MK UNIVERSITY

PATAN, GUJARAT

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MK University, Patan
Faculty of Engineering Technology,
Department of Electrical Engineering (EE)

B. TECH (Electrical Engineering) SEM-I									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTEE101	ENGINEERING MATHEMATICS-I	4	0	4	40	60	100
2	MAJOR	BTEE102	BASIC ELECTRICAL ENGINEERING	4	2	6	90	60	150
3	MAJOR	BTEE103	ENGINEERING PHYSICS	4	2	6	90	60	150
4	MINOR	BTEE104	PROGRAMING IN PYTHON	4	0	4	40	60	100
5	VAC	BTEE105	COMMUNICATION SKILL-I	2	0	2	0	50	50
TOTAL				18	4	22	260	290	550

B. TECH (Electrical Engineering) SEM-II									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTEE201	ENGINEERING MATHEMATICS-II	4	0	4	40	60	100
2	MAJOR	BTEE202	ELECTRICAL CIRCUITS	4	2	6	90	60	150
3	MAJOR	BTEE203	ELECTRONIC DEVICES	4	2	6	90	60	150
4	MINOR	BTEE204	ENGINEERING CHEMISTRY	4	0	4	40	60	100
5	VAC	BTEE205	ENVIRONMENTAL SCIENCE	2	0	2	0	50	50
TOTAL				18	4	22	260	290	550

B. TECH (Electrical Engineering) SEM-III

SR NO.	COURSE TYPE	COURSE CODE	CUORSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTEE301	ELECTROMAGNATIC THEORY	4	0	4	40	60	100
2	MAJOR	BTEE302	SIGNALS & SYSTEMS	4	0	4	40	60	100
3	MAJOR	BTEE303	ELECTRICAL MACHINES-I	4	2	6	90	60	150
4	MINOR	BTEE304	DATA STRUCTURES	4	2	6	90	60	150
5	SEC	BTEE305	WORKSHOP PRACTICE	0	2	2	00	50	50
TOTAL				16	6	22	260	290	550

B. TECH (Electrical Engineering) SEM-IV

SR NO.	COURSE TYPE	COURSE CODE	CUORSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTEE401	POWER SYSTEMS-I	4	0	4	40	60	100
2	MAJOR	BTEE402	ELECTRICAL MACHINES-II	4	2	6	90	60	150
3	MAJOR	BTEE403	CONTROL SYSTEMS	4	0	4	40	60	100
4	MINOR	BTEE404	MICROPROCESSORS & MICROCONTROLLERS	4	2	6	90	60	150
5	SEC	BTEE405	Indian Constitution	2	0	2	0	50	50
TOTAL				18	4	22	260	290	550

B. TECH (Electrical Engineering) SEM-V

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTEE501	POWER ELECTRONICS	4	2	6	90	60	150
2	MAJOR	BTEE502	POWER SYSTEMS-II	4	2	6	90	60	150
3	MAJOR	BTEE503	ELECTRICAL MEASUREMENTS	4	0	4	40	60	100
4	MINOR	BTEE504	RENEWABLES ENERGY SYSTEMS	4	0	4	40	60	100
5	VAC	BTEE505	MINI-PROJECT	0	4	4	50	00	50
TOTAL				16	8	24	310	240	550

B. TECH (Electrical Engineering) SEM-VI

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTEE601	HIGH VOLTAGE ENGINEERING	4	0	4	40	60	100
2	MAJOR	BTEE602	DIGITAL SIGNAL PROCESSING	4	2	6	90	60	150
3	MAJOR	BTEE603	ELECTRIC DRIVES	4	2	6	90	60	150
4	MINOR	BTEE604	MACHINE LEARNING FOR EE	4	0	4	40	60	100
5	SEC	BTEE605	APTITUDE & CARRER SKILLS	0	2	2	50	0	50
TOTAL				16	6	22	250	300	550

B. TECH (Electrical Engineering) SEM-VII

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTEE701	POWER SYSTEM PROTECTION	4	2	6	90	60	150
2	MAJOR	BTEE702	SMART GRID TECHNOLOGIES	4	2	6	90	60	150
3	MINOR	BTEE703	IOT FOR ELECTRICAL SYSTEMS	4	0	4	40	60	100
4	SEC	BTEE704	INDUSTRY 4.O & AUTOMATION	0	2	2	00	50	50
5	VAC	BTEE705	Project Phase-I	0	4	4	100	00	100
TOTAL				12	10	22	220	230	550

B. TECH (Electrical Engineering) SEM-VIII

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTEE801	RESEARCH METHDOLOGY IN EE	4	0	4	40	60	100
2	MAJOR	BTEE802	ELECTRICAL SYSTEM DESIGN	4	2	6	90	60	150
3	MINOR	BTEE803	EMBEDDED SYSTEMS FOR EE	4	2	6	90	60	150
4	SEC	BTEE804	Project Phase-II	0	10	10	100	100	200
TOTAL				12	14	26	320	280	600

SUBJECT CODE: BTEE101

SUBJECT NAME: ENGINEERING MATHEMATICS-I

Course Objective:

- The concept of rank of a matrix which is used to know the consistency of system of linear equations and also to find the eigen vectors of a given matrix.
- Finding maxima and minima of functions of several variables.
- Applications of first order ordinary differential equations. (Newton's law of cooling, Natural growth and decay)
- How to solve first order linear, nonlinear partial differential equations and also method of separation of variables technique to solve typical second order partial differential equations.
- Solving differential equations using Laplace Transforms.

Course Outcomes: At the end of the course students shall be able to

CO1	The concept of rank of a matrix which is used to know the consistency of system of linear equations and also to find the eigen vectors of a given matrix
CO2	Finding maxima and minima of functions of several variables
CO3	Applications of first order ordinary differential equations
CO4	How to solve first order linear, nonlinear partial differential equations and also method of separation of variables technique to solve typical second order partial differential equations

Unit	Content	Credit	Weightage
I	Matrices Introduction, types of matrices-symmetric, skew-symmetric, Hermitian, skew-Hermitian, orthogonal, unitary matrices. Rank of a matrix - echelon form, normal form, consistency of system of linear equations (Homogeneous and Non-Homogeneous). Eigen values and Eigen vectors and their properties (without proof), Cayley-Hamilton theorem (without proof), Diagonalization.	1	25%
II	Functions of Several Variables Limit continuity, partial derivatives and total derivative. Jacobian-Functional dependence and independence. Maxima and minima and saddle points, method of Lagrange multipliers, Taylor's theorem for two variables.	1	25%
III	Ordinary Differential Equations First order ordinary differential equations: Exact, equations reducible to exact form. Applications of first order differential equations - Newton's law of cooling, law of natural growth and decay. Linear differential equations of second and higher order with constant coefficients: Non-homogeneous term of the type f(x) = eax, sinax, cosax, xn , eax V and xn V. Method of variation of parameters.	1	25%

IV	Partial Differential Equations Introduction, formation of partial differential equation by elimination of arbitrary constants and arbitrary functions, solutions of first order Lagrange's linear equation and non-linear equations, Charpit's method, Method of separation of variables for second order equations and applications of PDE to one dimensional (Heat equation).	1	25%

TEXT BOOKS:

1. Higher Engineering Mathematics by B V Ramana ., Tata McGraw Hill.
2. Higher Engineering Mathematics by B.S. Grewal, Khanna Publishers.
3. Advanced Engineering Mathematics by Kreyszig, John Wiley & Sons.

REFERENCE BOOKS:

i)Advanced Engineering Mathematics by R.K Jain & S R K Iyenger, Narosa Publishers.
ii)Advanced Engineering Mathematics by Michael Green Berg, Pearson Publishers.
iii)Engineering Mathematics by N.P Bali and Manish Goyal.

SUBJECT CODE: BTEE102

SUBJECT NAME: BASIC ELECTRICAL ENGINEERING

Course Objectives:

- To introduce fundamental concepts of electric circuits, components, and laws governing electrical systems.
- To develop skills in analysing DC and AC circuits using network theorems and phasor diagrams.
- To understand the working principles of basic electrical machines and transformers.
- To provide hands-on experience in measuring electrical parameters and validating circuit theories.

Course Outcomes: At the end of the course students shall be able to

CO1	Apply Ohm's law, Kirchhoff's laws, and network theorems to solve DC circuits.
CO2	Analyze AC circuits using phasors, impedance, and power factor concepts.
C03	Explain the construction, working, and applications of transformers and rotating machines.
C04	Perform electrical measurements and verify circuit laws in a laboratory setup.

Unit	Content	Credit	Weightage
I	**DC Circuits & Network Theorems** • **Introduction to Electrical Systems:** Voltage, current, power, energy. • **Ohm's Law & Kirchhoff's Laws:** KVL, KCL, series-parallel circuits. • **Network Theorems:** Superposition, Thevenin's, Norton's, Maximum Power Transfer. • **Electrical Measurements:** Ammeter, voltmeter, wattmeter. • **Electromagnetism:** Faraday's law, Lenz's law, self and mutual inductance.	1	25%

II	**AC Circuits Fundamentals** • **AC Fundamentals:** Sinusoidal waveforms, frequency, period, RMS, average values. • **Phasor Representation:** Rectangular and polar forms, phasor diagrams. • **Single-phase AC Circuits:** R, L, C, RL, RC, RLC series and parallel circuits. • **Power in AC Circuits:** Active, reactive, apparent power, power factor. • **Three-phase Systems:** Star and delta connections, line and phase relationships.	1	25%
III	**Transformers & Rotating Machines** • **Single-phase Transformer:** Construction, principle, EMF equation, equivalent circuit, losses, efficiency. • **Three-phase Transformer:** Connections, applications. • **DC Machines:** Construction, working principle of DC generator and motor, characteristics. • **AC Machines:** Three-phase induction motor principle, slip, torque-speed characteristics. • **Special Machines:** Introduction to stepper and servo motors.	1	25%
IV	**Electrical Installations & Safety** • **Wiring Systems:** Types of wiring, cables, earthing. • **Protective Devices:** Fuses, MCBs, ELCBs, relays. • **Illumination:** Types of lamps, lighting calculations. • **Electrical Safety:** Hazards, precautions, first aid for electric shock. • **Energy Conservation:** Power factor improvement, energy-efficient devices.	1	25%

Textbooks:

- *Basic Electrical Engineering* – D. P. Kothari & I. J. Nagrath (McGraw Hill)
- *Fundamentals of Electrical Engineering* – Leonard S. Bobrow (Oxford)
- *Electrical Technology* – B. L. Theraja & A. K. Theraja (S. Chand)

Reference books:

- *Principles of Electrical Engineering* – V. K. Mehta & Rohit Mehta
- *Engineering Circuit Analysis* – William H. Hayt, Jack E. Kemmerly & Steven M. Durbin
- *Electric Machinery Fundamentals* – Stephen J. Chapman

Online Platforms:

- NPTEL: *Basic Electrical Circuits* – IIT Kharagpur
- Coursera: *Fundamentals of Electrical Engineering* – University of Colorado Boulder

PRACTICAL LIST:

Module 1: DC Circuits

- Verification of Ohm's Law.
- Verification of Kirchhoff's Voltage and Current Laws.
- Thevenin's and Norton's theorem verification.
- Maximum Power Transfer theorem.

