaying ability to work in team<br>CO 6</td><td>Total Marks</td><td rowspan="4"></td></tr>
<tr><td colspan="4">(10)</td><td colspan="4">(10)</td><td colspan="4">(10)</td><td colspan="4">(5)</td><td colspan="4">(5)</td><td>(40)</td></tr>
<tr><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-3</td><td>4-6</td><td>7-9</td><td>10</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td>0-1</td><td>2-3</td><td>4</td><td>5</td><td rowspan="2"></td></tr>
<tr><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td><td>P</td><td>F</td><td>VG</td><td>O</td></tr>
</table>

P-Poor F-Fair VG-Very Good O-Outstanding

# PROGRAMME ELECTIVE II

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL32A | ILLUMINATION ENGINEERING | PEC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

The basic objective of this course is to deliver the fundamental concepts of Illumination engineering in the analysis of architectural lighting systems.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the fundamental concepts of natural and artificial lighting schemes. | Understand |
| CO2 | Apply the laws of illumination and concept of polar curves for the calculation of illuminance at a point. | Apply |
| CO3 | Develop efficient indoor lighting systems. | Apply |
| CO4 | Develop efficient outdoor lighting systems. | Apply |
| CO5 | Identify suitable control methods for lighting and demonstrate various features of aesthetic lighting. | Apply |

**iii) SYLLABUS**

Types of illumination, Day lighting, Artificial light sources - Quality of good lighting, shadow, glare, reflection, Colour rendering and stroboscopic effect, Lighting schemes.
Luminous intensity, Lumen, Candle power, Illumination, M.H.C.P, M.S.C.P, M.H.S.C.P, Lamp efficiency, Laws of illumination, Illumination at horizontal and vertical plane from point source, Concept of polar curve.
DLOR and ULOR, Selection of lamp and luminance, Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaire, staircase, Corridor lighting and industrial building.
Street Lighting - Types of streets and their level of illumination required, Selection of lamp and luminaire, Calculation of illumination level available on road. Tunnel Lighting, Flood Lighting.
Special Features of Aesthetic Lighting: Monument and statue lighting, Sports lighting, Hospital lighting, Auditorium lighting, Lighting controllers dimmers, motion and occupancy sensors, photo sensors and timers. Lighting system design using software.

**iv) (a) TEXT BOOKS**

1) D.C. Pritchard, “Lighting”, Routledge, 6th Edition, 2014.
2) Jack L. Lindsey, “Applied Illumination Engineering”, Prentice-Hall; 1st Edition, 1991.

**(b) REFERENCES**

1) John Matthews, “Introduction to the Design and Analysis of Building Electrical Systems”, Springer, 1993.

2) M.A. Cayless, “Lamps and Lighting”, Routledge, 1996.
3) Craig DiLouie, “Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications”, CRC Press, 2005.
4) R. H. Simons and A. R. Bean, “Lighting Engineering Applied Calculations”, Routledge; 1st Edition, 2020.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction of Light**: Types of illumination, Day lighting, Artificial light sources- artificial lighting and total lighting, Quality of good lighting, Factors affecting the Physical processes- Incandescent and Halogen lamps, Fluorescent lamps, LPSV and HPSV lamps, mercury vapor lamps, metal halide lamps, LED lamps- modern trends. Supplementary lighting-shadow, glare, reflection, Colour rendering and stroboscopic effect, Methods of artificial lighting, Lighting systems-direct, indirect, semi direct, semi-indirect, Lighting scheme, General and localized. | 9 |
| II | **Measurement of Light:** Definition of luminous flux, Luminous intensity, Lumen, Candle power, Illumination, M.H.C.P, M.S.C.P, M.H.S.C.P, Lamp efficiency. Laws of illumination- Inverse square law and Lambert’s Cosine Law, Illumination at horizontal and vertical plane from point source, Concept of polar curve, measuring apparatus- Goniophotometer, Integrating sphere, lux meter. | 8 |
| III | **Design of Interior Lighting:** Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilization and factors such as LLF and CUF affecting it, Illumination required for various work planes, Types of fixtures and relative terms used for interior illumination such as DLOR and ULOR, Selection of lamp and luminance. Determination of Lamp Lumen output taking into account voltage and temperature variations, Calculation of wattage of each lamp and number of lamps needed, Layout of lamp luminaire, Calculation of space to mounting height ratio, Indian standard recommendation and standard practices for illumination levels in various areas, Special feature for entrance, staircase, Corridor lighting. | 10 |
| IV | **Design of Outdoor Lighting:** Street Lighting - Types of streets and their level of illumination required, Terms related to street lighting, Types of fixtures used and their suitable application, Various arrangements in street lighting, Requirements of good street lighting, Selection of lamp and luminaire, Calculation of illumination level available on road.<br>Tunnel Lighting, Calculation of their wattage and number and their arrangement, Calculation of space to mounting height ratio.<br>Flood Lighting: Terms related to flood lighting, Types of fixtures and their suitable applications, Selection of lamp and projector, Calculation of number of projectors and arrangement, Calculation of | 10 |

| | | |
|---|---|---|
| | space to mounting height ratio. | |
| **V** | **Special Features of Aesthetic Lighting:** Monument and statue lighting, Sports lighting, Hospital lighting, Auditorium lighting General Aspects of emergency lighting. Lighting controllers, dimmers, motion and occupancy sensors, photo sensors and timers. Lighting system design using software (e.g.: DIALux and Relux). Note: Case study of indoor and outdoor lighting design using software may be given as assignment. | **8** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL32B | ELECTRICAL DRAWING WITH CAD | PEC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to draw/simulate electrical and electronics circuit using software.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Develop various symbols and notations in electrical and electronics engineering drawings. | Apply |
| CO2 | Interpret drawings, draw interferences and workout other technical details. | Understand |
| CO3 | Outline various electrical and electronics circuits according to standard practices using CAD software. | Understand |
| CO4 | Construct a wiring diagram for house. | Apply |
| CO5 | Construct a Single line diagram for a substation. | Apply |

**iii) SYLLABUS**

Computer Aided Electrical Drawing **-** Procedure to be adopted for computer aided drawings. Draw and identify symbols and wiring diagram of electrical engineering.

Computer Aided Electronics Drawing **-** Symbols and notations of electronic components.

Combination of Electrical Circuits **-** Getting started, ending, commonly used blocks, Creating and Masking Sub-systems, Series and parallel circuits.
Construct wiring diagram for house.
Construct Single line diagram for a substation.

**iv) (a) TEXT BOOKS**

1) Sham Tickoo, *AutoCAD 2013 for Engineers and Designers*, Dreamtech Press, New Delhi, 1st Edition, 2013.
2) George Omura, *Mastering AutoCAD 2013 and AutoCAD LT 2013*, John Wiley & Sons Inc., Indianapolis, 1st Edition, 2012.
3) C. R. Dargan, *Electrical Engineering Drawing (With Estimating and Installation Designs)*, Computech Publications Ltd., New Delhi, Enlarged Edition, 2021.
4) N. D. Bhatt, *Engineering Drawing: Plane and Solid Geometry*, Charotar Publishing House Pvt. Ltd., 55th Edition, 2025.
5) B. R. Sharma, *Electrical Engineering Drawing*, Satya Prakashan, New Delhi, 3rd Edition, 1985.

### (b) REFERENCES

List of Open-Source Software/learning website:

1) https://www.falstad.com/circuit/
2) https://www.autodesk.com/education/edusoftware/overview?sorting=featured&page=1
3) https://www.ti.com/tool/TINA-TI
4) https://www.ni.com/en-in/support/downloads/softwareproducts/download.multisim.html #312060
5) https://www.proficad.com/
6) https://www.kicad.org/
7) Documentations from https://docs.kicad.org/
8) Manual from https://www.proficad.com/help/

## v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | Computer Aided Electrical Drawing<br>Procedure to be adopted for computer aided drawings, Draw and identify symbols and wiring diagram of electrical engineering. Symbols of practical units, symbol of decimal multiples and submultiples of unit.<br>Symbol of supplies-AC Supply single phase, three phase three wire, three phase four wire, D.C. supply.<br>Symbol of switches, distribution boards, fan, light fixtures, bell, buzzer, fuse, lighting arrestor.<br>Symbol of all types of motor starters, electrical instruments, CT/PT, Measuring instruments. | 9 |
| II | Computer Aided Electronics Drawing<br>Symbols and notations of: Electronic components - Resistor, Inductor, transformer and Capacitor Semiconductor device Diodes, Zener diode, Transistors PNP/ NPN, Tunnel diode, photo diode, varactor, FET, MOSFET, IGBT, UJT etc. Half-wave, full-wave and bridge rectifier, Power amplifier and voltage amplifier and different types of oscillators circuits. | 9 |
| III | Combination of Electrical Circuits<br>Getting started, ending, commonly used blocks, creating a model, Assigning Variables, Observing Variables during Simulation, Storing/Saving Data, Creating and Masking Sub-systems, Series and parallel R-L circuit, Series and parallel R-C circuit, Series and parallel R-L-C circuit, Resonance in AC Circuit. | 9 |
| IV | Prepare wiring diagram for house<br>Light, fan and power circuit, Godown/corridor wiring (With & without looping), Staircase wiring, Inverter wiring, Small Scale Industries (11KV rating). | 9 |

| | | |
|---|---|---|
| **V** | Substation and Earthing System<br>Draw single line diagram of substation and diagram of earthing System, 33KV/11KV substation with all protective devices, Substation: - Single bus bar arrangement, Earthing- Plate, Pipe as per I.S.S./B.I.S. | **9** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL32C | ELECTRIC DRIVES | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: This course provides a comprehensive understanding of electric drive systems, focusing on their design, control, and application in modern electrical and computer engineering domains. The course provides fundamentals of drives systems, details of various DC and AC drives and their applications.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Apply the fundamental concepts of electric drives | Apply |
| CO2 | Apply the appropriate configuration of controlled rectifiers for the speed control of DC motors | Apply |
| CO3 | Model chopper-fed DC motor drive and identify various quadrants of operation | Apply |
| CO4 | Explain the various speed control techniques of induction motors | Understand |
| CO5 | Explain the various speed control techniques of synchronous and BLDC motor drives. | Understand |

**iii) SYLLABUS**

Block diagram of electric drives, four quadrant operation of drives, Equivalent values of drive parameters- - steady state stability.

Rectifier control of DC drives- separately excited DC motor drives using single-phase and three phase-controlled rectifiers - dual converter control of DC motor.

Chopper control of DC drives -one quadrant, two quadrant and four quadrant chopper drives - -closed loop speed control for separately excited dc motor. Matlab simulation of chopper fed dc drives.

Three phase induction motor drives: Stator voltage control - Stator frequency control – v/f control - static rotor resistance speed control– static slip power recovery speed control. - space vector modulation

Synchronous motor drives self-controlled mode – load commutated CSI fed synchronous motor. Permanent magnet AC motor drives-Brushless DC motor drive, applications of Electric Drives

**iv) (a) TEXT BOOKS**

1) Gopal K. Dubey, *Fundamentals of Electrical Drives*, 2nd Edition, Narosa Publishing House, 2001.
2) Vedam Subrahmanyam, *Electric Drives: Concepts and Applications*, Tata McGraw Hill, 2002.
3) Bimal K. Bose, *Modern Power Electronics and AC Drives*, Prentice Hall, 2002.

### (b) REFERENCES

1) R. Krishnan, *Electric Motor Drives: Modeling, Analysis and Control*, Prentice Hall, 2001.
2) Mohamed A. El-Sharkawi, *Fundamentals of Electric Drives*, Cengage Learning, 2018.
3) Austin Hughes and Bill Drury, *Electric Motors and Drives: Fundamentals, Types and Applications*, 4th Edition, Elsevier, 2013.
4) W. Leonhard, *Control of Electrical Drives*, Springer, 3rd Edition, 2001.
5) MATLAB/Simulink Documentation – *Simscape Electrical™ Toolbox*, MathWorks


## v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Electric Drives :** Introduction to electric drives – block diagram – advantages of electric drives – dynamics of motor load system, fundamental torque equations, types of load – classification of load torque, four quadrant operation of drives, Equivalent values of drive parameters- steady state stability. Selection of motor power rating. Thermal modeling and heating/cooling curves. | 9 |
| II | **Rectifier control of DC drives**- Review of DC motor types, separately excited DC motor drives using controlled rectifiers- single-phase fully controlled rectifier fed drives (discontinuous and continuous mode of operation), critical speed - single-phase semi converter fed drives (continuous mode of operation) - three-phase semi converter and fully controlled converter fed drives (continuous mode of operation) - dual converter control of DC motor - circulating current mode. | 9 |
| III | **Chopper control of DC drives** - single quadrant chopper drive-motoring and regenerative braking control of separately excited dc motors -two quadrant and four quadrant chopper drives - chopper fed DC series motor drive - closed loop speed control for separately excited dc motor. Matlab simulation of chopper fed dc drives. | 9 |
| IV | Three phase induction motor drives: Stator voltage control - Stator frequency control – v/f control - static rotor resistance speed control employing chopper – static slip power recovery speed control scheme for speed control below and above synchronous speed. VSI fed Induction motor drives, Concept of space vector – field orientation principle - space vector modulation – reference vector & switching (dwell) times – space vector sequence. | 9 |

| | | |
|---|---|---|
| V | Synchronous motor drives – v/f control – open loop control – self-controlled mode – load commutated Inverter fed synchronous motor drive. Permanent magnet AC motor drives-Sinusoidal PMAC motor drives, Brushless DC motor drive. Current regulated VSI fed BLDC motor drive.<br>**Applications of Electric Drives:** Digital control of electric drives using microcontrollers and DSPs. Drives in Electric Vehicles and Industrial Automation. | **9** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL32D | INDUSTRIAL INSTRUMENTATION AND AUTOMATION | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: This course introduces basic terms and techniques applicable to instrumentation and various automation activities related to the industry and power sector. It also provides a basic idea of the recent developments in communication techniques and process control in industrial automation.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Interpret the sensors/transducers suitable for industrial applications. | Understand |
| CO2 | Explain the signal conditioning circuits for industrial instrumentation and automation. | Understand |
| CO3 | Illustrate the concepts of data transmission and virtual instrumentation related to automation. | Understand |
| CO4 | Develop the ladder logic for the process control applications using PLC programming. | Apply |
| CO5 | Explain the fundamental concepts of DCS and SCADA systems. | Understand |

**iii) SYLLABUS**

Sensors and Transducers: Process Control - block diagram of the process control loop, definition of elements. Sensor time response - first and second-order responses. Transducers- Characteristics and Choice of the transducer. Applications of Transducers

Signal conditioning circuits and Final control: Electronic amplifiers, Final control operation- signal conversion- actuators- control elements, Actuators- Electrical – Pneumatic- Hydraulic, Control elements-mechanical- electrical- fluid valves.

Data transmission and Virtual instrumentation system: Cable transmission of analog and digital data, Fiber optic data transmission, Pneumatic transmission. Process control Network. Virtual instrumentation system.

Programmable logic controllers (PLC): Programmable logic controllers, Standards Programming aspects- Ladder programming- realization of AND, OR logic, the concept of latching,

SCADA Architecture, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Protocols- DCS: Introduction, DCS Architecture, Control modes

**iv) (a) TEXT BOOKS**

1) Curtis D Johnson, *Process Control Instrumentation Technology*, PHI Learning Pvt Ltd New Delhi, 1997

2) Doeblin E.O, *Measurement Systems: Application and Design*, Fourth Edition, McGraw Hill, Newyork, 1992
3) DVS. Murty, *Transducers and Instrumentation*, Second Edition, PHI Learning Pvt Ltd New Delhi, 2013
4) Jovitha Jerome, *Virtual instrumentation using LabVIEW*, Prentice Hall of India, 2010.
5) William Bolton, *Programmable Logic Controllers*, Fifth edition, ELSEVIER INDIA Pvt Ltd New Delhi, 2011
6) Stuart A. Boyer, *SCADA: Supervisory Control and Data Acquisition*, Fourth edition, International Society of Automation, 2010

**(b) REFERENCES**

1) G.K.McMillan, *Process/Industrial Instrument and control and hand book* McGraw Hill, New York, 1999.
2) Michael P. Lucas, *Distributed Control system*, Van Nastrant Reinhold Company, New York.
3) Patranabis, D., *Principles of Industrial Instrumentation*, Second Edition Tata McGraw Hill Publishing Co. Ltd. New Delhi.
4) Robert B. Northrop, *Introduction to instrumentation and measurements*, CRC, Taylor and Francis 2005.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Sensors and Transducers:** Introduction to Process Control - block diagram of the process control loop. Sensor time response - first and second-order responses.<br>**Transducers:** Transducers, sensors, classification of transducers – characteristics - transducer output characteristics - choice of transducers<br>**Applications of Transducers:** Displacement measurement using Resistance Potentiometer- Capacitive differential pressure measurement, Flow measurement using Hotwire anemometer. Speed measurement- Variable reluctance tachometers | 10 |
| II | **Signal conditioning circuits:** Electronic amplifiers- Instrumentation Amplifiers, Log amplifiers, Isolation Amplifiers, Charge amplifiers, Phase-sensitive detectors.<br>**Final control:** Signal converters **-** P to I converter, I to P converter. Actuator – electrical, pneumatic, hydraulic. Control valve – characteristics - quick opening, linear, equal percentage- Valve types and functioning – solenoid valve - electric motor actuated control valve - selection of a control valve. | 9 |
| III | **Data transmission and Virtual instrumentation system:** Transmission Media - unguided and guided media, wired and wireless, UTP, coaxial and fibre optical cable. Fiber optic data transmission, Pneumatic transmission. Process control Network- | 9 |

| | | |
|---|---|---|
| | Characteristics of Communication Networks - Fieldbus and Profibus, radio-wireless communication - WLAN architecture.<br>**Virtual instrumentation system:** Virtual Instrumentation - Definition and Flexibility - Block diagram and Architecture - Virtual Instruments versus Traditional Instruments Instrumentation -VI Programming techniques -Graphical Programming Environment in Virtual Instrumentation | |
| **IV** | **Programmable logic controllers (PLC):** Programmable logic controllers- Organization- Hardware details- I/O- Power supply-CPU- Standards Programming aspects- Ladder programming-realization of AND, OR logic, the concept of latching, Introduction to Timer/Counters, Exercises based on Timers and Counters. | **9** |
| **V** | **SCADA:** Introduction, SCADA Architecture, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Trends in SCADA, Security Issues. Different Communication Protocols- IEC 60870-5-101 and DNP3<br>**DCS:** Introduction, DCS Architecture, Control modes- DCS versus SCADA terminology- DCS integration with PLC and Computers-Features and Advantages. | **8** |
| | **Total hours** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

## vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

## viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL32E | DIGITAL SYSTEM DESIGN USING VERILOG | PEC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: This course offers an exploration of digital system design using Verilog HDL, focusing on the HDL-based design flow, hierarchical modeling, and various design techniques. It covers gate-level, data-flow, and behavioral modeling for both combinational and sequential circuits, along with FSM design and Verilog implementation. The course also delves into FPGA-based design, synthesis, and verification, providing practical insights through real-world case studies.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the fundamentals of HDL-based design, modeling techniques, and basic Verilog constructs for digital system development. | Understand |
| CO2 | Summarize gate-level, data-flow, and behavioral modeling techniques in Verilog for combinational and sequential circuit design. | Understand |
| CO3 | Apply gate-level and data-flow modeling techniques, along with behavioral modeling constructs in designing combinational and sequential circuits in Verilog. | Apply |
| CO4 | Develop finite state machines (Mealy and Moore) in Verilog using state diagrams and transition tables. | Apply |
| CO5 | Apply FPGA design flow and verification techniques to develop and simulate digital systems using Verilog. | Apply |

**iii) SYLLABUS**

HDL & Verilog Design Flow – Hierarchical modeling, modules, data types, system tasks, and compiler directives. Gate-Level & Data Flow Modeling – Verilog gate primitives, combinational circuits, continuous assignments, and operators. Behavioral Modeling – Structured procedures, blocking/non-blocking statements, loops, and modeling combinational and sequential circuits. FSM Design – Mealy/Moore machines, state diagrams, state encoding, and Verilog implementation of sequence detectors and controllers. FPGA Design & Verification – FPGA/CPLD architecture, design flow, synthesis, testbenches, and real-world system case studies.

**iv) (a) TEXT BOOKS**

1) Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, 2nd Edition, Pearson Education.
2) Stephen Brown, Zvonko Vranesic, Fundamentals of Digital Logic with Verilog Design, 2nd Edition, McGraw Hill.
3) Nazeish M Botros, HDL Programming Fundamental: VHDL and Verilog, 2009 reprint, Dreamtech press.

### (b) REFERENCES


1) M. Morris Mano, Michael D. Ciletti, Digital Design: With an Introduction to the Verilog HDL, 5th Edition, Pearson.
2) Charles Roth, Lizy K. John, Byeong Kil Lee, Digital Systems Design Using Verilog, Cengage Learning.
3) J. Bhasker, A Verilog HDL Primer, 3rd Edition, BSP Publishers.
4) Peter J. Ashenden, Digital Design Using VHDL, Elsevier.


## v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to HDL and Verilog design flow**<br>Overview of Digital Design using Verilog HDL: HDL based design flow, trends in HDL, Hierarchical modelling concepts: Top up and bottom down design methodology, modules and module instances, parts of a simulation, design block, stimulus block, Basic concepts: data types, system tasks, compiler directives, Modules and Ports: Module definition, port declaration, connecting ports | 8 |
| II | **Gate level and Data flow modelling in Verilog**<br>Gate level modelling: modelling using basic Verilog gate primitives, Structural modelling of Combinational circuits using gates: Half Adder, Full Adder, Multiplexer, Gate delays.<br>Data flow modeling: Continuous assignments, delay specifications, expressions, operators, operands, operator types. | 9 |
| III | **Behavioral modelling in Verilog**<br>Structured procedures, initial and always, blocking and non-blocking statements, delay control, event control, conditional statements, multiway branching, loops. Modelling combinational circuits: Comparator, Encoder, Decoder, Modelling sequential circuits: Flipflops, Counter, shift registers. | 10 |
| IV | **Finite State Machine Design using Verilog**<br>FSM Basics: Introduction to Mealy and Moore machines, state diagram representation, State transition table and State encoding techniques. Design methodology: from specification to Verilog implementation, FSM Implementation in Verilog: Sequence detectors, Traffic light controller, Pattern recognizers | 9 |
| V | **FPGA-based Design and Verification**<br>Introduction to FPGA and CPLD, Architecture, Design Flow. Synthesis and Implementation on FPGA. Verification Techniques – Testbenches, Assertions, Functional and Timing Simulation. Case Studies on Real-World Digital System Designs using Verilog. | 9 |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL32F | INTRODUCTION TO NANOTECHNOLOGY | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

This course provides a comprehensive overview of synthesis and characterization of nanoparticles, nanocomposites and hierarchical materials with nanoscale features. This will provide the engineering students with necessary background for understanding various nanomaterials characterization techniques and develop an understanding of the basis of the choice of material for device applications. This course will give an insight into complete systems where nanotechnology can be used to improve our everyday life.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Demonstrate the synthesis of nanoparticles by various techniques. | Understand |
| CO2 | Explain working of basic instruments used in characterization of nanoparticles. | Understand |
| CO3 | Infer the application of nanotechnology to mechanical and civil domains. | Understand |
| CO4 | Classify the nanomaterials based on the dimensions. | Understand |
| CO5 | Interpret the suitability of nanomaterials for various device applications. | Understand |

**iii) SYLLABUS**

Introduction to Nanomaterials Nanotechnology: Frontier of future-an overview, Confinement of electron in 0D, 1D, 2D and 3D systems, Synthesis of Nanomaterials, Bottom-Up approach: Chemical Bath Deposition. Top-Down approach- Ball milling technique, Sputtering, Laser Ablation.

Characterization of Nanomaterials: Basic principles and instrumentations of Electron Microscopy, different imaging modes, comparison of SEM and TEM, AFM and STM, AFM and SEM. Basic principles of working of X-ray diffraction, Optical Spectroscopy.

Carbon Based Materials: Synthesis, Properties (electrical, Electronic and Mechanical), and Applications of Graphene, SWCNT, MWCNT, Fullerenes and other Carbon Materials.

Nanotechnology in Energy storage and conversion: Solar cells - Construction and working of Dye sensitized and Quantum dot sensitized solar cells. Batteries, Fuel Cells.

Applications of Nanotechnology: Nanotech Applications and Recent Breakthroughs, Recent Major Breakthroughs in Nanotechnology.