Module 2: AC Circuits

- Measurement of AC voltage, current, and frequency using CRO.
- Power factor measurement in R-L and R-C circuits.
- Study of series and parallel RLC resonance.
- Three-phase power measurement using two-wattmeter method.

Module 3: Machines & Transformers

- Open circuit and short circuit tests on single-phase transformer.
- Load test on DC shunt motor.
- Speed control of DC motor.
- Starting and reversing direction of three-phase induction motor.

Module 4: Safety & Installation

- Study of domestic wiring: stair case wiring, godown wiring.
- Measurement of earth resistance.
- Study of protective devices: MCB, ELCB, fuse.
- Energy audit of a laboratory/workshop.

SUBJECT CODE: BTEE103

SUBJECT NAME: ENGINEERING PHYSICS

Course Objectives:

- To provide a foundation in fundamental physics concepts relevant to electrical engineering applications.
- To understand electromagnetic theory, semiconductor physics, and materials science in electrical contexts.
- To apply physical principles to analyze and design electrical devices, circuits, and systems.
- To develop problem-solving skills through theoretical analysis and practical experimentation.

Course Outcomes: At the end of the course students shall be able to

CO1	Apply concepts of electromagnetism to analyze electric and magnetic fields in engineering systems.
CO2	Explain semiconductor physics and its relevance to electronic and electrical devices.
C03	Analyze wave optics, laser physics, and photonic devices used in optical communication and sensing.
C04	Characterize materials (dielectric, magnetic, superconducting) and their applications in electrical engineering.

Unit	Content	Credit	Weightage
I	**Electromagnetic Theory & Applications** • **Vector Analysis:** Gradient, divergence, curl, Gauss's and Stokes' theorems. • **Electrostatics:** Coulomb's law, electric field, Gauss's law, electric potential, capacitance. • **Magnetostatics:** Biot-Savart law, Ampere's law, magnetic materials, inductance. • **Maxwell's Equations:** Integral and differential forms, displacement current, electromagnetic waves. • **Applications:** Transmission lines, waveguides, antennas (basic concepts).	1	25%

II	**Semiconductor Physics & Devices** • **Band Theory of Solids:** Conductors, semiconductors, insulators, Fermi level. • **Intrinsic & Extrinsic Semiconductors:** Carrier concentration, mobility, conductivity. • **PN Junction Diode:** Formation, depletion region, forward and reverse bias, diode equation. • **Special Semiconductor Devices:** Zener diode, LED, photodiode, solar cells. • **Transistor Basics:** BJT and MOSFET structure (introduction). **Module 3: Wave Optics & Laser Physics**	1	25%
III	**Wave Optics & Laser Physics** • **Interference:** Young's double slit, thin films, Newton's rings. • **Diffraction:** Single slit, diffraction grating, resolving power. • **Polarization:** Types, Malus's law, Brewster's law. • **Lasers:** Stimulated emission, population inversion, He-Ne and semiconductor lasers. • **Applications:** Fiber optics, holography, optical sensors.	1	25%
IV	**Materials Science for Electrical Engineering** • **Dielectric Materials:** Polarization mechanisms, dielectric constant, losses, applications in capacitors. • **Magnetic Materials:** Dia-, para-, ferro-, ferri-magnetism, hysteresis, applications in transformers and motors. • **Superconductivity:** Meissner effect, Type I and II superconductors, applications in power transmission and MRI. • **Nanomaterials:** Quantum dots, carbon nanotubes, applications in sensors and electronics. • **Thermal Properties:** Thermal conductivity, expansion, thermoelectric effects.	1	25%

Textbooks:

- *Engineering Physics* – R. K. Gaur & S. L. Gupta (Dhanpat Rai Publications)
- *A Textbook of Engineering Physics* – M. N. Avadhanulu & P. G. Kshirsagar (S. Chand)
- *Fundamentals of Physics* – Halliday, Resnick & Walker (Extended for Engineers)

Reference books:

- *Electromagnetic Waves and Radiating Systems* – E. C. Jordan & K. G. Balmain
- *Principles of Electronics* – V. K. Mehta (for semiconductor sections)
- *Introduction to Solid State Physics* – Charles Kittel
- *Optics* – Ajoy Ghatak
- *Materials Science and Engineering* – William D. Callister

Online Platforms:

- NPTEL:
  - *Engineering Physics* – IIT Madras
  - *Electromagnetic Theory* – IIT Bombay

    - *Semiconductor Physics* – IIT Kanpur
- Coursera:
    - *Introduction to Electromagnetism* – Rice University
    - *Optics and Photonics* – MIT

PRACTICAL LIST:
Module 1: Electromagnetism & Measurements

- Magnetic Field Measurement using Helmholtz coil and Gauss meter.
- Verification of Biot-Savart Law for a current-carrying conductor.
- Measurement of Dielectric Constant of different materials.
- Study of Earth's Magnetic Field using tangent galvanometer.

Module 2: Semiconductor Devices & Characteristics

- V-I Characteristics of PN Junction Diode and Zener diode.
- Determination of Energy Band Gap of a semiconductor using four-probe method.
- Characteristics of Photodiode/LED and study of photoelectric effect.
- Solar Cell Characteristics: I-V curve, efficiency calculation.

Module 3: Optics & Lasers

- Determination of Wavelength using diffraction grating.
- Newton's Rings Experiment for wavelength determination.
- Verification of Malus's Law using polarizer-analyzer setup.
- Study of Laser Characteristics: Divergence, intensity profile.

Module 4: Material Properties & Applications

- Measurement of Thermal Conductivity of metals (Lee's disc method).
- Study of Hysteresis Loop for ferromagnetic materials.
- Determination of Planck's Constant using photoelectric effect.
- Demonstration of Superconductivity using high-Tc superconductor (Meissner effect demo).

SUBJECT CODE: BTEE104

SUBJECT NAME: PROGRAMING FOR ENGINNERS (PYTHON)
Course Objectives:

- To introduce Python as the primary programming language for EE.
- To develop proficiency in Python programming fundamentals, data structures, and libraries.
- To implement data manipulation, visualization, and basic analysis using Python.
- To prepare students for advanced EE topics through hands-on programming practice.

Course Outcomes: At the end of the course students shall be able to

CO1	Write, debug, and execute Python programs using core language constructs.
CO2	Use Python data structures (lists, dictionaries, sets, tuples) for efficient data handling.
C03	Perform data manipulation and analysis using NumPy and Pandas libraries.
C04	Create basic data visualizations using Matplotlib and Seaborn.

Unit	Content	Credit	Weightage
I	**Python Fundamentals** • **Introduction to Python:** History, features, installation, IDEs (Jupyter, VS Code). • **Basic Syntax:** Variables, data types, operators, input/output. • **Control Structures:** Conditional statements (if, elif, else), loops (for, while). • **Functions:** Definition, parameters, return values, lambda functions, scope. • **File Handling:** Reading/writing text and CSV files.	1	25%
II	**Data Structures in Python** • **Lists:** Creation, indexing, slicing, list comprehensions, methods. • **Tuples and Sets:** Immutable sequences, set operations. • **Dictionaries:** Key-value pairs, methods, dictionary comprehensions. • **Strings:** String methods, formatting, regular expressions (regex basics). • **Error Handling:** Try-except blocks, custom exceptions.	1	25%
III	**Data Manipulation with NumPy and Pandas** • **NumPy:** Arrays creation, array operations, broadcasting, mathematical functions. • **Pandas Series and Data Frames:** Creation, indexing, data selection, filtering. • **Data Cleaning:** Handling missing values, duplicates, data transformation. • **Data Aggregation:** Group By operations, pivot tables, merging/joining datasets.	1	25%
IV	**Data Visualization and Basic Analysis** • **Matplotlib:** Line plots, bar charts, scatter plots, histograms, customization. • **Seaborn:** Statistical visualizations, heatmaps, pair plots, styling. • **Exploratory Data Analysis (EDA):** Descriptive statistics, correlation, outlier detection. • **Mini-Project:** End-to-end analysis of a real-world dataset.	1	25%

Textbooks:

- Python for Data Analysis by Wes McKinney (O'Reilly)
- Python Crash Course by Eric Matthes (No Starch Press)
- Data Science from Scratch by Joel Grus (O'Reilly)

Reference books:

- Fluent Python by Luciano Ramalho (O'Reilly)
- Python Data Science Handbook by Jake VanderPlas (O'Reilly)
- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow by Aurélien Géron

Online Platforms:

- Python Official Documentation: docs.python.org
- Kaggle Learn: Python and Pandas courses
- Coursera: "Python for Everybody" by University of Michigan
- Real Python: Tutorials and articles
- Stack Overflow: Q/A for programming issues

PRACTICAL LIST:

Module 1 Practical's:

- Lab 1: Python environment setup, basic I/O, and arithmetic operations.
- Lab 2: Control structures: Create a number guessing game.
- Lab 3: Functions: Write reusable code for factorial, Fibonacci, and prime checks.
- Lab 4: File handling: Read/write CSV, log file processing.

Module 2 Practical's:

- Lab 5: List operations: Sorting, searching, list comprehensions.
- Lab 6: Dictionary and set manipulations: Word frequency counter.
- Lab 7: String processing and regex: Email/phone number validation.
- Lab 8: Error handling: Robust input validation and file reading.

Module 3 Practical's:

- Lab 9: NumPy arrays: Matrix operations, statistical calculations.
- Lab 10: Pandas Data Frame: Data loading, filtering, and basic analysis.
- Lab 11: Data cleaning: Handling missing data, outliers, duplicates.
- Lab 12: Data aggregation: Group By and merging datasets.

Module 4 Practical's:

- Lab 13: Matplotlib: Create multiple plot types with customization.
- Lab 14: Seaborn: Advanced visualizations for categorical/numerical data.
- Lab 15: EDA on a dataset: Summary stats, correlation, visual insights.
- Lab 16: Mini-Project: Analyze a dataset (e.g., Titanic, Iris) and present findings.

SEMESTER-II

SUBJECT CODE: BTEE201

SUBJECT NAME: ENGINEERING MATHEMATICS-II

Course Objectives:

- To provide a strong mathematical foundation in differential equations, transforms, and complex variables essential for electrical engineering analysis.
- To develop problem-solving skills for circuit analysis, signal processing, and control systems using advanced mathematical techniques.
- To apply Laplace and Fourier transforms in the modeling and analysis of electrical systems.
- To introduce numerical methods for solving engineering problems computationally.