**iv) (a) TEXT BOOKS**

1) A.K. Bandyopadhyay, *Nano Materials*, 2nd Edition, New Age Publishers, 2010.
2) C.N.R. Rao, P. John Thomas, G.U. Kulkarni, *Nanocrystals: Synthesis, Properties and Applications*, Springer Series in Materials Science 95, 2007.
3) T. Pradeep, *Nano Essentials*, 1st Edition, Tata McGraw-Hill, 2007.

4) Peter J. F. Harris, *Carbon Nanotube Science: Synthesis, Properties, and Applications*, 1st Edition, Cambridge University Press, 2011.
5) M.A. Shah, & K.A.Shah, *Nanotechnology: The Science of Small*, 1st Edition, Wiley India, 2011.


**(b) REFERENCES**


1) C.P. Poole, & F. J. Owens, *Introduction to Nanotechnology*, 1st Edition, Wiley, 2003.
2) Scientific American, *Understanding Nanotechnology*, Hachette Book Group USA, 2002.
3) M. Ratner, & D. Ratner, *Nanotechnology*, 1st Edition, Prentice Hall, 2003.
4) M. Wildon, K. Kannagara, G. Smith, M. Simmons, & B. Raguse, *Nanotechnology*, CRC Press, 2002.


**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Nanomaterials Nanotechnology:** Frontier of future-an overview, Length Scales, Variation of physical properties from bulk to thin films to nanomaterials, Confinement of electron in 0D, 1D, 2D and 3D systems, Surface to Volume Ratio, Synthesis of Nanomaterials: Bottom-Up approach: Chemical Routes for Synthesis of nanomaterials-Sol-gel, Precipitation, Solution Combustion synthesis, Hydrothermal, SILAR, Chemical Bath Deposition. Top-Down approach- Ball milling technique, Sputtering, Laser Ablation | 9 |
| II | **Characterization of Nanomaterials:** Basic principles and instrumentations of Electron Microscopy –Transmission Electron Microscope, Scanning Electron Microscope, Scanning Probes-Scanning Tunneling microscope, Atomic Force Microscope – different imaging modes, comparison of SEM and TEM, AFM and STM, AFM and SEM. Basic principles of working of X-ray diffraction, derivation of Debye-Scherrer equation, numericals on Debye Scherrer equation, Optical Spectroscopy- Instrumentation and application of IR, UV/VIS (Band gap measurement) | 9 |
| III | **Carbon Based Materials:** Introduction, Synthesis, Properties (electrical, Electronic and Mechanical), and Applications of Graphene, SWCNT, MWCNT, Fullerenes and other Carbon Materials: Carbon nanocomposites, nanofibres, nanodiscs, nanodiamonds. | 8 |
| IV | **Nanotechnology in Energy storage and conversion:** Solar cells - First generation, Second generation and third generation solar cells: Construction and working of Dye sensitized and Quantum dot sensitized solar cells. Batteries: Nanotechnology in Lithium-ion battery- working, Requirements of anodic and cathodic materials, classification based on ion storage mechanisms, limitations of graphite anodes, Advances in Cathodic materials, Anodic materials, Separators Fuel Cells: Introduction, construction, working of fuel | 10 |

| | | |
|---|---|---|
| | cells and nanotechnology in hydrogen storage and proton exchange membranes.<br>**Self-study for lifelong learning:**<br>Super capacitors: Introduction, construction and working of supercapacitor | |
| V | **Applications of Nanotechnology:** Nanotech Applications and Recent Breakthroughs: Introduction, Significant Impact of Nanotechnology and Nanomaterial, Medicine and Healthcare Applications, Biological and Biochemical Applications (Nano biotechnology), Electronic Applications (Nano electronics), Computing Applications (Nano computers), Chemical Applications (Nano chemistry), Optical Applications (Nano photonics), Agriculture and Food Applications, Recent Major Breakthroughs in Nanotechnology.<br>**Self-study for lifelong learning:**<br>Nano coatings (Photocatalysts) and super hydrophobic coatings (Lotus effect) | 9 |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL32G | INTRODUCTION TO SOFT COMPUTING | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

## i) COURSE OVERVIEW:

Goal of this course is to provide an exposure to the students on the fundamental concepts of different soft computing techniques, including the basics of Artificial Neural Networks, Fuzzy logic, Genetic algorithms and Machine learning. It gives an insight into the different types of Artificial Neural Network architectures, the learning processes and algorithms, the properties and operations of fuzzy logic, the working of a fuzzy logic system, the operators of Genetic Algorithms and some hybrid systems. This course also provides a broad introduction to non-traditional metaheuristic optimization techniques and data clustering algorithms.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the basics of Fuzzy Logic, Artificial Neural Networks and Genetic algorithm. | Understand |
| CO2 | Apply fuzzy logic techniques to control a system. | Apply |
| CO3 | Explain the different Artificial Neural Network architectures and the different learning methods for training of ANNs. | Understand |
| CO4 | Infer the optimal solution of a given problem using genetic algorithm techniques. | Understand |
| CO5 | Explain the Non-traditional Metaheuristic Optimization Techniques and data clustering algorithms. | Understand |

## iii) SYLLABUS

Basic Introduction – Difference between soft computing and hard computing; artificial intelligence.

Fuzzy logic - Fuzzy set properties and operations; membership functions, Fuzzy logic systems; Applications.

Artificial Neural Networks - Biological foundations; ANN models; architecture; Learning process; Supervised and unsupervised learning; Back propagation network, Radial Basis Function, Data Clustering Algorithms.

Genetic Algorithm – basic concepts, operators, steps.

Hybrid Systems - Adaptive Neuro-fuzzy Inference System (ANF1S), Genetic algorithm based back propagation networks, fuzzy back propagation networks.
Introduction to Non-traditional Metaheuristic Optimization Techniques.

## iv) (a) TEXT BOOKS

1) Timothy J. Ross, *Fuzzy logic with Engineering Applications*, Wiley Publications, 3rd edition, 2010.

2) S. Rajasekharan, G. A. Vijayalakshmi Pai, *Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications*, Prentice Hall India, 2003.
3) S. N. Sivanandan, S. N. Deepa, *Principles of Soft Computing*, Wiley India, 2007.
4) Simon Haykin, *Neural Networks a Comprehensive foundation*, Pearson Education, 1999.
5) Suran Goonatilake & Sukhdev Khebbal (Eds.), *Intelligent Hybrid Systems*, John Wiley, 1995.
6) D. E. Goldberg, *Genetic Algorithms in Search Optimisation and Machine Learning*, Pearson Education, 1989.
7) Tom Mitchell, *Machine Learning*, McGraw Hill, 1997.

**(b) REFERENCES**

1) Bart Kosko, *Neural Network and Fuzzy Systems*, Prentice Hall of India, 2002.
2) Zurada J. M., *Introduction to Artificial Neural Systems*, Jaico Publishers, 2003.
3) Hassoun Mohammed H., *Fundamentals of Artificial Neural Networks*, Prentice Hall of India, 2002.
4) J. S. R. Jang, C. T. Sun, E. Mizutani, *Neuro-Fuzzy and Soft Computing*, Prentice Hall, 1997.
5) Driankov D., Hellendoorn H., Reinfrank M, *An Introduction to Fuzzy Control*, Narosa Publications, 1993.
6) Ronald R. Yager and Dimitar P. Filev, *Essentials of Fuzzy Modelling & Control*, John Wiley & Sons, Inc, 2002.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction**: Conventional and Modern Control System, Soft and Hard Computing, Artificial Intelligence. **Fuzzy Logic**: Introduction to crisp sets and fuzzy sets, Properties, Basic fuzzy set operations, examples. Membership function, types, Fuzzy relations - Cardinality of Fuzzy relations, Operations on Fuzzy relations, Properties of Fuzzy relations. **Fuzzy logic controller**: Block diagram - Fuzzification, rule base, inference engine and defuzzification - simple fuzzy logic controllers with example. | 7 |
| II | **Artificial Neural Networks**: Biological foundations – ANN models - Characteristics of ANN - Types of activation function - McCulloch-Pitts neuron model, Logic implementations using McCulloch-Pitts neuron model. **Neural network architecture and learning**: Single layer, multilayer, recurrent network architectures. Knowledge representation - Learning process - Supervised and unsupervised learning. **Learning algorithms**: Error correction learning - Hebbian learning – Boltzmann learning - competitive learning. | 9 |

| | | |
|---|---|---|
| **III** | Linear Separability, Pattern Classification: Perceptrons.<br>Back propagation network and its architecture, Derivation of the back-propagation algorithm – Case study. Radial basis function networks.<br>Classification and Regression Trees – Data Clustering Algorithms – K-Means, Fuzzy C-Means, Subtractive Clustering. | **10** |
| **IV** | **Genetic Algorithm**: Introduction - basic concepts of Genetic Algorithm - encoding, fitness function, reproduction, cross over, mutation operator, bit-wise operators, generational cycle.<br>**Introduction to Non-traditional Metaheuristic Optimization Techniques**: Random Optimization, Simulated Annealing, Tabu Search, Ant Colony Optimization, Particle Swarm Optimization, Harmony Search, Memetic Algorithms, Evolutionary Algorithms. | **12** |
| **V** | **Hybrid Systems**: Adaptive Neuro-fuzzy Inference System (ANF1S), Genetic algorithm based back propagation networks, fuzzy back propagation networks, examples.<br>Case studies – Applications in Control Systems, Renewable energy systems etc. | **7** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL32H | INTERNET OF THINGS | PEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

The goal of this course is to introduce students to the different architectures used for connected smart devices. This course will enable students to program embedded devices used in different levels of IoT application. It also aims to expose students to design and develop Internet of Things based solutions.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the role of computer networks in IoT. | Understand |
| CO2 | Classify the different communication standards for IoT applications. | Understand |
| CO3 | Explain the functionalities and applications of various sensors and transmit the data to cloud-based platforms. | Understand |
| CO4 | Develop programs for IoT devices using micro-python language. | Apply |
| CO5 | Develop an IoT based solution for real time applications. | Apply |

**iii) SYLLABUS**

Introduction to IoT: Definition, Characteristics, Physical and Logical Design, IoT Functional Blocks, Communication Models, APIs, Enabling Technologies, and Design Challenges. Computer Networks: Internet Protocols, OSI Model, TCP/IP, IP Addressing, Network Components, and SDN. IoT and M2M Communications: M2M Concepts, Standards (Bluetooth-LE, Zigbee, NFC, WiFi, LoRaWAN), Cloud Services (CoAP, MQTT, JSON, HTTP/HTTPS), and Edge Computing. Sensor Technologies: Wireless Sensor Networks, Data Acquisition using Sensors, Edge AI, and TinyML. Embedded Devices: Python and MicroPython Programming, Sensor Interfacing using Raspberry Pi, ARM EMBED, ESP32, Arduino, and IoT Security. IoT Applications: Smart Grids, Home Automation, Smart Metering, Weather Stations, Smart Farming, Smart Cities, and Healthcare.

**iv) (a) TEXT BOOKS**

1) Simone Cirani, Internet of things: Architecture, protocols and standards, Wiley, 2019.
2) Charles Bell, MicroPython for the Internet of Things: A Beginner's Guide to programming with Python on Microcontrollers, Apress, 2017.
3) B.K Thripathy, J Anuradha, Internet of things (IoT) - technologies, applications, challenges and solutions, CRC press, 2018.

4) Raj Kamal, Internet of Things: Architecture and Design Principles, McGraw Hill (India) Private Limited, 2017.
5) Peter Waher, Mastering Internet of Things: Design and create your own IoT applications using Raspberry Pi 3, 1st Edition, Packt Publishing, 2018.