Course Outcomes: At the end of the course students shall be able to

CO1	Solve ordinary and partial differential equations applicable to electrical circuits and systems.
CO2	Apply complex analysis and Fourier transforms to analyze AC circuits and signals.
C03	Utilize Laplace transforms to solve differential equations and analyze system stability.
C04	Implement numerical methods to approximate solutions for electrical engineering problems.

Unit	Content	Credit	Weightage
I	**Differential Equations & Applications** • **First-Order ODEs:** Linear, exact, Bernoulli's equations. • **Higher-Order Linear ODEs:** Homogeneous and non-homogeneous equations with constant coefficients. • **Methods of Solution:** Variation of parameters, undetermined coefficients. • **Applications in EE:** RL, RC, RLC circuits; harmonic oscillators; mechanical-electrical analogs. • **Partial Differential Equations:** Wave and heat equations (basic concepts).	1	25%
II	**Complex Variables & Fourier Analysis** • **Complex Numbers & Functions:** Analytic functions, Cauchy-Riemann equations. • **Complex Integration:** Cauchy's theorem, residue theorem, evaluation of integrals. • **Fourier Series:** Representation of periodic signals, Dirichlet's conditions. • **Fourier Transform:** Definition, properties, convolution theorem. • **Applications:** Signal analysis, filter design, modulation, AC circuit analysis.	1	25%

III	**Laplace Transforms & System Analysis** • **Laplace Transform:** Definition, properties, transforms of elementary functions. • **Inverse Laplace Transform:** Partial fraction expansion, convolution method. • **Solution of ODEs & Systems:** Using Laplace transforms. • **Transfer Functions:** Poles and zeros, stability analysis (Routh-Hurwitz). • **Applications:** Circuit analysis, control systems, communication systems.	1	25%
IV	**Numerical Methods for Engineers** • **Root Finding:** Bisection method, Newton-Raphson method. • **Interpolation & Curve Fitting:** Lagrange interpolation, least squares method. • **Numerical Integration:** Trapezoidal rule, Simpson's rule. • **Numerical Solutions of ODEs:** Euler's method, Runge-Kutta methods (2nd & 4th order). • **Applications:** Solving circuit equations, signal approximation, system simulation.	1	25%

Textbooks:

- *Advanced Engineering Mathematics* – Erwin Kreyszig (Wiley)
- *Higher Engineering Mathematics* – B. S. Grewal (Khanna Publishers)
- *Engineering Mathematics – Vol. II* – H. K. Dass (S. Chand)

Reference books:

- *A Course in Engineering Mathematics (Vol. II)* – N. P. Bali & Manish Goyal
- *Complex Variables and Applications* – James Ward Brown & Ruel V. Churchill
- *Numerical Methods for Engineers* – Steven C. Chapra & Raymond P. Canale
- *Signals and Systems* – Alan V. Oppenheim (for transform applications)

Online Platforms:

- NPTEL:
  - *Engineering Mathematics – II* – IIT Kharagpur
  - *Complex Analysis* – IIT Madras
  - *Laplace Transforms* – IIT Bombay
- Coursera:
  - *Differential Equations for Engineers* – University of Hong Kong
  - *Introduction to Numerical Methods* – University of Michigan

SUBJECT CODE: BTEE202

SUBJECT NAME: ELECTRICAL CIRCUITS

Course Objectives:

- To provide a fundamental understanding of electric circuit theory, components, and analysis techniques.
- To analyse DC and AC circuits using network theorems, phasor diagrams, and frequency domain methods.
- To understand transient and steady-state behaviour of RLC circuits under various excitations.
- To develop skills in designing, simulating, and testing electrical circuits using software and laboratory equipment.

Course Outcomes: At the end of the course students shall be able to

CO1	Apply network theorems to analyze linear DC and AC circuits.
CO2	Analyze transient and steady-state responses of first and second-order circuits.
C03	Use phasor analysis and frequency domain techniques for AC circuit analysis.
C04	Design, simulate, and test electrical circuits in laboratory and virtual environments.

Unit	Content	Credit	Weightage
I	**Basic Circuit Concepts & DC Analysis** • **Circuit Elements:** R, L, C, independent and dependent sources. • **Network Topology:** Nodes, branches, loops, Kirchhoff's laws. • **Network Theorems:** Superposition, Thevenin's, Norton's, Maximum Power Transfer, Reciprocity. • **Mesh & Nodal Analysis:** For DC circuits with multiple sources. • **Power Calculations:** Power in resistive networks, energy concepts.	1	25%
II	**AC Circuit Analysis & Phasors** • **AC Fundamentals:** Sinusoidal waveforms, RMS, average values, form factor. • **Phasor Representation:** Complex numbers, impedance, admittance. • **Single-phase AC Circuits:** Series and parallel RLC circuits, resonance. • **Power in AC Circuits:** Real, reactive, apparent power, power factor, power triangle. • **Three-phase Circuits:** Balanced star and delta connections, power measurement.	1	25%
III	**Transient Analysis & Frequency Response** • **First-order Circuits:** RC and RL circuits, step and impulse response. • **Second-order Circuits:** Series and parallel RLC circuits, damping conditions. • **Laplace Transform in Circuit Analysis:** S-domain impedance, network functions. • **Frequency Response:** Bode plots, bandwidth, quality factor. • **Introduction to Filters:** Low-pass, high-pass, band-pass, band-stop concepts.	1	25%
IV	**Two-port Networks & Network Synthesis** • **Two-port Parameters:** Z, Y, h, ABCD parameters, inter-relationships. • **Interconnection of Two-ports:** Series, parallel, cascade connections.	1	25%

	• **Image Parameters:** Characteristic impedance, propagation constant. • **Network Synthesis:** Driving point impedance, Foster and Cauer forms. • **Introduction to Network Graphs:** Incidence matrix, tie-set, cut-set matrices.		

Textbooks:

- *Electric Circuits* – James W. Nilsson & Susan Riedel (Pearson)
- *Network Analysis* – M. E. Van Valkenburg (Prentice Hall)
- *Fundamentals of Electric Circuits* – Charles K. Alexander & Matthew N. O. Sadiku (McGraw Hill)

Reference books:

- *Engineering Circuit Analysis* – William H. Hayt, Jack E. Kemmerly & Steven M. Durbin
- *Circuit Theory (Analysis and Synthesis)* – A. Chakrabarti
- *Linear Networks and Systems* – B. D. O. Anderson & R. W. Newcomb
- *Network Theory: Analysis and Synthesis* – S. P. Ghosh & A. K. Chakraborty

Online Platforms:

- NPTEL:
  - *Circuit Theory* – IIT Madras
  - *Network Analysis* – IIT Kharagpur
- Coursera:
  - *Linear Circuits* – Georgia Institute of Technology
  - *Fundamentals of Electrical Engineering* – Rice University

Practical List:

Module 1: DC Circuit Analysis

- Verification of Kirchhoff's Voltage and Current Laws in a resistive network.
- Verification of Thevenin's and Norton's Theorems.
- Maximum Power Transfer Theorem verification.
- Superposition Theorem verification with multiple sources.

Module 2: AC Circuit Analysis

- Study of R, L, C in AC circuits and measurement of impedance.
- Power and Power Factor Measurement in single-phase AC circuits.
- Series and Parallel Resonance in RLC circuits.
- Three-phase Power Measurement using two-wattmeter method.

Module 3: Transient & Frequency Response

- Transient Response of RC Circuit (charging and discharging).
- Transient Response of RL Circuit with step input.
- Frequency Response of RC Low-pass and High-pass Filters.
- Study of Second-order RLC Circuit step response and damping.

Module 4: Network Parameters & Synthesis

- Determination of Z and Y Parameters for a two-port network.
- Determination of ABCD Parameters for a two-port network.
- Cascade Connection of Two-port Networks.
- Design and Testing of a Passive Filter (e.g., Chebyshev/Butterworth filter).

SUBJECT CODE: BTEE203

SUBJECT NAME: ELECTRONIC DEVICES

Course Objectives:

- To introduce fundamental principles of semiconductor physics and electronic devices.
- To analyze the operation, characteristics, and applications of diodes, transistors, and other semiconductor devices.
- To understand the behavior and modeling of electronic devices in circuits.
- To provide hands-on experience in testing and characterizing electronic devices in laboratory settings.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the working principles of semiconductor devices such as diodes, BJTs, and MOSFETs.
CO2	Analyze and model diode and transistor circuits for basic amplifier and switching applications.
C03	Characterize operational amplifiers and understand their linear and non-linear applications.
C04	Design, test, and troubleshoot basic electronic circuits in a laboratory environment.

Unit	Content	Credit	Weightage
I	**Semiconductor Fundamentals & Diodes** • **Semiconductor Basics:** Energy bands, intrinsic and extrinsic semiconductors, carrier transport. • **PN Junction Diode:** Formation, built-in potential, forward and reverse bias, I-V characteristics. • **Diode Models:** Ideal diode, piecewise linear, small-signal model. • **Diode Applications:** Rectifiers (half-wave, full-wave), clippers, clampers. • **Special Diodes:** Zener diode, LED, photodiode, varactor diode.	1	25%
II	**Bipolar Junction Transistors (BJTs)** • **BJT Construction & Operation:** NPN and PNP transistors, current components. • **BJT Configurations:** Common emitter, common base, common collector. • **Biasing & Stabilization:** Fixed bias, voltage divider bias, thermal runaway. • **Small-Signal Analysis:** Hybrid model, h-parameters, CE amplifier analysis. • **Frequency Response:** Low and high-frequency response of CE amplifier.	1	25%
III	**Field Effect Transistors (FETs)** • **JFET & MOSFET Structure:** N-channel and P-channel, enhancement and depletion modes. • **FET Characteristics:** Drain and transfer characteristics. • **Biasing of FETs:** Fixed bias, self-bias, voltage divider	1	25%

	bias. • **FET Amplifiers:** Common source amplifier, small-signal model. • **MOSFET Applications:** Switching, CMOS basics.		
IV	**Operational Amplifiers & Applications** • **Op-Amp Basics:** Ideal vs practical op-amp, open-loop and closed-loop configurations. • **Linear Applications:** Inverting and non-inverting amplifiers, summing amplifier, integrator, differentiator. • **Non-Linear Applications:** Comparator, zero-crossing detector, Schmitt trigger. • **Oscillators:** RC phase shift, Wien bridge oscillators using op-amps. • **Introduction to Power Amplifiers:** Class A, B, AB amplifiers.	1	25%

Textbooks:

- *Electronic Devices and Circuit Theory* – Robert L. Boylestad & Louis Nashelsky (Pearson)
- *Microelectronic Circuits* – Adel S. Sedra & Kenneth C. Smith (Oxford University Press)
- *Electronic Principles* – Albert Paul Malvino & David J. Bates (McGraw Hill)

Reference books:

- *Fundamentals of Microelectronics* – Behzad Razavi (Wiley)
- *Electronic Devices: Conventional Current Version* – Thomas L. Floyd (Pearson)
- *Solid State Electronic Devices* – Ben G. Streetman & Sanjay Banerjee (Pearson)
- *Op-Amps and Linear Integrated Circuits* – Ramakant A. Gayakwad (Pearson)

Online Platforms:

- NPTEL:
  - *Electronic Devices and Circuits* – IIT Madras
  - *Analog Circuits* – IIT Roorkee
- Coursera:
  - *Introduction to Electronics* – Georgia Institute of Technology
  - *Semiconductor Devices* – University of Colorado Boulder

Practical List:

Module 1: Diodes & Applications

- V-I Characteristics of PN Junction Diode and determination of static and dynamic resistance.
- Half-wave and Full-wave Rectifier with and without filter capacitors.
- Clipper Circuits (positive, negative, and biased clippers).
- Zener Diode as Voltage Regulator and load regulation study.

Module 2: Bipolar Junction Transistors

- Input and Output Characteristics of BJT in CE configuration.
- Voltage Divider Bias Circuit for BJT and stability factor calculation.
- Single-stage CE Amplifier – gain and frequency response measurement.
- Emitter Follower (CC Amplifier) – input and output impedance measurement.

Module 3: Field Effect Transistors

- Drain and Transfer Characteristics of JFET/MOSFET.
- Common Source JFET Amplifier – gain and bandwidth measurement.

- MOSFET as a Switch – driving LED or relay.
- Study of CMOS Inverter – voltage transfer characteristics.

Module 4: Operational Amplifiers

- Inverting and Non-inverting Amplifiers using op-amp (741/LM358).
- Op-amp as Integrator and Differentiator.
- Op-amp Comparator and Schmitt Trigger circuits.
- RC Phase Shift Oscillator using op-amp.

SUBJECT CODE: BTEE204

SUBJECT NAME: ENGINEERING CHEMISTRY

Course Objectives:

- To provide foundational knowledge of chemistry relevant to electronics and communication engineering.
- To understand the principles of electrochemistry, corrosion, and materials science.
- To study the chemistry of semiconductors, nanomaterials, and polymers used in electronic devices.
- To develop skills in analysing chemical processes and materials for ECE applications.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain electrochemical principles and their applications in batteries and sensors.
CO2	Analyze corrosion mechanisms and methods of corrosion protection.
C03	Understand semiconductor materials, doping, and nanotechnology for electronics.
C04	Evaluate the properties and applications of polymers, composites, and green materials in ECE.

Unit	Content	Credit	Weightage
I	**Electrochemistry & Battery Technology** • **Electrochemical Cells:** Galvanic and electrolytic cells, electrode potentials, Nernst equation. • **Batteries:** Primary (Zn-C, alkaline), secondary (Lead-acid, Li-ion, Ni-Cd, Ni-MH). • **Fuel Cells:** Types, working principles, applications. • **Supercapacitors:** Principles and applications in electronics. • **Applications:** Energy storage for portable electronics, IoT devices, and EVs.	1	25%
II	**Corrosion & Protection Methods** • **Corrosion Principles:** Types (dry, wet, galvanic, pitting, crevice), mechanisms. • **Electrochemical Theory of Corrosion:** Oxidation-reduction reactions, Pourbaix diagrams. • **Corrosion Control:** Cathodic and anodic protection, coatings, inhibitors. • **Materials Selection for ECE:** Corrosion-resistant alloys, coatings for PCBs and connectors. • **Case Studies:** Corrosion in electronic packaging, solder joints, and connectors.	1	25%

III	**Semiconductor Materials & Nanotechnology** • **Semiconductor Chemistry:** Band theory, intrinsic and extrinsic semiconductors. • **Doping:** n-type and p-type semiconductors, diffusion, ion implantation. • **Nanomaterials:** Synthesis methods (top-down, bottom-up), properties. • **Quantum Dots & Nanowires:** Applications in LEDs, sensors, and photovoltaics. • **Carbon Nanotubes & Graphene:** Structure, properties, and electronic applications.	1	25%
IV	**Polymers, Composites & Green Materials** • **Polymer Chemistry:** Classification, polymerization mechanisms, conducting polymers. • **Electronic Applications:** Polymers in PCBs, encapsulants, adhesives, flexible electronics. • **Composites:** Types, properties, and applications in ECE (thermal management, EMI shielding). • **Green Chemistry & Sustainable Materials:** Biodegradable polymers, e-waste management. • **Analytical Techniques:** Introduction to spectroscopy (IR, UV-Vis) and microscopy (SEM, TEM) for material characterization.	1	25%

Textbooks:

- Engineering Chemistry – Jain & Jain
- Engineering Chemistry – Shikha Agarwal
- A Textbook of Engineering Chemistry – S. S. Dara & S. S. Umare

Reference books:

- Principles of Electronic Materials and Devices – S. O. Kasap
- Corrosion Engineering – Mars G. Fontana
- Nanotechnology: Principles and Practices – Sulabha K. Kulkarni
- Polymer Science and Technology – Joel R. Fried
- Green Chemistry: Theory and Practice – Paul T. Anastas & John C. Warner

Online Platforms:

- NPTEL:
  - *Engineering Chemistry* – IIT Madras
  - *Corrosion Science* – IIT Bombay
  - *Nanotechnology* – IIT Roorkee
- Coursera:
  - *Introduction to Chemistry: Structures and Solutions* – Duke University
  - *Nanotechnology and Nano sensors* – Technion – Israel Institute of Technology

SEMESTER-III

SUBJECT CODE: BTEE301

SUBJECT NAME: ELECTROMAGNETIC THEORY

Course Objectives:

- To understand the fundamental principles of electromagnetism and their mathematical formulation.
- To analyse electrostatic and magnetostatic fields, boundary conditions, and field mapping.
- To study Maxwell's equations and their application to wave propagation in different media.
- To introduce transmission lines, waveguides, and antennas as practical applications of electromagnetic theory in communication systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Apply vector calculus to analyze electrostatic and magnetostatic fields.
CO2	Solve boundary value problems using Laplace's and Poisson's equations.
C03	Derive and interpret Maxwell's equations in differential and integral forms.
C04	Analyze wave propagation, transmission lines, and basic antenna principles.

Unit	Content	Credit	Weightage
I	**Vector Analysis & Electrostatics** • **Vector Algebra:** Dot, cross products, gradient, divergence, curl. • **Coordinate Systems:** Cartesian, cylindrical, spherical transformations. • **Coulomb's Law & Electric Field:** Field due to point charges, line, surface, and volume distributions. • **Gauss's Law:** Applications, electric flux density. • **Electric Potential:** Potential difference, energy, capacitance, Laplace's and Poisson's equations.	1	25%
II	**Magnetostatics & Magnetic Materials** • **Biot-Savart Law:** Magnetic field due to current elements. • **Ampere's Circuital Law:** Applications to solenoids, toroids. • **Magnetic Flux Density & Vector Potential.** • **Magnetic Materials:** Permeability, magnetization, boundary conditions. • **Inductance:** Self and mutual inductance, magnetic energy.	1	25%
III	**Maxwell's Equations & Time-Varying Fields** • **Faraday's Law:** Transformer and motional EMF, Lenz's law. • **Displacement Current:** Modification of Ampere's law.	1	25%

	• **Maxwell's Equations:** Integral and differential forms, physical interpretation. • **Boundary Conditions:** Dielectric-dielectric, dielectric-conductor interfaces. • **Poynting Theorem:** Power flow, energy conservation.		
IV	**Electromagnetic Waves & Applications** • **Wave Equation:** Derivation from Maxwell's equations, plane wave solution. • **Wave Propagation:** In lossless and lossy media, skin depth, polarization. • **Transmission Lines:** Telegrapher's equations, characteristic impedance, VSWR, Smith chart basics. • **Waveguides:** Rectangular waveguide modes, cut-off frequency. • **Antenna Basics:** Radiation mechanism, Hertzian dipole, antenna parameters.	1	25%

Textbooks:
- Engineering Electromagnetics – William H. Hayt & John A. Buck
- Electromagnetic Waves and Radiating Systems – Edward C. Jordan & Keith G. Balmain
- Elements of Electromagnetics – Matthew N. O. Sadiku

Reference books:
- Classical Electrodynamics – John David Jackson
- Introduction to Electrodynamics – David J. Griffiths
- Antenna Theory: Analysis and Design – Constantine A. Balanis
- Fields and Waves in Communication Electronics – Simon Ramo, John R. Whinnery, & Theodore Van Duzer

Online Platforms:
- NPTEL:
  - *Electromagnetic Theory* – IIT Kharagpur (Prof. K. B. G. Sharma)
  - *Electromagnetic Fields* – IIT Bombay
  - *Antenna and Wave Propagation* – IIT Roorkee
- Coursera:
  - *Electrodynamics: Electric and Magnetic Fields* – Korea Advanced Institute of Science and Technology (KAIST)
  - *Antenna Basics* – University of Colorado Boulder

SUBJECT CODE: BTEE302

SUBJECT NAME: SIGNALS AND SYSTEMS

Course Objectives:
- To introduce fundamental concepts of continuous-time and discrete-time signals and systems.
- To develop skills in analysing signals and systems using time-domain and frequency-domain techniques.
- To apply Fourier, Laplace, and Z-transforms for system analysis and design.
- To understand the relationship between continuous-time and discrete-time systems and their applications in communication and signal processing.

Course Outcomes: At the end of the course students shall be able to

CO1	Classify signals and systems and analyze their properties in

	time and frequency domains.
CO2	Apply Fourier series and Fourier transform to analyze periodic and aperiodic signals.
C03	Utilize Laplace and Z-transforms to solve differential/difference equations and analyze system stability.
C04	Understand sampling, reconstruction, and the relationship between continuous and discrete systems.

Unit	Content	Credit	Weightage
I	**Introduction to Signals and Systems** • **Signals:** Continuous-time (CT) and discrete-time (DT) signals, classifications (deterministic/random, periodic/aperiodic, energy/power). • **Basic Operations:** Time shifting, scaling, reversal, even and odd signals. • **Systems:** Properties (linearity, time-invariance, causality, stability, memory, invertibility). • **Elementary Signals:** Unit step, unit impulse, ramp, exponential, sinusoidal. • **Convolution:** CT and DT convolution, properties, system response via convolution.	1	25%
II	**Fourier Analysis of Signals** • **Fourier Series (FS):** Trigonometric and exponential forms, Dirichlet conditions, properties. • **Fourier Transform (FT):** Definition, properties (linearity, time-shift, scaling, duality, convolution). • **Frequency Response:** Magnitude and phase spectra. • **Parseval's Theorem:** Energy and power spectral density. • **Applications:** Filtering, modulation, spectral analysis.	1	25%
III	**Laplace Transform and System Analysis** • **Laplace Transform (LT):** Definition, region of convergence (ROC), properties. • **Inverse Laplace Transform:** Partial fraction expansion. • **System Representation:** Transfer function, poles and zeros. • **Stability Analysis:** BIBO stability, Routh-Hurwitz criterion. • **Applications:** Circuit analysis, control systems, solving differential equations.	1	25%
IV	**Z-Transform and Discrete-Time Systems** • **Z-Transform:** Definition, ROC, properties, inverse Z-transform. • **DT Systems:** Difference equations, system function, frequency response. • **Sampling Theorem:** Nyquist rate, aliasing, reconstruction.	1	25%

	• **Discrete Fourier Transform (DFT):** Introduction and basic properties. • **Applications:** Digital filters, DT signal processing, introduction to DSP.		