**(b) REFERENCES**

1) Qusay F. Hassan, Internet of Things A to Z: Technologies and applications, IEEE press, 2018
2) Gary Smart, Practical Python Programming for IoT: Build advanced IoT projects using Raspberry Pi MQTT, RESTful APIs, Web Sockets, and Python 3, Packt Publishing Ltd, 2020.
3) Gaston C. Hillar, MQTT Essentials - A Lightweight IoT Protocol, Packt Publishing Ltd, 2017.
4) Alasdair Gilchrist, Industry 4.0 The Industrial Internet of Things, Apress, 2016.
5) David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, First Edition, Cis CO Press, 2017.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction: Definition, Characteristics, and Evolution of IoT. Physical Design of IoT: Things in IoT, IoT Protocols. Logical Design of IoT: IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies. Design Challenges: Power consumption, security, scalability, and interoperability. Computer Networks: Internet protocols and standards, OSI model, TCP/IP protocol suite. IP Addressing: IPv4, IPv6, Subnetting. Network Components: Switches, Routers, Access points, Servers, Clients, Ports, Gateways. Sizing of Network: LAN, MAN, WAN, Software-Defined Networking (SDN). | 8 |
| II | IoT and M2M Communications: Introduction to M2M, Applications, and Key Differences from IoT. M2M Standards: Bluetooth-LE, Zigbee, NFC, WiFi, LoRaWAN. Data Logging and Cloud Services: CoAP, MQTT, JSON, HTTP/HTTPS. Edge Computing in IoT: Concept, advantages, and applications. | 10 |
| III | Sensor Technologies for IoT: Wireless sensor networks. Common Sensors and Data Acquisition: Voltage, Current, Speed, Temperature, Humidity, and Motion sensors. Edge AI for IoT: Basics of AI on embedded devices and TinyML. Data Logging to Cloud Services: Cloud protocols and programming. | 10 |

| | | |
|---|---|---|
| **IV** | Embedded Devices for IoT: Introduction to Python and Embedded Programming using MicroPython. Sensor Interfacing and Data Acquisition: Using target boards like Raspberry Pi 4B, ARM EMBED, ESP32, Arduino. IoT Security: Threats, Encryption methods, and Secure Communication. Hands-on Assignments: Hardware implementation using IoT development boards. | **9** |
| **V** | IoT Applications: Energy Management and Smart Grids IoT-based Home Automation Smart Metering for Electricity Consumers IoT-based Weather Stations Smart Farming and Precision Agriculture IoT in Smart Cities. IoT for Healthcare: Remote patient monitoring, wearable health devices. | **8** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

## vii) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

## viii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

## ix) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

# INSTITUTE ELECTIVE 1

| Course Code | Course Name | Category | L-T-P-J | Credit | Year of Introduction |
|---|---|---|---|---|---|
| 23IEL31A | INTRODUCTION TO FLIGHT DYNAMICS AND CONTROL | IEC | 3-0-0-0 | 3 | 2023 |

**i) COURSE OVERVIEW**: This course provides a fundamental understanding of control systems, aerodynamics, aircraft stability, and flight dynamics, catering to students from various engineering disciplines. It covers key concepts such as airfoil characteristics, aircraft motion, flight control systems, and emerging technologies like UAV control and AI-driven flight automation, equipping students with the foundational knowledge required for aerospace applications.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain fundamental concepts of control systems, stability, and state-space representation. | Understand |
| CO2 | Utilize aerodynamic concepts to analyse airfoil characteristics, calculate aerodynamic forces, and assess aircraft performance parameters such as lift, drag, and stalling behaviour. | Apply |
| CO3 | Make use of root locus and Routh-Hurwitz criteria to assess the stability of control systems and understand the impact of control surfaces on aircraft stability. | Apply |
| CO4 | Explain aircraft dynamics, flight control systems, and stability augmentation techniques. | Understand |
| CO5 | Explain modern flight control technologies, UAV applications, and future trends in aerospace automation. | Understand |

**iii) SYLLABUS**

Introduction to flight dynamics, open-loop and closed-loop control, transfer function, time-domain analysis, state-space representation, controllability, and observability.

Standard atmosphere, aerodynamic flows, Mach and Reynolds numbers, airfoil characteristics, lift and drag, stalling, drag polar, flight equations, thrust and power requirements, range, and endurance.

Stability concepts, Routh-Hurwitz criterion, root locus, aircraft control surfaces (elevator, aileron, rudder, flaps, spoilers), wind tunnels, and flow similarity.

ircraft motion modes (short period, phugoid, spiral divergence, Dutch roll), static and dynamic stability, lateral and longitudinal dynamics, autopilot systems, and stability augmentation.

Fly-by-wire systems, UAV control challenges, AI and adaptive control in aerospace, flight simulation tools, and future trends in aerospace automation.

**iv) a) TEXT BOOKS**

1. John D. Anderson Jr., *Introduction to Flight*, McGraw-Hill, 2021.
2. Etkin B. & Reid L.D., *Dynamics of Flight: Stability and Control*, Wiley, 1996.
3. Nelson R.C., *Flight Stability and Automatic Control*, McGraw-Hill, 1998.
4. Cook M.V., *Flight Dynamics Principles*, Butterworth-Heinemann, 2012.

5. Stevens B.L. & Lewis F.L., *Aircraft Control and Simulation*, Wiley, 2015.

**b) REFERENCES**

1. Anderson J.D. Jr. *Fundamentals of Aerodynamics*, McGraw-Hill, 2016.
2. Houghton E.L., & Carpenter P.W. *Aerodynamics for Engineering Students*, Elsevier, 2017.
3. Abbott, I.H. & von Doenhoff A.E. *Theory of Wing Sections*, Dover Publications, 1959.
4. McCormick B.W., *Aerodynamics, Aeronautics, and Flight Mechanics*, Wiley, 1994.
5. McLean D. *Automatic Flight Control*, Prentice Hall, 1990.
6. Roskam J. *Airplane Flight Dynamics and Automatic Flight Controls*, DAR corporation, 2001.
7. Austin R. *Unmanned Aircraft Systems: UAV Design, Development and Deployment*, Wiley, 2011.
8. Dorf R.C. & Bishop R.H., *Modern Control Systems*, Pearson, 2021.
9. Ogata K., *Modern Control Engineering*, Pearson, 2010.
10. Kuo B.C., *Automatic Control Systems*, Pearson, 2018.
11. Nise N.S., *Control Systems Engineering*, Wiley, 2021.
12. D'Azzo J.J., *Linear Control System Analysis and Design*, McGraw-Hill, 2011.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Fundamentals of Control Systems and Stability**<br>**Introduction to control system**: Open loop and closed loop control systems - Transfer function of LTI systems – characteristic equation – Type and order of system. Time domain analysis of control systems: Standard test signals – Transient and steady state responses – first and second order systems – time domain specifications – step responses of first and second order systems.<br>**Introduction to state space**: state equation of linear continuous time systems – Eigen values and Eigen vectors of system matrix – concept of controllability & observability – relationship between state equations and transfer function. | 8 |
| II | **Aerodynamics and Aircraft Performance**<br>**Introduction to Aerodynamics:** standard atmosphere – definition of altitudes–density, pressure and temperature altitudes.<br>Aerodynamic flows – inviscid and viscous flows – incompressible and compressible flows – Mach number – laminar and turbulent flows – Reynolds number.<br>**Airfoils**: Airfoil nomenclature – symmetric and cambered airfoils – generation of lift. Wing geometry –aspect ratio – chord line – angle of attack.<br>**Aerodynamic forces and moments**: aerodynamic coefficients – lift, drag and moment coefficients – lift curve, drag curve – stalling of airfoil. | 10 |

| | | |
|---|---|---|
| | **Aircraft Performance**: Drag Polar – Equation of motion of aircraft for level, un–accelerated flight. Thrust and power required for level, un–accelerated flight– thrust and power available – condition for maximum velocity. | |
| III | **Aircraft Stability and Control Surfaces**<br>**Concept of stability:** Bounded Input Bounded Output stability – stability of feedback system – location of poles and stability – Routh Hurwitz stability criterion.<br>**Root locus:** General rules for constructing Root loci – stability from root loci – effect of addition of poles and zeros.<br>**Control surfaces**: elevator – aileron – rudder – dihedral angle and its effects – flaps and slots – spoilers.<br>Flow similarity – Wind tunnels – open and close wind tunnels. | 9 |
| IV | **Aircraft Dynamics and Flight Control**<br>**Aircraft dynamic modes**: Short period, phugoid, spiral divergence, and Dutch roll (concepts only, minimal mathematics).<br>**Aircraft Stability and Control**: Static and dynamic stability – conditions for longitudinal static stability. Longitudinal and lateral dynamics (linear state space model) – Longitudinal dynamic modes - short period, phugoid. Lateral and directional dynamic stability – Spiral divergence and dutch roll (concepts only - mathematical derivations not needed)<br>**Autopilot and flight control systems**: Actuators, displacement autopilots, pitch displacement, attitude hold, velocity hold.<br>Block diagrams and control design for aircraft stability augmentation systems. | 9 |
| V | **Emerging Trends in Flight Control and UAV Applications**<br>Introduction to fly-by-wire control systems: Digital flight control and electronic stability.<br>Unmanned Aerial Vehicles (UAVs): Flight control challenges, stability considerations, autonomous navigation.<br>Introduction to Adaptive and Intelligent Control: AI and machine learning applications in aerospace control.<br>Flight Simulation and Software Tools: Introduction to computational tools for flight dynamics analysis.<br>Future Trends in Aerospace Control: Hypersonic flight, space vehicle control, and automation in modern aircraft. | 9 |
| | **Total hours** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

## vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

## viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L-T-P-J | Credit | Year of Introduction |
|---|---|---|---|---|---|
| 23IEL31B | INTRODUCTION TO POWER PROCESSING | IEC | 3-0-0-0 | 3 | 2023 |

**i) COURSE OVERVIEW**

This course introduces power electronics and its applications in power conversion, electric drives, renewable energy, and electric vehicles. It covers power semiconductor devices, AC-DC, DC-DC, and DC-AC converters, motor control, solar and wind energy systems, power supplies, and EV powertrains and charging technologies. Students will gain fundamental knowledge of power processing systems used in industrial, renewable energy, and transportation sectors.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the power semiconductor devices and wide bandgap devices. | Understand |
| CO2 | Explain the operation of AC-DC rectifiers, DC-DC converters, DC-AC inverters, AC voltage controllers, and the impact of Total Harmonic Distortion. | Understand |
| CO3 | Utilize power electronic converters to control electric motor drives and implement applications in industrial systems like heating, lighting, robotics, and automation. | Apply |
| CO4 | Illustrate the power electronics applications in renewable energy systems, including solar PV, wind energy, energy storage, grid integration, microgrids, and smart grids. | Understand |
| CO5 | Explain power supplies and power electronics in electric vehicles, powertrain, charging technologies and energy storage solutions. | Understand |

**iii) SYLLABUS**

Power semiconductor devices – Diode, SCR, MOSFET, IGBT – operation and characteristics, wide bandgap devices (SiC, GaN), applications in renewable energy and transportation.

Single-phase fully controlled rectifier (R, RL load), DC-DC converters – Buck, Boost, Buck-Boost, single-phase full bridge inverter – square-wave operation, sinusoidal PWM, THD, introduction to AC voltage controllers.

Electric drives – block diagram, 4-quadrant DC motor, v/f control of induction motor, industrial applications – heating, lighting, robotics, traction, aerospace.

Solar PV systems – off-grid, on-grid, MPPT, wind energy systems, energy storage – lithium-ion batteries, hydrogen fuel cells, grid integration, microgrids.

Linear and switched-mode power supplies (SMPS), EV classifications – HEV, PHEV, BEV, powertrain schematic, EV charging – fast/wireless, energy storage – lithium-ion batteries, hydrogen fuel cells, future trends.

**iv) (a) TEXTBOOKS**


1) Ned Mohan, Tore M. Undeland, William P. Robbins, *Power Electronics: Converters, Applications, and Design*, Wiley, 3rd Edition, 2002.
2) Muhammad H. Rashid, *Power Electronics: Circuits, Devices & Applications*, Pearson, 4th Edition, 2013.
3) P.S. Bimbhra, *Power Electronics*, Khanna Publishers, 6th Edition, 2018.
4) Gopal K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing, 2nd Edition, 2010.
5) Andrzej M. Trzynadlowski, *Introduction to Modern Power Electronics*, 3rd Edition, Wiley, 2015.
6) Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.


**(b) REFERENCES**


1) Robert W. Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer, 2nd Edition, 2001.
2) M.D. Singh, K.B. Khanchandani, *Power Electronics*, McGraw Hill, 2nd Edition, 2007.
3) Bimal K. Bose, *Modern Power Electronics and AC Drives*, Pearson, 1st Edition, 2001.
4) R. Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Pearson, 1st Edition, 2001.
5) Chetan Singh Solanki, *Solar Photovoltaics: Fundamentals, Technologies, and Applications*, PHI Learning, 3rd Edition, 2021.
6) James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2nd Edition, 2012.
7) Ali Emadi, *Advanced Electric Drive Vehicles*, CRC Press, 1st Edition, 2014.
8) D.P. Kothari, K.C. Singal, Rakesh Ranjan, *Renewable Energy Sources and Emerging Technologies*, PHI Learning, 2nd Edition, 2011.
9) Jahangir Hossain, Hemanshu Roy Pota, *Renewable Energy Integration*, Academic Press, 1st Edition, 2014.
10) Daniel M. Mitchell, *DC-DC Switching Regulator Analysis*, McGraw Hill, 1st Edition, 1988.
11) Abbasi S. A. and N. Abbasi, *Renewable Energy Sources and their Environmental Impact*, Prentice Hall of India, 2001.
12) Sawhney G. S., *Non-Conventional Energy Resources*, PHI Learning, 2012.
13) Abad, Gonzalo, *Power electronics and electric drives for traction applications*. USA: Wiley, 2017.