Textbooks:

- Signals and Systems – Alan V. Oppenheim, Alan S. Willsky, & S. Hamid Nawab
- Signals and Systems – Simon Haykin & Barry Van Veen
- Signals, Systems and Communications – B. P. Lathi

Reference books:

- Linear Systems and Signals – B. P. Lathi
- Fundamentals of Signals and Systems – Michael J. Roberts
- Signal Processing and Linear Systems – B. P. Lathi
- Digital Signal Processing: Principles, Algorithms, and Applications – John G. Proakis & Dimitris G. Manolakis

Online Platforms:

- NPTEL:
    - *Signals and Systems* – IIT Bombay (Prof. S. C. Dutta Roy)
    - *Principles of Signals and Systems* – IIT Kharagpur
- Coursera:
    - *Digital Signal Processing* – École Polytechnique Fédérale de Lausanne (EPFL)
    - *Signals and Systems* – Rice University

SUBJECT CODE: BTEE303

SUBJECT NAME: ELECTRICAL MACHINES-I

Course Objectives:

- To introduce the fundamental principles, construction, and operation of basic electrical machines.
- To analyze the performance characteristics of DC machines, transformers, and single-phase AC machines.
- To understand the principles of electromechanical energy conversion in rotating and static machines.
- To develop skills in testing, analyzing, and evaluating the performance of electrical machines through laboratory experiments.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the construction, working principles, and types of DC machines and transformers.
CO2	Analyze the performance characteristics of DC generators and motors under various operating conditions.
C03	Evaluate transformer performance through equivalent circuits, efficiency, and voltage regulation.
C04	Conduct standard tests on DC machines and transformers and interpret experimental results.

Unit	Content	Credit	Weightage
I	**Principles of Electromechanical Energy Conversion** • **Introduction to Electrical Machines:** Classification, applications, basic laws. • **Magnetic Circuits:** Flux, mmf, reluctance, BH	1	25%

	curve, magnetic materials. • **Electromechanical Energy Conversion:** Force/torque production in magnetic fields. • **AC and DC Windings:** Lap and wave windings, EMF equation, winding factors. • **Losses in Electrical Machines:** Copper loss, core loss, friction & windage losses.		
II	**DC Machines** • **Construction:** Stator, rotor, field and armature windings, commutator, brushes. • **DC Generators:** Types (shunt, series, compound), EMF equation, characteristics (open circuit, load). • **DC Motors:** Types, torque equation, speed-torque characteristics. • **Starting and Speed Control:** Starters (3-point, 4-point), armature and field control methods. • **Testing of DC Machines:** Brake test, Swinburne's test, Hopkinson's test.	1	25%
III	**Transformers** • **Construction:** Core and shell type, winding arrangements, cooling methods. • **Transformer Principles:** EMF equation, ideal transformer, actual transformer. • **Equivalent Circuit:** Referred parameters, phasor diagrams. • **Performance:** Efficiency, all-day efficiency, voltage regulation. • **Testing:** Open circuit and short circuit tests, Sumpner's test, polarity test.	1	25%
IV	**Special Transformers & Single-Phase AC Machines** • **Autotransformers:** Construction, advantages, applications. • **Instrument Transformers:** Current transformer (CT), potential transformer (PT). • **Three-Phase Transformers:** Connections (star-star, delta-delta, star-delta), phase groups. • **Single-Phase Motors:** Split-phase, capacitor-start, capacitor-run, shaded-pole motors. • **Applications:** Selection of machines for domestic and industrial use.	1	25%

Textbooks:

- *Electrical Machines* – D. P. Kothari & I. J. Nagrath (McGraw Hill)
- *Electrical Machinery* – P. S. Bimbhra (Khanna Publishers)
- *Theory and Performance of Electrical Machines* – J. B. Gupta (S. K. Kataria & Sons)

Reference books:

- *Electric Machinery Fundamentals* – Stephen J. Chapman (McGraw Hill)
- *Principles of Electrical Machines* – V. K. Mehta & Rohit Mehta (S. Chand)
- *Electrical Machines* – Ashfaq Hussain (Dhanpat Rai & Co.)
- *Transformers and Induction Motors* – M. V. Deshpande (PHI Learning)

Online Platforms:

- NPTEL:
  - *Electrical Machines – I* – IIT Kharagpur
  - *DC Machines and Transformers* – IIT Madras
- Coursera:
  - *Electric Machines* – University of Colorado Boulder
  - *Power Electronics and Motors* – University of Colorado Boulder

Practical List:

- Study of Magnetic Circuit and determination of BH curve.
- Constructional Study of DC Machine: Identification of parts and winding diagram.
- EMF Generation in DC Generator: Measurement of generated EMF vs. speed.
- Demonstration of Lap and Wave Windings on a DC machine armature.
- Open Circuit Characteristic (OCC) of DC Shunt Generator.
- Load Characteristics of DC Shunt and Compound Generators.
- External Characteristic of DC Series Generator.
- Hopkinson's Test on two identical DC machines.
- Speed-Torque Characteristics of DC Shunt Motor.
- Speed Control of DC Shunt Motor by armature and field control methods.
- Brake Test on DC Shunt Motor for efficiency determination.
- Study of DC Motor Starters (3-point and 4-point starters).
- Open Circuit and Short Circuit Tests on Single-Phase Transformer to find parameters.
- Load Test on Single-Phase Transformer – efficiency and regulation.
- Polarity Test and Parallel Operation of Single-Phase Transformers.
- Sumpner's Test on two identical single-phase transformers.

SUBJECT CODE: BTEE304

SUBJECT NAME: DATA STRUCTURES

Course Objectives:

- To introduce fundamental data structures and algorithms essential for efficient problem-solving in computing and embedded systems.
- To develop skills in designing, implementing, and analysing algorithms for real-world engineering applications.
- To understand time and space complexity analysis using asymptotic notations.
- To prepare students for software development roles in embedded systems, IoT, and communication systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze algorithm efficiency using asymptotic notations and select appropriate data structures for given problems.
CO2	Implement and utilize linear data structures (arrays, linked lists, stacks, queues) for data processing tasks.
C03	Design and apply non-linear data structures (trees, graphs, hash tables) for efficient data storage and retrieval.
C04	Solve real-world engineering problems using algorithmic paradigms

	(searching, sorting, greedy, dynamic programming).

Unit	Content	Credit	Weightage
I	**Algorithm Analysis & Linear Data Structures** • **Algorithm Analysis:** Asymptotic notations (Big-O, Omega, Theta), time-space trade-offs. • **Arrays & Lists:** Static vs dynamic arrays, Python lists, memory allocation. • **Linked Lists:** Singly, doubly, circular linked lists; insertion, deletion, traversal. • **Stacks & Queues:** LIFO/FIFO principles, implementations, applications (parsing, scheduling). • **Python Collections:** Built-in data structures (list, tuple, set, dict) and their complexities.	1	25%
II	**Trees & Hierarchical Data Structures** • **Trees:** Terminology, binary trees, traversals (in-order, pre-order, post-order). • **Binary Search Trees (BST):** Insertion, deletion, searching, balanced BST concepts. • **Heaps:** Min-heap, max-heap, heap operations, priority queues. • **Tries:** Structure, applications in autocomplete and dictionary implementations. • **Tree Applications:** Hierarchical clustering, decision trees (ML context), file systems.	1	25%
III	**Graphs & Hashing** • **Graphs:** Terminology, representations (adjacency list/matrix), BFS, DFS. • **Graph Algorithms:** Shortest path (Dijkstra), minimum spanning tree (Prim, Kruskal). • **Hashing:** Hash functions, collision resolution (chaining, open addressing), load factor. • **Hash Tables:** Python dictionaries, sets, applications in data indexing and de-duplication. • **Graph Applications:** Social network analysis, recommendation systems, pathfinding.	1	25%
IV	**Algorithmic Paradigms & Optimization** • **Searching Algorithms:** Linear search, binary search, interpolation search. • **Sorting Algorithms:** Bubble, selection, insertion, merge, quick, heap sorts. • **Greedy Algorithms:** Activity selection, Huffman coding, coin change problem. • **Dynamic Programming:** Fibonacci, knapsack, longest common subsequence. • **Algorithmic Thinking for ECE:** Space-time trade-offs in embedded systems, real-time constraints.	1	25%

Textbooks:

- Data Structures and Algorithms in Python – Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser

- Introduction to Algorithms – Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein
- Problem Solving with Algorithms and Data Structures Using Python – Brad Miller & David Ranum

Reference books:

- The Algorithm Design Manual – Steven S. Skiena
- Algorithms – Robert Sedgewick & Kevin Wayne
- Cracking the Coding Interview – Gayle Laakmann McDowell
- Python Algorithms – Magnus Lie Hetland

Online Platforms:

- Leet Code – Coding practice and interview preparation
- Hacker Rank – Algorithms and data structures challenges
- Geeks for Geeks – Tutorials and examples
- Visualgo – Algorithm visualizations
- NPTEL: *Data Structures and Algorithms* – IIT Delhi
- Coursera: *Algorithms Specialization* – Stanford University

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Algorithm complexity analysis using Python's timeit module.
- Lab 2: Implementation of linked lists and operations (insert, delete, reverse).
- Lab 3: Stack applications – expression evaluation, parenthesis matching.
- Lab 4: Queue simulation – task scheduling using circular queue.

Module 2 Practicals

- Lab 5: Binary Search Tree implementation and traversal.
- Lab 6: Heap implementation and priority queue for task prioritization.
- Lab 7: Trie implementation for autocomplete system.
- Lab 8: Application of trees in hierarchical data (JSON/XML parsing).

Module 3 Practicals

- Lab 9: Graph representation and BFS/DFS traversal.
- Lab 10: Shortest path algorithm (Dijkstra) implementation.
- Lab 11: Hash table implementation with collision handling.
- Lab 12: Graph analysis on social network data (using NetworkX).

Module 4 Practicals

- Lab 13: Sorting algorithm comparison and performance analysis.
- Lab 14: Greedy algorithm – activity selection problem.
- Lab 15: Dynamic programming – knapsack problem.
- Lab 16: Mini-project – Building a sensor data processing system using efficient data structures.

SUBJECT CODE: BTEE305

SUBJECT NAME: WORKSHOP PRACTICE

Course Objectives:

- To introduce basic workshop tools, equipment, and safety practices for electrical and mechanical fabrication.
- To develop hands-on skills in electrical wiring, soldering, assembly, and basic mechanical operations.
- To familiarize students with common electrical components, materials, and their applications in practical setups.
- To enable students to design, fabricate, and test simple electrical and electronic assemblies.

Course Outcomes: At the end of the course students shall be able to

CO1	Identify and use common workshop tools, equipment, and measuring instruments safely.
CO2	Perform electrical wiring, soldering, and assembly of basic electrical circuits.
C03	Fabricate simple mechanical components using basic machining and joining techniques.
C04	Assemble, test, and troubleshoot basic electrical and electronic assemblies.

Practical List

Module 1: Workshop Safety & Basic Tools

- Introduction to Workshop Safety: Personal protective equipment (PPE), safety signs, handling tools and machines.
- Identification and Use of Hand Tools: Screwdrivers, pliers, wrenches, hammers, hacksaws, files.
- Measurement Tools: Vernier caliper, micrometer, multimeter, clamp meter.
- Study of Electrical Symbols and Wiring Diagrams.

Module 2: Electrical Wiring & Soldering

- Domestic Wiring Practices: Single-way, two-way switch wiring, godown wiring.
- Soldering Practice: Through-hole and surface mount soldering, desoldering techniques.
- Crimping and Termination: Wire crimping, terminal lugs, cable gland fitting.
- Assembly of a Distribution Board (DB) with MCB, ELCB, and indicator lamps.

Module 3: Mechanical Fabrication & Machining

- Sheet Metal Work: Cutting, bending, and joining (riveting, pop riveting).
- Drilling and Tapping: Use of drilling machine, tapping threads in metal plates.
- Pipe Threading and Bending for conduit installation.
- Fabrication of a Small Chassis/Enclosure for electrical panels.

Module 4: Electrical Assembly & Testing

- Assembly of a Simple Power Supply Unit (transformer, rectifier, filter, regulator).
- Testing of Electrical Components: Resistors, capacitors, inductors, fuses, relays.
- Building and Testing a Relay-based Control Circuit (e.g., motor start/stop).
- Final Project: Design and assembly of a small electrical control panel for a given application (e.g., lighting control, fan regulator).

SEMESTER-IV

SUBJECT CODE: BTEE401

SUBJECT NAME: POWER SYSTEMS-I

Course Objectives:

- To introduce the fundamental concepts, components, and structure of electrical power systems.
- To analyze the performance of transmission lines under different operating conditions.
- To understand the principles of power system modeling, per-unit systems, and fault analysis.
- To develop skills in load flow analysis and voltage regulation in power networks.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the structure, components, and configurations of electrical power systems.
CO2	Model and analyze transmission line parameters and performance.
C03	Perform per-unit system calculations and symmetrical fault analysis.
C04	Apply load flow and voltage control techniques in power system networks.

Unit	Content	Credit	Weightage
I	**Introduction to Power Systems** • **Structure of Power Systems:** Generation, transmission, distribution, and utilization. • **Types of Power Plants:** Thermal, hydro, nuclear, renewable energy sources. • **Power System Components:** Generators, transformers, circuit breakers, relays, isolators. • **Power System Configurations:** Radial, ring, interconnected systems. • **Voltage Levels and Standards:** LV, MV, HV, EHV classifications; Indian and international standards.	1	25%
II	**Transmission Line Parameters & Performance** • **Transmission Line Parameters:** Resistance, inductance, and capacitance calculations for single-phase and three-phase lines. • **Line Modeling:** Short, medium, and long transmission lines; ABCD parameters. • **Performance of Transmission Lines:** Voltage regulation, efficiency, Ferranti effect, power transfer capability. • **Corona Effect:** Causes, factors, advantages, and disadvantages. • **Insulators and Towers:** Types, design considerations, and applications.	1	25%
III	**Per-Unit System & Fault Analysis** • **Per-Unit System:** Advantages, base values, conversion, and representation of power system components.	1	25%

	• **Symmetrical Fault Analysis:** Transient and steady-state fault currents, short-circuit MVA, circuit breaker ratings. • **Sequence Networks:** Positive, negative, and zero sequence components. • **Symmetrical Components:** Transformation, representation of unbalanced systems. • **Introduction to Unsymmetrical Faults:** Single line-to-ground, line-to-line, and double line-to-ground faults.		
IV	**Load Flow Analysis & Voltage Control** • **Load Flow Problem:** Bus classification (PQ, PV, slack), power flow equations. • **Load Flow Methods:** Gauss-Seidel and Newton-Raphson methods. • **Voltage Control:** Methods of voltage regulation, tap-changing transformers, shunt capacitors, series compensation. • **Reactive Power Management:** Importance, sources of reactive power, VAR compensation. • **Introduction to Power System Stability:** Steady-state and transient stability concepts.	1	25%

Textbooks:

- *Power System Analysis* – Hadi Saadat (McGraw Hill)
- *Power System Engineering* – I. J. Nagrath & D. P. Kothari (McGraw Hill)
- *Electrical Power Systems* – C. L. Wadhwa (New Age International)

Reference books:

- *Power System Analysis and Design* – J. Duncan Glover, Mulukutla S. Sarma, & Thomas J. Overbye (Cengage Learning)
- *Modern Power System Analysis* – D. P. Kothari & I. J. Nagrath (McGraw Hill)
- *Power System Analysis* – John J. Grainger & William D. Stevenson (McGraw Hill)
- *Electrical Power Systems* – B. M. Weedy, B. J. Cory, et al. (Wiley)

Online Platforms:

- NPTEL:
  - *Power System Analysis* – IIT Kharagpur
  - *Power System Engineering* – IIT Madras
  - *Electrical Power Generation, Transmission, and Distribution* – IIT Roorkee
- Coursera:
  - *Power System: Generation, Transmission, and Distribution* – University at Buffalo
  - *Electric Power Systems* – University at Buffalo

SUBJECT CODE: BTEE402

SUBJECT NAME: ELECTRICAL MACHINES-II

Course Objectives:

- To understand the construction, operation, and performance characteristics of AC machines.
- To analyze the working principles of three-phase induction motors, synchronous machines, and fractional horsepower motors.
- To study speed control, starting methods, and applications of AC machines in industrial systems.
- To develop experimental skills for testing, analyzing, and evaluating the performance of AC machines.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the construction, operation, and types of three-phase induction motors and synchronous machines.
CO2	Analyze the performance characteristics of induction motors and synchronous generators.
C03	Evaluate methods of speed control, starting, and braking of AC motors.
C04	Conduct standard tests on AC machines and interpret experimental results.

Unit	Content	Credit	Weightage
I	**Three-Phase Induction Motors** • **Construction:** Stator, rotor (squirrel cage and wound rotor), types of enclosures. • **Operating Principle:** Rotating magnetic field, slip, torque production. • **Equivalent Circuit:** Per-phase equivalent circuit, power flow diagram. • **Performance Characteristics:** Torque-slip characteristics, starting torque, maximum torque, efficiency. • **Starting Methods:** Direct-on-line (DOL), star-delta, autotransformer, rotor resistance starting.	1	25%
II	**Speed Control & Testing of Induction Motors** • **Speed Control Methods:** Stator voltage control, frequency control (V/f control), pole changing, rotor resistance control. • **Braking Methods:** Plugging, dynamic braking, regenerative braking. • **Testing of Induction Motors:** No-load test, blocked rotor test, circle diagram. • **Industrial Applications:** Selection of motors for pumps, fans, compressors, conveyors. • **Energy Efficiency:** Efficiency standards, energy-efficient motors.	1	25%
III	**Synchronous Machines** • **Construction:** Salient pole and cylindrical rotor types, field and armature windings. • **Synchronous Generator:** EMF equation, voltage regulation, parallel operation, load sharing.	1	25%

	• **Synchronous Motor:** Principle, starting methods, V-curves, hunting and damping. • **Power Angle Characteristics:** Steady-state and transient stability concepts. • **Excitation Systems:** Types, voltage regulation using AVR.		
IV	**Special AC Machines & Applications** • **Single-Phase Induction Motors:** Types (split-phase, capacitor-start, capacitor-run, shaded-pole), applications. • **AC Commutator Motors:** Universal motor, repulsion motor. • **Synchronous Reluctance & Permanent Magnet Motors:** Construction, characteristics, applications. • **Fractional Horsepower Motors:** Selection, applications in home appliances and small machines. • **Introduction to Servo and Stepper Motors.**	1	25%

Textbooks:

- *Electrical Machines* – D. P. Kothari & I. J. Nagrath (McGraw Hill)
- *Electrical Machinery* – P. S. Bimbhra (Khanna Publishers)
- *Alternating Current Machines* – M. G. Say (Pitman Publishing)

Reference books:

- *Electric Machinery Fundamentals* – Stephen J. Chapman (McGraw Hill)
- *Theory and Performance of Electrical Machines* – J. B. Gupta (S. K. Kataria & Sons)
- *Electrical Machines* – Ashfaq Hussain (Dhanpat Rai & Co.)
- *AC Machines* – M. V. Deshpande (PHI Learning)

Online Platforms:

- NPTEL:
  - *Electrical Machines – II* – IIT Kharagpur
  - *AC Machines and Synchronous Machines* – IIT Madras
- Coursera:
  - *Electric Machines and Drives* – University of Colorado Boulder
  - *Rotating Machines* – University of Manchester

Practical List:

- No-Load and Blocked Rotor Tests on three-phase induction motor.
- Performance Characteristics – Torque, speed, current, power factor vs. load.
- Study of Starting Methods – Star-delta starter, autotransformer starter.
- Circle Diagram – Construction and determination of performance parameters.
- Speed Control by V/f Method using variable frequency drive (VFD).
- Speed Control by Rotor Resistance (for wound rotor induction motor).
- Plugging and Dynamic Braking of induction motor.
- Efficiency Determination by direct loading (brake test).
- Open Circuit and Short Circuit Tests on three-phase synchronous generator.
- Determination of Voltage Regulation by synchronous impedance method.
- V-Curves and Inverted V-Curves of synchronous motor.

- Parallel Operation of Two Synchronous Generators.
- Study of Single-Phase Induction Motors – capacitor-start and capacitor-run motors.
- Characteristics of Universal Motor under AC and DC supply.
- Study of Stepper Motor – step angle, torque-speed characteristics.
- Final Project: Design and testing of a small motor control panel for an industrial application (e.g., conveyor system, water pump)

SUBJECT CODE: BTEE403

SUBJECT NAME: CONTROL SYSTEMS

Course Objectives:

- To introduce fundamental concepts of control systems, modeling, and analysis.
- To develop skills in time-domain and frequency-domain analysis of linear time-invariant systems.
- To apply stability criteria and design techniques for feedback control systems.
- To introduce state-space analysis and digital control systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Model physical systems using differential equations and transfer functions.
CO2	Analyze system performance using time-domain and frequency-domain methods.
C03	Apply stability criteria (Routh-Hurwitz, Nyquist, Bode) to feedback systems.
C04	Design PID controllers and introduce state-space representation of systems.