**(c) Additional Online Learning Resources**

**NPTEL Courses (IITs, IISc):**

- *Introduction to Power Electronics* (IIT Delhi)
- *Fundamentals of Electric Drives* (IIT Madras)
- *Energy Storage & Renewable Energy Systems* (IIT Delhi)
- *Non-conventional Energy Sources* (IIT Madras)

## v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | **Fundamentals of Power Processing**<br>Introduction to power processing – Elements of power electronics – Power semiconductor devices – Uncontrolled, semicontrolled, and fully controlled switches – Diode, SCR, MOSFETs, IGBTs: Principle of operation – Advantages of wide bandgap devices: SiC, GaN – Applications of power electronics in modern systems. | 9 |
| II | **Power Conversion Circuits**<br>AC-DC conversion: Single-phase fully controlled SCR-based bridge rectifier with R and RL load (continuous mode only) – Principle of operation and waveforms – DC-DC Converters (Non-isolated): Buck, Boost, Buck-Boost converter – Circuit operation, voltage gain, and waveforms in continuous conduction mode – DC-AC conversion: Single-phase half and full bridge inverter with R load – Square-wave operation – Types of PWM: Single pulse, multiple pulse, sinusoidal PWM – Total harmonic distortion (THD) – AC-AC conversion: Single-phase AC voltage controller with R load – Waveforms. | 9 |
| III | **Electric Drives & Industrial Applications**<br>Electric motor drives: Introduction – Block diagram of an electric drive – 4-quadrant operation of a separately excited DC motor – Circuit diagram and waveforms – Induction motor drives: Principle of operation – v/f control – Power electronics applications in industrial systems: Heating, lighting, robotics, automation – Power electronics in aerospace and railway traction systems. | 9 |
| IV | **Power Processing in Renewable Energy Systems**<br>Solar photovoltaic (PV) systems: Principle of operation – Off-grid and on-grid solar systems – Block diagram – Maximum power point tracking (MPPT) – Wind energy conversion systems (WECS): Working principle – Grid integration – Energy storage technologies: Lithium-ion batteries, lead-acid batteries, supercapacitors, hydrogen fuel cells – Microgrids and smart grids: Concept and applications. | 9 |
| V | **Power Processing in Power Supplies & Electric Vehicles**<br>Power supplies: Principle of operation – Linear power supply, switched-mode power supply (SMPS) – Power supply requirements: Isolation, protection, regulation – Electric vehicles (EVs): Introduction to HEV, PHEV, BEV – Block schematic of power train – Energy storage in EVs: Li-ion batteries, hydrogen fuel cells – Charging technologies: Fast charging, wireless charging – Future trends in power electronics: AI, IoT, wide bandgap devices. | 9 |
| | **Total hours** | **45** |

### vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

### vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

### viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L-T-P-J | Credit | Year of Introduction |
|---|---|---|---|---|---|
| 23IEL31C | ELECTRICAL DRIVES AND CONTROL FOR AUTOMATION | IEC | 3-0-0-0 | 3 | 2023 |

## i) COURSE OVERVIEW

This course introduces the principles of electric drives and their role in control and automation systems. It covers the working, characteristics, and applications of DC machines, transformers, induction motors, synchronous machines, and special motors. The course also explores modern motor control techniques, including PLC-based motor control, digital controllers, and industrial automation applications. Case studies on electric drives in robotics, CNC machines, and electric vehicles provide insights into real-world applications.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the working principles, characteristics, and performance of DC machines, transformers, and induction motors. | Understand |
| CO2 | Explain the construction, operation, and applications of synchronous machines, stepper motors, and servo motors. | Understand |
| CO3 | Apply motor control strategies using digital controllers, variable frequency drives (VFDs), DSP-based controllers, and programmable logic controllers (PLCs) in industrial automation scenarios. | Apply |
| CO4 | Explain the role of electric drives in industrial automation, robotics, and electric vehicles, supported by case studies. | Understand |
| CO5 | Explain emerging trends in IoT-enabled motor control, AI-based predictive maintenance, and Industry 4.0 applications. | Understand |

## iii) SYLLABUS

DC generators – EMF equation – types of excitations – armature reaction – OCC and load characteristics – DC motors: principle, torque equation, types, characteristics, efficiency, and applications.

Transformers - Principle of operation, EMF equation, vector diagrams, losses and efficiency, OC and SC tests, equivalent circuit, auto transformers – applications.

Alternators – EMF equation – voltage regulation – synchronous motors – stepper motors – BLDC and PMSM motors – servo motors – applications in automation.

Motor control techniques – servo control – digital controllers – VFDs – DSP-based controllers – PLCs – automation case studies.

Electric drives in automation – robotics – CNC machines – electric vehicles – HVAC systems – IoT-based motor control – Industry 4.0 applications.

## iv) (a) TEXTBOOKS

1) P.S. Bimbhra, *Electrical Machinery*, Khanna Publishers, 7th Edition, 2011.

2) J.B. Gupta, *Theory and Performance of Electrical Machines*, S.K. Kataria & Sons, 15th Edition, 2021.
3) Hughes & Drury, *Electric Motors and Drives: Fundamentals, Types and Applications*, Elsevier, 5th Edition, 2019.
4) B.L. Theraja & A.K. Theraja, *A Textbook of Electrical Technology - Volume II*, S. Chand, 24th Edition, 2019.
5) D.P. Kothari & I.J. Nagrath, *Electric Machines*, McGraw-Hill, 5th Edition, 2017.

**(b) REFERENCES**

1) V.K. Mehta & Rohit Mehta, *Principles of Electrical Machines*, S. Chand, 3rd Edition, 2018.
2) R.K. Rajput, *Electrical Machines*, Laxmi Publications, 6th Edition, 2019.
3) Kenjo & Sugawara, *Stepping Motors and Their Microprocessor Control*, Clarendon Press, 2nd Edition, 1994.
4) R. Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Prentice Hall, 1st Edition, 2001.
5) P.C. Sen, *Principles of Electric Machines and Power Electronics*, Wiley, 3rd Edition, 2013.
6) John W. Webb & Ronald A. Reis, *Programmable Logic Controllers: Principles and Applications*, Pearson, 5th Edition, 2014.
7) G.K. Dubey, *Fundamentals of Electrical Drives*, Narosa Publishing House, 2nd Edition, 2002.
8) Ion Boldea & Syed A. Nasar, *Electric Drives*, CRC Press, 2nd Edition, 2005.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **DC Machines**<br>DC generators - Principle of operation – EMF equation – types of excitation – armature reaction – open circuit characteristics (OCC) and load characteristics – applications of DC generators.<br>DC motors - Principle of operation – torque equation – types and characteristics – losses and efficiency – industrial applications. | 9 |
| II | **Transformers**<br>Principle of operation – EMF equation – vector diagrams – losses and efficiency – open circuit (OC) and short circuit (SC) tests – equivalent circuit – efficiency calculations – maximum efficiency – all-day efficiency – auto transformers – industrial applications. | 9 |
| III | **Special Motors**<br>Principle of alternators – EMF equation – voltage regulation by EMF method.<br>Synchronous motors – principle of operation and starting methods.<br>Stepper motors: principle of operation, types, and applications.<br>BLDC and PMSM motors: construction, working, and applications.<br>Servo motors and their role in automation. | 9 |

| | | |
|---|---|---|
| **IV** | **Motor Control Techniques**<br>Introduction to motor controllers – servo control – digital controllers – variable frequency drives (VFDs) – DSP-based motor controllers – programmable logic controllers (PLCs) in motor control – industrial automation using motor controllers – case studies in robotics and CNC machines. | **9** |
| **V** | **Electric Drives in Automation**<br>Applications of electric drives in robotics, CNC machines, and electric vehicles – motor control in HVAC systems – IoT-enabled motor control – AI-based predictive maintenance – Industry 4.0 applications – case studies on automation and smart manufacturing. | **9** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L-T-P-J | Credit | Year of Introduction |
|---|---|---|---|---|---|
| 23IEL31D | ARTIFICIAL INTELLIGENCE IN POWER SYSTEMS | IEC | 3-0-0-0 | 3 | 2023 |

**i) COURSE OVERVIEW**

This course explores the application of AI in power systems, covering machine learning, deep learning, and data analytics for renewable energy forecasting, smart grids, predictive maintenance, and system optimization. It also addresses ethical and cybersecurity challenges in AI-driven power systems.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the fundamentals of power systems and AI techniques applicable to them. | Understand |
| CO2 | Explain AI-based forecasting, optimization, and control strategies in power systems. | Understand |
| CO3 | Explain predictive maintenance, fault detection, and real-time monitoring using AI. | Understand |
| CO4 | Explain AI-based techniques for load forecasting, predictive maintenance, grid stability, optimization, and control in power system operations. | Understand |
| CO5 | Apply AI methods to develop solutions for real-time monitoring, fault detection, optimal power dispatch, and adaptive control in power systems. | Apply |

**iii) SYLLABUS**

Power generation, transmission, and distribution overview, AI and machine learning basics, supervised, unsupervised, and reinforcement learning, common AI algorithms.

Data acquisition, preprocessing, and feature extraction, AI/ML applications (regression, classification, clustering, time-series analysis), overview of Python libraries and simulation tools.

AI-driven forecasting for solar and wind energy, smart grids, IoT integration, energy storage optimization, demand response strategies.

Load forecasting, predictive maintenance, fault detection, real-time grid monitoring, AI for grid stability and contingency analysis.

AI-based optimization in power dispatch and unit commitment, AI-driven voltage and frequency regulation, adaptive control, ethical considerations, cybersecurity in AI applications.

**iv) (a) TEXTBOOKS**

1) S.A. Soman, S.A. Khaparde, and Shubha Pandit, *Artificial Intelligence in Power System Analysis*, CRC Press, 2020.

2) James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley-IEEE Press, 2012.
3) Amit Kumar, Om Pal, and Arun Kumar Singh, *Artificial Intelligence and Machine Learning in Power System Operations*, Springer, 2023.
4) Jan Machowski, Janusz W. Bialek, and James R. Bumby, *Power System Dynamics: Stability and Control*, Wiley, 2020.


**(b) REFERENCES**


1) Mohammad Shahidehpour and Muwaffaq Alomoush, *Restructured Electric Power Systems: Analysis of Electricity Markets with Equilibrium Models*, Wiley-IEEE Press, 2001.
2) Bin Lu and M. Shahidehpour, *Short-Term Load Forecasting Using Stochastic Learning Networks*, IEEE Transactions on Power Systems, 2005.
3) Trevor Hastie, Robert Tibshirani, and Jerome Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, Springer, 2017.
4) Francisco D. Bianchi, Hernán De Battista, and Ricardo J. Mantz, *Wind Turbine Control Systems: Principles, Modelling and Gain Scheduling Design*, Springer, 2006.
5) Research papers and IEEE Transactions on Power Systems and Smart Grids.