Unit	Content	Credit	Weightage
I	**Introduction to Control Systems & Modeling** • **Control System Concepts:** Open-loop vs closed-loop systems, examples. • **Mathematical Modeling:** Differential equations of physical systems (mechanical, electrical). • **Transfer Function:** Definition, poles and zeros, block diagram reduction. • **Signal Flow Graphs:** Mason's gain formula. • **Modeling Examples:** DC motor, spring-mass-damper, thermal systems.	1	25%
II	**Time-Domain Analysis** • **Standard Test Signals:** Step, ramp, impulse, parabolic. • **First and Second-Order Systems:** Step response, transient specifications (rise time, settling time, peak overshoot, steady-state error). • **Steady-State Error:** Error constants (Kp, Kv, Ka), types of systems. • **Stability Analysis:** Concept of stability, Routh-Hurwitz criterion. • **Introduction to PID Controllers:** P, I, D actions.	1	25%

III	**Frequency-Domain Analysis** • **Frequency Response:** Bode plots, gain margin, phase margin. • **Polar Plots & Nyquist Stability Criterion:** Nyquist path, encirclements, stability assessment. • **Relative Stability:** Gain and phase margins from Bode and Nyquist plots. • **Correlation Between Time and Frequency Domain.** • **Compensation Techniques:** Lag, lead, lag-lead compensators.	1	25%
IV	**State-Space Analysis & Digital Control** • **State-Space Representation:** State variables, state equations, transfer function to state-space conversion. • **State Transition Matrix, Controllability & Observability.** • **Introduction to Digital Control Systems:** Sampling, Z-transform, difference equations. • **Digital PID Controllers.** • **Case Studies:** Temperature control, speed control of DC motor, robotics applications.	1	25%

Textbooks:

- Automatic Control Systems – Benjamin C. Kuo
- Modern Control Engineering – Katsuhiko Ogata
- Control Systems Engineering – Norman S. Nise

Reference books:

- Feedback Control of Dynamic Systems – Gene F. Franklin, J. David Powell, & Abbas Emami-Naeini
- Control Systems: Principles and Design – M. Gopal
- Digital Control Systems – K. P. Ramachandran
- Linear System Theory and Design – Chi-Tsong Chen

Online Platforms:

- NPTEL:
  - *Control Engineering* – IIT Madras
  - *Control Systems* – IIT Bombay
  - *Modern Control Systems* – IIT Kharagpur
- Coursera:
  - *Control of Mobile Robots* – Georgia Institute of Technology
  - *Introduction to Control System Design* – University of Colorado Boulder

SUBJECT CODE: BTEE404

SUBJECT NAME: MICR0PROCESSORS AND MICROCONTROLLERS

Course Objectives:

- To introduce the architecture, programming, and interfacing of microprocessors and microcontrollers.
- To develop skills in assembly language and embedded C programming for 8086 and 8051.
- To understand peripheral interfacing techniques (memory, I/O, timers, serial communication).
- To design and implement embedded systems for real-world applications.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the architecture and organization of 8086 microprocessor and 8051 microcontrollers.
CO2	Write assembly and embedded C programs for data manipulation and control applications.
C03	Interface memory, I/O devices, timers, and serial communication modules with microprocessors/microcontrollers.
C04	Design and implement embedded systems for applications like sensor interfacing, motor control, and data acquisition.

Unit	Content	Credit	Weightage
I	**8086 Microprocessor Architecture & Programming** • **8086 Architecture:** Registers, pins, memory segmentation, addressing modes. • **Instruction Set:** Data transfer, arithmetic, logical, branching, string instructions. • **Assembly Language Programming:** Tools (MASM, DEBUG), writing and debugging programs. • **Interrupts:** Types, interrupt vector table, handling. • **Memory Interfacing:** Address decoding, memory mapping.	1	25%
II	**8051 Microcontroller Architecture & Programming** • **8051 Architecture:** Registers, memory organization, SFRs, clock, reset. • **8051 Instruction Set:** Addressing modes, instruction types. • **Assembly & Embedded C Programming:** Programming timers, interrupts, I/O ports. • **Development Tools:** Keil µVision, simulators, programmers. • **Comparison:** Microprocessor vs Microcontroller.	1	25%
III	**Peripheral Interfacing with 8086 & 8051** • **Interfacing with 8086:** 8255 PPI, 8259 PIC, 8253/8254 Timer, 8251 USART. • **Interfacing with 8051:** LED, LCD, keypad, stepper motor, ADC/DAC interfacing. • **Serial Communication:** RS-232, UART, SPI, I²C basics.	1	25%

	• **Memory Interfacing:** RAM, ROM, EEPROM with 8051. • **Case Study:** Interfacing sensors (temperature, IR) with microcontrollers.		
IV	**Advanced Microcontrollers & Embedded Systems Design** • **Advanced 8051 Features:** Power-saving modes, watchdog timer. • **Introduction to ARM Cortex-M:** Architecture overview, features. • **Real-Time Operating Systems (RTOS) Basics:** Tasks, scheduling, inter-task communication. • **Embedded System Design Methodology:** Requirements, design, testing, debugging. • **Mini-Project:** Design of an embedded system (e.g., digital thermometer, home automation).	1	25%

Textbooks:

- Microprocessor 8086: Architecture, Programming and Interfacing – Sunil Mathur
- The 8051 Microcontroller and Embedded Systems – Muhammad Ali Mazidi, Janice Gillispie Mazidi, & Rolin D. McKinlay
- Microprocessors and Interfacing – Douglas V. Hall

Reference books:

- Advanced Microprocessors and Peripherals – A. K. Ray & K. M. Bhurchandi
- 8051 Microcontroller: Internals, Instructions, Programming & Interfacing – Subrata Ghoshal
- Embedded C Programming and the Atmel AVR – Richard H. Barnett, Sarah Cox, & Larry O'Cull
- ARM System Developer's Guide – Andrew N. Sloss, Dominic Symes, & Chris Wright

Online Platforms:

- NPTEL:
  - *Microprocessors and Microcontrollers* – IIT Kharagpur
  - *Embedded Systems* – IIT Delhi
- Coursera:
  - *Embedded Systems Essentials with ARM* – ARM Education
  - *Introduction to Embedded Systems Software and Development Environments* – University of Colorado Boulder

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Study of 8086 architecture and familiarization with MASM/DEBUG.
- Lab 2: Assembly language program for addition/subtraction of 16-bit numbers.
- Lab 3: Code conversion (BCD to binary, binary to ASCII).
- Lab 4: Sorting an array in ascending/descending order.

Module 2 Practicals

- Lab 5: Study of 8051 architecture and Keil µVision IDE.
- Lab 6: Assembly program for 8-bit arithmetic operations.

- Lab 7: Embedded C program for LED blinking and pattern generation.
- Lab 8: Timer programming for generating delay and square wave.

Module 3 Practicals

- Lab 9: Interfacing LEDs and switches with 8051.
- Lab 10: Interfacing 16x2 LCD with 8051.
- Lab 11: Interfacing 4x4 keypad with 8051.
- Lab 12: Interfacing ADC and temperature sensor (LM35) with 8051.

Module 4 Practicals

- Lab 13: Interfacing stepper motor with 8051.
- Lab 14: Serial communication between 8051 and PC (UART).
- Lab 15: Introduction to ARM Cortex-M (simple LED control using STM32/Arduino).
- Lab 16: Mini-project – Digital clock with alarm using 8051.

SEMESTER-V

SUBJECT CODE: BTEE501

SUBJECT NAME: POWER ELECTORNICS

Course Objectives:

- To understand the principles, characteristics, and applications of power semiconductor devices.
- To analyze and design AC-DC, DC-DC, DC-AC, and AC-AC power converters.
- To study modulation techniques, control strategies, and protection methods in power electronic systems.
- To develop practical skills in designing, simulating, and testing power electronic circuits.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the operation, characteristics, and ratings of power semiconductor devices.
CO2	Analyze and design various power converters (rectifiers, choppers, inverters, cycloconverters).
C03	Apply modulation techniques (PWM) and control strategies in power electronic systems.
C04	Simulate, build, and test power electronic circuits in laboratory environments.

Unit	Content	Credit	Weightage
I	**Power Semiconductor Devices** • **Introduction to Power Electronics:** Applications, advantages, and system overview. • **Power Diodes:** Static and dynamic characteristics, reverse recovery, types (Schottky, fast recovery). • **Thyristors (SCR):** Structure, V-I characteristics, turn-on and turn-off methods, ratings, protection. • **Power Transistors:** BJT, MOSFET, IGBT – characteristics, switching behavior, gate/base drive requirements. • **Other Devices:** TRIAC, DIAC, GTO, MCT – basics and applications.	1	25%
II	**AC-DC Converters (Rectifiers)** • **Single-Phase Rectifiers:** Half-wave, full-wave (center-tapped, bridge) with R, RL, RLE loads. • **Three-Phase Rectifiers:** Half-wave, full-wave bridge configurations. • **Effect of Source Inductance,** input current harmonics, power factor. • **Controlled Rectifiers:** Phase-angle control, single-phase and three-phase controlled rectifiers. • **Applications:** Battery chargers, DC power supplies, HVDC transmission.	1	25%
III	**DC-DC Converters (Choppers) & DC-AC Converters (Inverters)** • **DC-DC Converters:** Step-down (buck), step-up (boost), buck-boost converters – operation and analysis.	1	25%

	• **Switched-Mode Power Supplies (SMPS):** Flyback, forward converters. • **Single-Phase Inverters:** Half-bridge, full-bridge, voltage control methods (single PWM, multiple PWM). • **Three-Phase Inverters:** 180° and 120° conduction modes, voltage control, harmonic reduction. • **PWM Techniques:** Sinusoidal PWM, space vector PWM (basic concepts).		
IV	**AC-AC Converters & Applications** • **AC Voltage Controllers:** Single-phase and three-phase controllers with R and RL loads. • **Cycloconverters:** Single-phase to single-phase, principle and applications. • **Power Electronic Applications:** UPS, induction heating, speed control of DC and AC motors. • **Protection and Cooling:** Snubber circuits, heat sinks, thermal management. • **Introduction to Power Quality:** Harmonics, power factor correction, filters.	1	25%

Textbooks:

- *Power Electronics: Converters, Applications, and Design* – Ned Mohan, Tore M. Undeland, William P. Robbins (Wiley)
- *Power Electronics* – M. H. Rashid (Pearson)
- *Power Electronics: Essentials and Applications* – L. Umanand (Wiley)

Reference books:

- *Fundamentals of Power Electronics* – Robert W. Erickson & Dragan Maksimović (Springer)
- *Power Electronics: Circuits, Devices & Applications* – Muhammad H. Rashid (Pearson)
- *Power Electronics Handbook* – Muhammad H. Rashid (Elsevier)
- *Modern Power Electronics and AC Drives* – Bimal K. Bose (Pearson)

Online Platforms:

- NPTEL:
  - *Power Electronics* – IIT Kharagpur
  - *Power Electronic Converters* – IIT Madras
  - *Industrial Drives & Power Electronics* – IIT Roorkee
- Coursera:
  - *Introduction to Power Electronics* – University of Colorado Boulder
  - *Power Electronics Specialization* – University of Colorado Boulder

PRACTICAL LIST:

Module 1: Power Device Characteristics

- V-I Characteristics of SCR and triggering methods.
- Characteristics of MOSFET and IGBT – switching times and gate drive requirements.
- Study of Snubber Circuits for device protection.
- Thermal Management – heat sink design and temperature measurement.