**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Fundamentals of Power Systems & Introduction to AI**<br>Fundamentals of Power Systems - Overview of Power Generation, Transmission, and Distribution, Overview of conventional and renewable power plants.<br>Introduction to AI and Machine Learning - History and evolution of AI, Core concepts in machine learning: supervised, unsupervised, and reinforcement learning, Overview of common algorithms. | 9 |
| II | **AI Techniques and Tools for Power Systems Applications**<br>Data Acquisition and Preprocessing: Data sources in power systems (SCADA, PMU, smart meters), Data cleaning and feature extraction techniques.<br>AI/ML Algorithms for Energy Applications: Regression, classification, clustering, and time-series analysis, Introduction to deep learning and neural networks tailored for forecasting and classification tasks.<br>Software Tools & Platforms: Overview of Python libraries (TensorFlow, PyTorch, Scikit-learn), Simulation and modeling platforms for power systems. | 9 |
| III | **AI in Renewable Energy Integration & Smart Grids**<br>Solar and wind energy generation forecasting using AI, Handling variability and uncertainty in renewable outputs.<br>Smart Grid Technologies: Role of AI in optimizing smart grid operations, Integration of IoT, advanced metering infrastructure (AMI), and 5G communications. | 9 |

| | | |
|---|---|---|
| | Energy Storage and Demand Response: AI-driven energy storage management strategies, Demand response programs and optimization of energy distribution. | |
| **IV** | **AI Applications in Power System Operations**<br>Load Forecasting and Demand Prediction: Short-term and long-term forecasting models, Case examples using time-series forecasting techniques.<br>Predictive Maintenance and Fault Detection: Condition monitoring and anomaly detection in critical infrastructure, AI-driven approaches to predictive maintenance of equipment.<br>Grid Stability and Real-Time Monitoring: Techniques for real-time data analytics and fault diagnosis, AI methods for managing dynamic stability and contingency analysis. | **9** |
| **V** | **Optimization, Control, and Future Directions**<br>Optimization in Power Systems: Techniques for optimal power flow (OPF) and unit commitment using AI, Energy dispatch optimization and cost minimization strategies.<br>Advanced Control Systems: AI-driven control for voltage and frequency regulation, Fault-tolerant and adaptive control systems in real-time operations.<br>Ethical, Security, and Future Trends: Ethical considerations and cybersecurity challenges in AI applications. | **9** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

# MINORS/HONOURS

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3MB | CLOUD COMPUTING FOR INTERNET OF THINGS | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

This course provides a comprehensive understanding of cloud computing concepts, virtualization technologies, cloud architecture, and major cloud platforms like AWS, Microsoft Azure, and Google Cloud. It covers the fundamental characteristics, service, and deployment models of cloud computing, along with hands-on experience in deploying and managing applications on popular cloud platforms. The course also focuses on virtualization techniques, cloud services, and security aspects, including compliance, identity management, and monitoring tools, preparing students to effectively work with modern cloud technologies.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the fundamental concepts of cloud computing, including its characteristics, service models, deployment models, and evolution. | Understand |
| CO2 | Demonstrate the principles of virtualization technologies, including hypervisors, virtual machines, containers, and various virtualization techniques. | Understand |
| CO3 | Analyze cloud architecture and evaluate key cloud services, such as storage, compute, and database solutions across major platforms. | Understand |
| CO4 | Deploy and manage cloud-based applications, using hands-on experience with AWS, Microsoft Azure, and Google Cloud platforms. | Understand |
| CO5 | Evaluate cloud security risks and implement monitoring tools, ensuring data privacy, compliance, and effective resource management. | Understand |

**iii) SYLLABUS**

.Cloud computing characteristics, service models (IaaS, PaaS, SaaS), deployment models (public, private, hybrid, community), virtualization technologies (hypervisors, virtual machines, containers), virtualization techniques (hardware, storage, network), cloud architecture, cloud services (storage, compute, database), AWS, Microsoft Azure, Google Cloud, cloud security risks, data privacy, compliance, IAM, encryption, cloud monitoring tools (CloudWatch, Azure Monitor, Stackdriver).

**iv) (a) TEXT BOOKS**

1) Thomas, E., Zaigham M., Ricardo P., Cloud Computing Concepts, Technology & Architecture, Prentice Hall, 2013.
2) Buyya, R., Broberg, J., & Goscinski, A. M., Cloud Computing: Principles and Paradigms. Wiley, 2013.

3) Miller, M. Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online. Que Publishing, 2008.

**(b) REFERENCES**

1) Marinescu, D. C., “Cloud computing: theory and practice.”, Morgan Kaufmann, 2017.
2) Buyya, R., Broberg, J., & Goscinski, A. M., “Cloud computing: Principles and paradigms” John Wiley & Sons, 2011.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Module 1: Introduction to Cloud Computing and IoT**<br>Definition and characteristics: On-demand self-service, broad network access, resource pooling, rapid elasticity, measured service, evolution of cloud computing: Grid computing, utility computing, virtualization, service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), deployment models: Public cloud, private cloud, hybrid cloud, community cloud. | 8 |
| II | **Module 2: Cloud Infrastructure for IoT**<br>Introduction to virtualization: Concept of hypervisors (Type 1 and Type 2), virtual machines (VMs) and containers, virtualization techniques: Hardware virtualization, storage virtualization, network virtualization, popular virtualization tools: VMware, VirtualBox, Docker containers. | 10 |
| III | **Module 3: Cloud-based IoT Data Management**<br>Cloud architecture: Layered architecture of cloud, client-server architecture, cloud storage and networking basics, cloud services and applications: Storage services (Amazon S3, Azure Blob Storage, Google Cloud Storage), compute services (EC2, Azure VMs, Google Compute Engine), database services (RDS, Cosmos DB, BigQuery), case studies: AWS, Microsoft Azure, Google Cloud. | 10 |
| IV | **Module 4: Cloud Security for IoT**<br>Amazon Web Services (AWS): Overview of AWS services (EC2, S3, Lambda, RDS), hands-on: Creating and managing VMs on AWS, Microsoft Azure: Overview of Azure services (Virtual Machines, Blob Storage, Functions), hands-on: Deploying a web app on Azure, Google Cloud Platform (GCP): Overview of GCP services (Compute Engine, Cloud Functions, Cloud SQL), hands-on: Setting up a project on GCP. | 9 |
| V | **Module 5: Cloud-based IoT Application Development**<br>Cloud security: Security risks in the cloud, data privacy and compliance (GDPR, HIPAA), identity and access management (IAM), firewalls and encryption in the cloud, cloud monitoring and management: Tools (CloudWatch (AWS), Azure Monitor, Stackdriver (GCP)). | 8 |
| | **Total hours** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

## vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

## viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3MD | ELECTRICAL SYSTEM DESIGN AND BUILDING SERVICES | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: Goal of this course is to expose the students to the fundamental concepts of Electrical System Design for Buildings, the methodology of design, the Regulatory standards and essential building services. Also, the course introduces the students to the efficient use of Computer aided design with MS Excel.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the various building services and various codes and standards involved in the design of electrical system of buildings | Understand |
| CO2 | Develop the basis of design (BOD) for the project as per the given floor layout | Apply |
| CO3 | Develop the electrical schematic of electric installation in a domestic building and select the suitable protective devices and cables | Apply |
| CO4 | Explain the design requirements of electrical installations in high-rise buildings. | Understand |
| CO5 | Design the PV system for a domestic building | Apply |
| CO6 | Explain the building energy management systems and lightning protection in buildings | Understand |

**iii) SYLLABUS**

Electrical System Design in Building Construction - The Indian Electricity Act 2003, National Electric Code (NEC 2011), National Building Code (NBC 2016)- Classification of voltages

Design phase for electrical systems and develop the basis of design (BOD) for the project as per the given floor layout. Space requirements for a proper electrical installation as per NEC

Design of electrical installations for domestic buildings - selection of main distribution board, sub distribution board, MCB, ELCB, MCCB - Electrical system layout designing

Design requirements for high rise apartments and substation - Metering Panels - Cabling - Auxiliary and Emergency Power Supply

Lightning protection system for a building – components - Code of practice for the protection of buildings – Smart buildings and green buildings

**iv) (a) TEXT BOOKS**

1) Theodore R Bosela, “Electrical Systems Design”, Prentice Hall; 1 edition, (August 18, 2002)

2) M. K. Giridharan, “Electrical Systems Design”, I K International Publishers, New Delhi, 2nd edition, 2016
3) Aleksandar Mratinkovic & Co., “Electrical Systems Design”, 3G E-Learning LLC (1 April 2017)
4) Ruzhu Wang, Xiaoqiang Zhai, “Handbook of Energy Systems in Green Buildings”, Springer; 1st ed. 2018 edition

**(b) REFERENCES**

1) Steven J. Marrano “Electrical System Design and Specification Handbook for Industrial Facilities”, Fairmont Press, 1998
2) V. K. Jain & Amitabh Bajaj, “Design of Electrical Installations” Lakshmi Publications Pvt. Ltd
3) Solanki C. S., “Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers”, Prentice Hall India Learning Private Limited (2013)
4) National Electric Code, Bureau of Indian Standards publications, 2011.
5) Relevant Indian Standard – Specifications (IS – 732, IS – 746, IS – 3043, IS – 900)
6) National Electrical Code (NEC) 2017 Handbook

**(c) DATA BOOK (Approved for use in the examination):**

1) M K Giridharan, *Electrical Systems Design Data Hand book,* I K International Publishers, New Delhi, 2011

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| **I** | Electrical System Design in Building Construction. Role of Statutes: The Indian Electricity Act 2003, National Electric Code (NEC 2011), IEC. National Building Code (NBC 2016), Types of buildings (residential, commercial, industrial) and their electrical needs. Classification of Building services – Major and Minor building services – Design aspects of building services, Classification of voltages, standards and specifications. | **8** |
| **II** | Design phase for electrical systems based on project size and develop the basis of design (BOD) for the project. Procedures of calculating and designing the electrical system based on Plot area, Floor Area Ratio (FAR), Load Power Density (LPD), Total Connected Load (TCL), Transformer and Generator Capacity. Need of MS Excel tool for efficient design methodology. Space requirements for electrical installation as per NEC, room spaces to house electrical equipment- need for cable duct and cable trays- structural reinforcement for heavy equipment, clearances around electrical equipment. | **9** |
| **III** | General aspects of the design of electrical installations for domestic dwellings as per NEC guidelines. MCB – types and Working principle, MCCB. RCCB- working, RCBO. Selection of protective devices, cables and DB. Connected load calculation, sub circuits, selection of main distribution board, sub distribution board, MCB, | **10** |

| | | |
|---|---|---|
| | ELCB- selection of cables for sub circuit. Electrical drawings for the given project including floor plans and schematic diagrams.<br>*Practical Exercise – Design of electrical system of residential building using MS Excel.* | |
| **IV** | Design requirements for high rise apartments- commercial and residential – Substations, Primary and Secondary protection - Metering Panels – Cabling – Auxiliary and Emergency Power Supply Systems.<br>Introduction to Solar PV Systems: off-grid and on-grid systems – Components of PV system - Solar panel efficiencies - Design of a PV system for domestic application | **10** |
| **V** | Lightning protection system for a building and building services, Role of grounding in lightning protection systems.<br>Building Energy Management Systems - Energy-efficient design principles for electrical systems - Smart metering, real-time energy management and energy-saving technologies.<br>Concept of smart buildings - green buildings. | **8** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3MF | SMART GRID AND ENERGY STORAGE SYSTEMS | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: The course aims to provide students with a conceptual introduction to smart grids, its architecture, components and communication technologies. It also aims to expose the students to the fundamental concepts of energy storage systems used in different applications.

**vi) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Summarize the need, benefits, various components and functions of Smart Grid. | Understand |
| CO2 | Explain the various Smart Grid Technologies. | Understand |
| CO3 | Outline the functions of various communication networks in Smart Grid. | Understand |
| CO4 | Interpret the role of energy storage in power systems. | Understand |
| CO5 | Summarize energy storage applications for smart grids. | Understand |

**vii) SYLLABUS**

Evolution of Electric Grid-Conventional Grid vs Smart Grid, Smart Grid Reference Architecture-Introduction to Smart Meters.

Smart Substations, Substation Automation, Smart Appliances, Smart Sensors, Home and Building Automation.

Communication Networks for Smart Grid: Interoperability and connectivity - Home Area Network (HAN), Neighborhood-Area Networks (NANs), Sensor and Actuator Networks, Cloud computing in Smart Grid.

Introduction to Energy storage in power systems: Need and role of energy storage systems in power system- Scope of energy storage, needs and opportunities in energy storage,

Energy Storage Technologies: Role of Energy Storage Systems-Applications - Overview of energy storage technologies - Thermal, Mechanical, Chemical, Electrochemical, Electrical.

**viii) (a) TEXT BOOKS**

1) Stuart Borlase “Smart Grid Infrastructure Technology and Solutions”, CRC Press; 2nd Edition.
2) Janies Momoh, “Smart Grid: Fundamentals of Design and Analysis”, Wiley, 2012.
3) S. Chowdhury, “Microgrids and Active Distribution Networks.” Institution of Engineering and Technology, 2009.

4) Janaka Ekanayake, Kythira Liyanage, Jianzhong Wu, Akihiko Yokohama, Nick Jenkins- “Smart Grids Technology and Applications”, Wiley, 2012.
5) Osaka T., Datta M,, “Energy Storage Systems in Electronics-New Trends in Electrochemical Technology”, CRC Press 2000.
6) A Ralph Zito, Energy storage: A new approach, Wiley, 2010.
7) Frank S. Barnes and Jonah G. Levine, Targe Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press, 2011.


**(b) REFERENCES**


1) Barker, Preston, Price, Rudy F., “Cybersecurity for the Electric Smart Grid: Elements and Considerations”, Nova Science Publishers Inc, 2012.
2) Eric D. Knapp, Raj Samani, “Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure”, Syngress; 1st Edition, 2013.
3) Richard J. Campbell, “The Smart Grid and Cybersecurity: Regulatory Policy and Issues”, Congressional Research Service, 2011.
4) Dariusz Kloza, Vagelis Papakonstantinou, Sanjay Goel, Yuan Hong, “Smart grid security”, Springer, 2015.
5) Roger C. Dugan, “Electrical Power Systems Quality”, McGraw-Hill Publication, 3rd Edition. 2012.
6) G.T.Heydt, “Electric Power Quality”, Stars in a Circle Publications, 2nd Edition.1991.
7) Broussely M. and Pistoia G., “Industrial Applications of Batteries from Cars to Aerospace and Energy Storage”, Elsevier, 2007.
8) Nazri G. A. and Pistoia G., “Lithium Batteries - Science and Technology”, Kluwer Academic Publishers, 2004.
9) Larminie J., Dicks A. and Wiley-Blackwell, “Fuel Cell Systems Explained”, 2nd Edition,Wiley Publications, 2013.
10) Pistoia, Gianfranco, and Boryann Liaw, “Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost”, Springer International Publishing AG, 2018.
11) Robert A. Huggins, “Energy Storage”, Springer Science & Business Media, 2010.


**ix) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Smart Grid:** Evolution of Electric Grid, Conventional Grid vs Smart Grid, Benefits, Challenges and Key Application Areas of Smart Grid.<br>**Smart Grid Components:** Smart Grid Architecture, Smart Meters, Real Time Pricing- Intelligent Electronic Devices (IED), Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU). | 9 |
| II | **Smart Grid Technologies:** Smart Substations, Substation Automation, Feeder automation, Fault detection, Isolation, and Service Restoration (FDISR), Geographic Information System (GIS), | 9 |

| | | |
|---|---|---|
| | Outage Management System (OMS). Smart Appliances, Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI). | |
| **III** | **Communication Networks for Smart Grid:** Interoperability and connectivity - Home Area Network (HAN), Neighborhood-Area Networks (NANs), Sensor and Actuator Networks (SANETs). **Cloud computing in Smart Grid:** Private, public and Hybrid cloud. Cloud architecture of smart grid. | **9** |
| **IV** | **Introduction to Energy storage in power systems:** Need and role of energy storage systems in power system- Scope of energy storage, needs and opportunities in energy storage, Energy and power balance in a storage unit, comparison of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market. | **9** |
| **V** | **Energy Storage Technologies:** Role of Energy Storage Systems Applications - Overview of energy storage technologies - Thermal, Mechanical, Chemical, Electrochemical, Electrical - Comparison of Various Storage Technologies-Criteria for Selection of Storage. | **9** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3MH | INTRODUCTION TO AUTOMOTIVE ELECTRICAL AND ELECTRONIC SYSTEMS | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: The goal of this course is to equip students with a fundamental knowledge of the various electrical and electronic systems that operate within automobiles

**x) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Classify the various types of batteries used in automotive vehicles. | Understand |
| CO2 | Outline the key components of charging system and the components and mechanisms of the starter system. | Understand |
| CO3 | Explain the ignition systems and fuel injection systems in automotive vehicles. | Understand |
| CO4 | Explain the components of automotive lighting systems and various instrumentation systems. | Understand |
| CO5 | Summarize the various types of sensors and actuators used in automobiles. | Understand |

**xi) SYLLABUS**

Principle of lead acid battery & constructional details-Capacity Rating, Battery charging methods, Battery tests. Developments in storage.
Charging system: Working and constructional details of Alternators Starting system: Requirement of starter motor -Starter drive mechanisms.
Battery coil and Magneto ignition system, Centrifugal and Vacuum advance mechanisms, Spark plugs, constructional details and types. Electronically assisted ignition system; Non-contact triggering devices - Electronic fuel injection system overview.
Lighting, Instrumentation types -Sensors and applications in Automobile, Actuators. Introduction to internet of things (IOT) and its automotive applications.

**xii) (a) TEXT BOOKS**

1) Kohli.P.L. "Automotive Electrical Equipment", Tata McGraw-Hill Co Ltd,1st Edition, 2009.
2) Tom Denton, "Automobile Electrical and Electronic Systems", Elsevier Butterworth-Heinemann, 3rd Edition, 2004.

**(b) REFERENCES**

1) Al Santini "Automotive Electricity and Electronics, Cengage Learning", Automobile Engineering, 2013.
2) Robert Bosch, "Automotive Handbook", Bently Publishers,1st Edition, 2004.
3) William B. Ribbens, Norman P. Mansour, "Understanding automotive electronics", Newnes, 6th Edition, 2003.
4) Jim Horner, "Automotive Electrical Hand Book", Penguin, 1986.

5) Barry Hollembeak, Automotive Electricity & Electronics, Cengage Learning, 5th Edition 2010.

**xiii) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| **I** | **Batteries:** Principle of lead acid battery & constructional details, Effect of temperature on electrolyte, Capacity Rating, Battery charging methods, Battery tests. Developments in storage: Nickel metal hydride battery, Lithium-ion battery, Fuel cells, Ultra capacitors. | **9** |
| **II** | **Charging system:** Working of three phase Alternators, Rectification, voltage regulation, current regulation.<br>**Starting system:** Requirement of starter motor, Starter Motor types, construction and characteristics, Starter drive mechanisms, Starting circuit, Starter Switches. | **9** |
| **III** | **Battery coil and Magneto ignition system**: Centrifugal and Vacuum advance mechanisms, Spark plugs - constructional details and types. Electronically assisted ignition system, Non-contact triggering devices - Fully electronic ignition System, Distributorless ignition.<br>**Electronic fuel injection system overview:** D jetronic, K jetronic and L jetronic fuel injection; Injections schemes – Single point, Multi point, Sequential, Direct injection, Common rail direct injection, Gasoline direct injection, Supercritical injection. | **9** |
| **IV** | **Lighting:** Types of headlights, headlight reflectors, headlight lenses, indicator lamp details, lighting circuit, projector headlights; Horn and wiper mechanisms.<br>**Instrumentation:** Speedometer, Fuel Level Indicator, Oil Pressure and Coolant Temperature Indicators, Display devices – LED, LCD, Onboard diagnostics (OBD), OBD – II | **9** |
| **V** | **Sensors and applications in Automobile**: Pressure sensors, Temperature sensors, Position sensors, Lambda sensor, Air flow sensor, Wheel speed sensor, Knock sensor, Optical sensors.<br>**Actuators:** Solenoids, Stepper motors, Relays, Piezoelectric. Introduction to internet of things (IOT) and its automotive applications. | **9** |
| | **Total hours** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

## vii) CONTINUOUS ASSESSMENT TEST

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

## viii) END SEMESTER EXAMINATION

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3HB | ANALYSIS OF ELECTRICAL MACHINES | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

Goal of this course is to expose the students to analyze electrical machine behavior using voltage and torque equations. This course also imparts knowledge to apply generalized machine theory to various motor types and understand transient and steady-state machine dynamics.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Outline the basic elements of generalised theory. | Understand |
| CO2 | Develop the basic two pole model representation of electrical machines | Apply |
| CO3 | Develop the linear transformation equations of rotating electrical machines incorporating the concept of power invariance. | Apply |
| CO4 | Develop the general equations for voltage and torque of all rotating machines. | Apply |
| CO5 | Make use of generalised theory to learn the steady state and transient behaviour of all rotating machines. | Apply |

**iii) SYLLABUS**

Unified approach to the analysis of electrical machine performance - basic two pole model of rotating machines- per unit system.
Primitive machine - transformer and rotational voltages in the armature voltage and torque equations resistance, inductance and torque matrix.
Transformations - passive linear transformation in machines- Park's transformation-invariance of power.
DC Machines- Application of generalized theory to separately excited, shunt and series machines- Steady state and transient analysis, transfer functions.
Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model, Balanced steady state analysis-power angle curves.
Induction Machines- Primitive machine representation- Steady State Operation-Equivalent circuit. Single phase induction motor- Voltage and Torque equations.

**iv) (a) TEXT BOOKS**

1) Bhimbra P. S., *Generalized Theory of Electrical Machines*, Khanna Publishers, 6th Edition, Delhi 2017.
2) Charles V. Johnes, *Unified Theory of Electrical Machines*. New York, Plenum Press, 2nd Edition 1985.
3) Bernad Adkins, Ronald G. Harley, *General theory of ac Machines*. London, Springer Publications, 2013.

4) Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, *Analysis of Electrical Machines and Drive Systems*, John Wiley & Sons, 3rd Edition 2013.

**(b) REFERENCES**

1) Charles Concordia, *Synchronous Machines- Theory and Performance*, John Wiley and Sons Incorporate, Newyork.1988.
2) Say M. G., *Introduction to Unified Theory of Electrical Machines,* Pitman Publishing, 4th Edition 1978.
3) Alexander S Langsdorf M. N., *Theory of Alternating Current Machinery*, Tata McGraw Hill, 2nd Edition, 2001.
4) NPTEL: http://nptel.ac.in/courses/108106023/

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Unified approach** to the analysis of electrical machine performance –conventions- - basic two pole model of rotating machines- DC compound and shunt machines with interpoles, single phase series machine, three phase induction machine-per unit system – Transformer with movable secondary, transformer and rotational voltages in the armature -Primitive machine - voltage and torque equations-resistance, inductance and torque matrix. | 9 |
| II | **Transformations** - passive linear transformation in machines-transformation from a displaced brush axis-transformation from three phase to two phase and from rotating axes to stationary axes-Clark's and Park's transformation- invariance of power - Restrictions of the Generalized theory of machines | 9 |
| III | **DC Machines**: Application of generalized theory to separately excited DC generator: steady state and transient analysis, Separately excited DC motor- steady state and transient analysis, Transfer function of separately excited DC generator and motor- DC shunt and series motors: Steady state analysis and characteristics. | 9 |
| IV | **Synchronous Machines**: synchronous machine reactance and time constants-Primitive machine model, Balanced steady state analysis-power angle curves, phasor diagram of salient pole and cylindrical rotor synchronous machines. | 9 |
| V | **Induction Machines**: Primitive machine representation-Transformation- Steady state operation-Equivalent circuit.<br>Single phase induction motor- Revolving Field Theory- Equivalent circuit- Voltage and Torque equations -Cross field theory-Comparison between single phase and poly phase induction motor. | 9 |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3HD | ANALYSIS OF POWER ELECTRONIC CIRCUITS | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: This course provides an in-depth understanding of power electronic circuits with a strong emphasis on analysis, design, and simulation. Emphasis is placed on analytical techniques, mathematical modeling, and simulation using MATLAB/Simulink to evaluate converter performance in real-world scenarios such as motor drives, renewable energy systems, and electric vehicles.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the switching behavior, losses, and control requirements of semiconductor devices used in power electronic circuits | Understand |
| CO2 | Apply the performance and waveform characteristics of various rectifier circuits including source inductance and filtering effects. | Apply |
| CO3 | Apply control strategies for DC-DC converters under continuous and discontinuous conduction modes | Apply |
| CO4 | Compare the operation of different Voltage source Inverters and their control schemes. | Understand |
| CO5 | Explain the operation of Multilevel inverters and resonant converters. | Understand |

**iii) SYLLABUS**

Characteristics of Ideal and Real switches - Static and Dynamic Characteristics Driver circuit and Snubbers – Conduction and Switching loss - Power dissipation and selection of heat sink

Single-phase converter - full converter and semi converter Three-phase converter - Full converter & semi converter – analysis with RLE loads continuous conduction only – inversion mode - effect of source inductance

Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers, PWM control-Time ratio control – Current limit control, Source filter and its design, multiphase chopper.

Single phase full Bridge Inverters –Analysis with RL load - Three phase bridge inverter Common mode voltage; PWM principle - Sinusoidal pulse width modulation- Unipolar and Bipolar modulation, Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Fixed Switching Frequency Current Control, PWM rectifiers

Multilevel Inverters Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters ZVS & ZCS. Case studies on high-power converter applications: Drives, PV inverters, EV chargers etc. MATLAB/Simulink for circuit analysis of power electronic converter circuits. Design and simulation of power conversion system.

**iv) (a) TEXT BOOKS**


1) Rashid, M. H. *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson Education, 2013.
2) Mohan, N., Undeland, T. M., & Robbins, W. P. *Power Electronics: Converters, Applications and Design*, 3rd Edition, Wiley India, 2011.


**(b) REFERENCES**


1) Erickson, R. W., & Maksimovic, D. *Fundamentals of Power Electronics*, 2nd Edition, Springer, 2001.
2) Bimal K. Bose, *Modern Power Electronics and AC Drives*, Pearson Education, 2002.
3) Kassakian, J. G., Schlecht, M. F., & Verghese, G. C. *Principles of Power Electronics*, Addison-Wesley, 1991.
4) Billings, K., & Morey, T. *Switch Mode Power Supply Design*, 3rd Edition, McGraw-Hill Education, 2010.
5) MATLAB Documentation – *Simscape Electrical Toolbox*, MathWorks Inc.


**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Fundamentals of Power Electronic Circuits:** Characteristics of Ideal and Real switches – Power loss in practical switches, Static and Dynamic Characteristics for MOSFET and IGBT– Conduction and Switching loss - Power dissipation and selection of heat sink, Snubber circuits and gate/base drive circuits. | 9 |
| II | **Analysis of Rectifier Circuits:** Single-phase and three-phase controlled and uncontrolled rectifiers, Performance parameters: ripple, THD, power factor, Discontinuous conduction mode analysis, Source inductance effect and freewheeling diode operation, Input and output filter design for rectifiers. | 9 |
| III | **Analysis of DC-DC Converters** : Buck, Boost, Buck-Boost, Cuk, and SEPIC converters. Continuous and discontinuous mode operation. Design of Power circuit.<br>**Isolated DC-DC converters**: Flyback, Forward, Push-pull, Half Bridge and Full-bridge converters. | 9 |
| IV | **Inverter and AC-AC Converter Analysis:** Voltage source inverter analysis. Single-phase and three-phase inverter. PWM principle - Sinusoidal pulse width modulation- unipolar and bipolar modulation- Harmonic analysis and filter design. Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control PWM rectifiers. | 9 |
| V | **Multilevel Inverter** operation: diode clamped, flying capacitor, cascaded H-bridge. | 9 |

| | | |
|---|---|---|
| | **Resonant Converters**: ZVS & ZCS. Case studies on high-power converter applications: Drives, PV inverters, EV chargers etc. MATLAB/Simulink for circuit analysis of power electronic converter circuits. Design and simulation of power conversion system. | |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3HF | OPERATION AND CONTROL OF POWER SYSTEMS | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

This course provides a comprehensive introduction to analytical techniques used in the operation and control of modern power systems. Key topics include load dispatch strategies, energy scheduling methods, and the fundamentals of power system security. Students will also explore state estimation techniques, equipping them with the tools to assess and enhance system reliability and performance.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the fundamental concepts of economic load dispatch, unit commitment and power system security | Understand |
| CO2 | Apply optimization techniques and priority-list methods to solve constrained unit commitment and hydrothermal scheduling problems under different system constraints | Apply |
| CO3 | Illustrate the principles of energy interchange and power pooling in utility-level energy contracts, banking, and unit commitment-based interchange evaluations | Understand |
| CO4 | Explain voltage control techniques such as transformer tap settings, midline boosters, and static VAR compensators to maintain voltage profiles in power systems | Understand |
| CO5 | Apply state estimation techniques using weighted least squares and phasor measurement units for monitoring and analyzing power system conditions | Apply |

**iii) SYLLABUS**

Optimum load dispatch - First order gradient method base point and participation factors. Economic dispatch versus unit commitment.

Scheduling energy problems - types of scheduling problems- Scheduling energy - The Hydrothermal Scheduling Problem

Interchange contracts – Energy interchange between utilities - Interchange evaluation with unit commitment.

Voltage control using Transformers- control by mid line boosters-compensation of transmission line- AGC including excitation system.

Power system security- Factors Affecting Power System Security - Contingency Analysis: Detection of Network Problems.

Introduction to State estimation in power system, Maximum Likelihood Weighted Least Squares Estimation

The Use of Phasor Measurement Units (PMUs) - Application of Power Systems State Estimation - Importance of Data Verification and Validation.

**iv) (a) TEXT BOOKS**


1) Allen J. Wood, Bruce F. Wollenberg & Gerald B. Sheblé, “Power Generation, Operation, and Control”, 3rd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey.
2) John Gainger& William Stevenson, “Power System Analysis”, McGraw-Hill, Inc,, 1994.
3) Vadhera S. S., Power System Analysis and Stability, Khanna Publishers, 5th edition, 2013.
4) Kirchmayer L. K., Economic Control of Interconnected Systems, John Wiley & Sons, 1959.
5) Nagrath I. J., Kothari D. P., Modern Power System Analysis, Tata McGraw-Hill, 3rd edition, 2003.
6) Weedy B. M., Electric Power Systems, John Wiley and Sons, New York, 1987.
7) Hadi Sadat, Power System Analysis, Tata McGraw-Hill, 2nd edition, 2003.


**(b) REFERENCES**


1) Ali Abur,Antonio Gómez Expósito, Power System State Estimation: Theory and Implementation, CRC Press, 2004.
2) Monticelli A., State Estimation in Electric Power System-A Generalised Approach Springer, 1999.


**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction**- Review of economic load dispatch-Optimum load dispatch - First order gradient method base point and participation factors. Economic dispatch versus unit commitment. Unit Commitment Solution Methods - Priority-List Methods – Security Constrained Unit Commitment. | 9 |
| II | Generation with limited Supply-Take or pay fuel supply contract-Introduction to Hydro Thermal Coordination-Long range and short range scheduling.<br>**Hydro-electric plant models**-scheduling energy problems - types of scheduling problems- Scheduling energy - The Hydrothermal Scheduling Problem - Hydro scheduling with storage limitation - Introduction to Pumped storage hydro plants. | 9 |
| III | **Inter change evaluation** and power pools- Interchange contracts – Energy interchange between utilities - Interchange evaluation with unit commitment - Energy banking- power pools.<br>**Voltage control**: voltage control using Transformers- control by mid line boosters-compensation of transmission line- AGC including excitation system, MVAR control application of voltage regulator - static VAR compensators. | 9 |

| | | |
|---|---|---|
| **IV** | **Power system security**- Factors Affecting Power System Security - Contingency Analysis: Detection of Network Problems - Generation Outages - Transmission Outages - An Overview of Security Analysis. | **9** |
| **V** | **Introduction to State estimation in power system**: Maximum Likelihood Weighted Least Squares Estimation - State Estimation of an AC Network - Sources of Error in State Estimation - Detection and Identification of Bad Measurements - Estimation of Quantities Not Being Measured - Network Observability and Pseudo-measurements - Phasor Measurement Units (PMUs) - Application of Power Systems State Estimation - Importance of Data Verification and Validation. | **9** |
| | **Total hours** | 45 |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours

| Course Code | Course Name | Cate-gory | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23EEL3HH | AUTOMOTIVE ELECTRICAL AND ELECTRONIC SYSTEMS | VAC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**: The goal of this course is to give students a general overview of the diverse electrical and electronic systems found in automobiles.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Classify the various types of batteries and typical wiring system used in automotive vehicles. | Understand |
| CO2 | Outline the principle of generator/alternator and the mechanisms of the starter system. | Understand |
| CO3 | Summarize the ignition systems and the components of automotive lighting systems. | Understand |
| CO4 | Explain energy management systems and chassis electrical systems in automotive vehicles. | Understand |
| CO5 | Summarize the various types of sensors and actuators used in automobiles. | Understand |

**iii) SYLLABUS**

Low and high voltage automobile cables, typical wiring system, symbols used in automobile electrical systems. Storage Battery: lead acid battery -Capacity Rating, Battery charging methods, Battery tests.

Generator/ Alternator - Working and constructional details of Alternators Starting system: Requirement of starter motor -Starter drive mechanisms.

Ignition systems: Battery coil and Magneto ignition system, Centrifugal and Vacuum advance mechanisms, working of battery and magneto ignition systems, Principle of automobile illumination, headlamp mounting and construction, sealed beam auxiliary lightings.

Engine management Systems - Combined ignition and fuel management systems. Exhaust emission control, Digital control techniques. Spark plugs, constructional details and types. Chassis Electrical systems - Anti-Lock brakes (ABS), Active suspension, Traction control, electronic control of automatic transmission- Anti Lock brakes (ABS), Active suspension, Traction control, electronic control of automatic transmission.

Components of an EV, EV batteries, chargers, drives, transmission and power devices – Transducers and Sensors applications in Automobiles.

**iv) (a) TEXT BOOKS**

1) Kohli.P. L. "Automotive Electrical Equipment", Tata McGraw-Hill Co Ltd,1st Edition,2009.
2) Tom Denton, "Automobile Electrical and Electronic Systems", Elsevier Butterworth-Heinemann, 3rd Edition,2004.

3) S.S. Thipse, “Alternative Fuels” JAICO Publishing House, New Delhi,2010.
4) W. Bolton, Longman, “Mechatronics” Pearson publications, 2nd Edition 2007.

**(b) REFERENCES**

1) Al Santini, “Automotive Electricity and Electronics, Cengage Learning”, AUTOMOBILE ENGINEERING, 2013
2) Robert Bosch, “Automotive Handbook”, Bently Publishers,1st Edition,2004
3) William B. Ribbens, Norman P. Mansour, “Understanding automotive electronics”, Newnes, 6th Edition,2003
4) Jim Horner, “Automotive Electrical Hand Book”, Penguin, 1986
5) Barry Hollembeak, Automotive Electricity & Electronics, Cengage Learning,5th Edition 2010.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction:** Earth return and insulated systems, 6 volts and 12 volts system, fusing of circuits, low and high voltage automobile cables, cable specifications, diagram of typical wiring system, and symbols used in automobile electrical systems. **Storage Battery:** Principle of lead acid battery & constructional details, Effect of temperature on electrolyte, Capacity Rating, Battery charging methods, Battery tests. Developments in storage: Nickel metal hydride battery, Lithium-ion battery, Fuel cells, Ultra capacitors. | 9 |
| II | **Generator/ Alternator:** Principle of generation of direct current, generator, shunt dynamos, armature reaction, action of three brush generator and battery in parallel, setting of third brush, voltage and current regulators, cutout relay - construction, working and adjustment. Construction and working of alternator and output control. **Starter Motor & Drives:** Battery motor starting system, condition at starting, behavior of starter during starting, series motor and its characteristics, considerations affecting size of motor, types of drives, starting circuit. | 9 |
| III | **Ignition systems:** Ignition fundamentals, working of battery and magneto ignition systems, comparison of battery and magneto ignition system, advantages and disadvantages of conventional ignition systems, Types of solid-state ignition systems, components, construction and working, high energy ignition distributors, electronic spark timing control. **Lighting system and Dashboard Instruments.** Principle of automobile illumination, head lamp mounting and construction, sealed beam auxiliary lightings, horn, windscreen-wipers, signalling devices, electrical fuel pump, fuel, oil and temperature gauge, speedometer, odometer, etc. (Dash board instruments) | 9 |

| | | |
|---|---|---|
| **IV** | **Engine management Systems:** Combined ignition and fuel management systems. Exhaust emission control, Digital control techniques – Dwell angle calculation, Ignition timing calculation and Injection duration calculation. Complete vehicle control systems, Artificial intelligence and engine management. Hybrid vehicles and fuel cells.<br>**Chassis Electrical systems**: Antilock brakes (ABS), Active suspension, Traction control, electronic control of automatic transmission, other chassis electrical systems, Central locking, Air bags and seat belt tensioners, seat heaters. | **9** |
| **V** | **Electrical and hybrid vehicles:** Components of an EV, EV batteries, chargers, Hybrid electric vehicles, HEV drivetrain components.<br>**Sensors and applications in Automobile**: Pressure sensors, Temperature sensors, Position sensors, Lambda sensor, Air flow sensor, Wheel speed sensor, Knock sensor, Optical sensors.<br>**Actuators:** Solenoids, Stepper motors, Relays, Piezoelectric. Introduction to internet of things (IOT) and its automotive applications. | **9** |
| | **Total hours** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests : 02
- Maximum Marks : 30
- Test Duration : 1 ½ hours
- Topics : 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks : 60
- Exam Duration : 3 hours