Module 2: Rectifier Circuits

- Single-Phase Uncontrolled Full-Wave Rectifier with capacitive filter.
- Single-Phase Phase-Controlled Rectifier with R and RL loads.

- Three-Phase Uncontrolled Bridge Rectifier.
- Power Factor Measurement and improvement using capacitors.

Module 3: DC-DC Converters & Inverters

- Buck Converter – design and analysis of step-down DC-DC converter.
- Boost Converter – design and analysis of step-up DC-DC converter.
- Single-Phase PWM Inverter using MOSFET/IGBT with resistive load.
- Three-Phase Inverter – generation of three-phase AC from DC.

Module 4: Applications & Control

- AC Voltage Controller using TRIAC/DIAC for lamp dimming.
- Speed Control of DC Motor using chopper.
- Variable Frequency Drive (VFD) for induction motor speed control.
- Final Project: Design and implementation of a switched-mode power supply (SMPS) or solar inverter.

SUBJECT CODE: BTEE502

SUBJECT NAME: POWER SYSTEMS-II

Course Objectives:

- To analyze unsymmetrical faults and understand protection schemes in power systems.
- To study power system stability, its types, and improvement techniques.
- To learn about power system protection, relay coordination, and switchgear.
- To introduce advanced topics like HVDC transmission, FACTS, and power system economics.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze unsymmetrical faults using symmetrical components and sequence networks.
CO2	Evaluate power system stability and apply methods to improve transient and steady-state stability.
C03	Design and coordinate protection schemes using relays, circuit breakers, and switchgear.
C04	Understand advanced power system technologies like HVDC, FACTS, and economic operation.

Unit	Content	Credit	Weightage
I	**Unsymmetrical Fault Analysis** • **Symmetrical Components:** Transformation, sequence impedances, sequence networks. • **Unsymmetrical Faults:** Single line-to-ground (LG), line-to-line (LL), double line-to-ground (LLG) faults. • **Analysis Using Bus Impedance Matrix:** Fault current calculations, fault MVA. • **Open Conductor Faults:** Analysis and effects on system performance. • **Computer Methods:** Software tools for fault analysis.	1	25%
II	**Power System Stability** • **Introduction:** Steady-state, transient, and dynamic	1	25%

	stability. • **Swing Equation:** Derivation, inertia constant, equal area criterion. • **Transient Stability:** Critical clearing angle and time, factors affecting stability. • **Stability Improvement:** Methods – high-speed circuit breakers, auto-reclosing, braking resistors, FACTs devices. • **Voltage Stability:** Concepts, PV and QV curves, collapse prevention.		
III	**Power System Protection** • **Protection Philosophy:** Zones of protection, primary and backup protection. • **Relays:** Electromagnetic, static, numerical relays – overcurrent, distance, differential relays. • **Circuit Breakers:** Types (oil, SF6, vacuum), arc interruption, ratings. • **Protection Schemes:** Transformer, generator, transmission line, and busbar protection. • **Relay Coordination:** Time-current grading, coordination studies.	1	25%
IV	**Advanced Power Systems** • **HVDC Transmission:** Types (monopolar, bipolar, homopolar), converters, control, applications. • **Flexible AC Transmission Systems (FACTS):** Devices – SVC, STATCOM, TCSC, UPFC. • **Power System Economics:** Load forecasting, unit commitment, economic dispatch, tariff structures. • **Substation Design:** Layout, equipment, grounding, and safety. • **Smart Grid:** Introduction, components, benefits, and challenges.	1	25%

Textbooks:

- *Power System Analysis* – Hadi Saadat (McGraw Hill)
- *Power System Engineering* – I. J. Nagrath & D. P. Kothari (McGraw Hill)
- *Power System Protection and Switchgear* – B. Ravindranath & M. Chander (Wiley)

Reference books:

- *Power System Stability and Control* – Prabha Kundur (McGraw Hill)
- *Power System Protection* – C. Christopoulos & A. Wright (IET)
- *HVDC Transmission* – J. Arrillaga (Wiley)
- *Flexible AC Transmission Systems (FACTS)* – Y. H. Song & A. T. Johns (IET)
- *Power System Economics* – Steven Stoft (Wiley)

Online Platforms:

- NPTEL:
  - *Power System Protection* – IIT Kharagpur
  - *Power System Stability* – IIT Bombay
  - *HVDC Transmission* – IIT Roorkee
- Coursera:

- *Power System: Generation, Transmission, and Distribution* – University at Buffalo
- *Smart Grids* – University at Buffalo

PRACTICAL LIST:

Module 1: Fault Analysis

- Symmetrical Components Analysis of an unbalanced three-phase system.
- Calculation of Fault Currents for LG, LL, and LLG faults using sequence networks.
- Simulation of Unsymmetrical Faults using MATLAB/ETAP.
- Study of Effect of Faults on voltage profile and system stability.

Module 2: Stability Studies

- Swing Equation Simulation for a single-machine infinite bus system.
- Determination of Critical Clearing Time using equal area criterion.
- Effect of Automatic Voltage Regulator (AVR) on transient stability.
- Voltage Stability Analysis using PV and QV curves.

Module 3: Protection & Relay Testing

- Overcurrent Relay Characteristics – IDMT curve plotting.
- Differential Protection of Transformer using relay test set.
- Distance Relay Testing – impedance measurement and zone setting.
- Coordination Study of overcurrent relays in a radial distribution system.

Module 4: Advanced Systems & Design

- HVDC System Simulation – rectifier and inverter operation.
- FACTS Device Study – simulation of SVC/STATCOM for voltage control.
- Economic Dispatch Problem using Lagrange multiplier method.
- Design of a Protection Scheme for a small power system (mini-project).

SUBJECT CODE: BTEE503

SUBJECT NAME: ELECTRICAL MEASUREMENTS

Course Objectives:

- To understand the principles, operation, and applications of various electrical measuring instruments.
- To learn methods for measuring voltage, current, power, energy, frequency, and power factor in AC and DC systems.
- To study instrument transformers, transducers, and modern digital measurement techniques.
- To develop skills in calibration, error analysis, and selection of appropriate measuring instruments for different applications.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the working principles of analog and digital electrical measuring instruments.
CO2	Measure electrical parameters such as voltage, current, power, energy, and frequency using appropriate instruments.
C03	Analyze errors, accuracy, and calibration methods in electrical measurements.
C04	Apply transducer-based and digital measurement techniques in modern electrical systems.

Unit	Content	Credit	Weightage
I	**Fundamentals of Electrical Measurements** • **Introduction to Measurements:** Significance, types of measurements, units and standards. • **Measurement Errors:** Types (systematic, random), accuracy, precision, sensitivity, resolution. • **Analog Instruments:** Permanent Magnet Moving Coil (PMMC), Moving Iron (MI), electrodynamometer types. • **Measurement of Voltage and Current:** Voltmeters, ammeters, extension of range (shunts, multipliers). • **Galvanometers:** Principles, types, sensitivity, applications.	1	25%
II	**Measurement of Power and Energy** • **Power Measurement in DC and AC Circuits:** Wattmeter types (electrodynamometer, induction). • **Single-Phase and Three-Phase Power Measurement:** One-wattmeter, two-wattmeter, and three-wattmeter methods. • **Energy Measurement:** Single-phase and three-phase energy meters (induction type), calibration. • **Power Factor Measurement:** Power factor meter (electrodynamometer, moving iron types). • **Maximum Demand Indicators** and industrial metering.	1	25%
III	**Instrument Transformers & Bridge Measurements** • **Instrument Transformers:** Current Transformer (CT) and Potential Transformer (PT) – construction, ratio, errors, burden. • **DC Bridges:** Wheatstone bridge, Kelvin double bridge for resistance measurement. • **AC Bridges:** Maxwell, Hay, Schering, Wien bridges for inductance, capacitance, and frequency measurement. • **Frequency Measurement:** Vibrating reed, Weston frequency meter, digital frequency counters. • **Phase Sequence Indicators** and synchroscopes.	1	25%
IV	**Transducers & Digital Measurement Techniques** • **Transducers:** Classification (active/passive), resistive, inductive, capacitive transducers. • **Temperature Measurement:** RTD, thermocouple, thermistor. • **Digital Instruments:** Digital voltmeter, multimeter, frequency counter, oscilloscope. • **Data Acquisition Systems (DAS):** Signal conditioning, analog-to-digital conversion, interfacing. • **Smart Meters & IoT in**	1	25%

	Measurements: Introduction to smart metering, wireless sensor networks.		

Textbooks:

- *Electrical and Electronic Measurements and Instrumentation* – A. K. Sawhney (Dhanpat Rai & Co.)
- *Modern Electronic Instrumentation and Measurement Techniques* – Albert D. Helfrick & William D. Cooper (Pearson)
- *Electrical Measurements and Measuring Instruments* – R. K. Rajput (S. Chand)

Reference books:

- *Electronic Instrumentation* – H. S. Kalsi (McGraw Hill)
- *Measurement Systems: Application and Design* – Ernest O. Doebelin (McGraw Hill)
- *Principles of Electrical Measurement* – Slawomir Tumanski (IOP Publishing)
- *Digital and Analog Measurements* – N. K. De (S. Chand)

Online Platforms:

- NPTEL:
  - *Electrical Measurements and Measuring Instruments* – IIT Kharagpur
  - *Instrumentation and Measurements* – IIT Madras
- Coursera:
  - *Measurements and Instrumentation* – University of Colorado Boulder
  - *Sensors and Sensor Circuit Design* – University of Colorado Boulder

SUBJECT CODE: BTEE504

SUBJECT NAME: RENEWABLE ENERGY SYSTEMS

Course Objectives:

- To introduce the principles, technologies, and applications of renewable energy sources.
- To analyze the design, operation, and integration of solar, wind, biomass, and other renewable energy systems.
- To understand the environmental, economic, and policy aspects of renewable energy deployment.
- To develop skills in modeling, sizing, and evaluating renewable energy systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the principles and characteristics of major renewable energy sources.
CO2	Design and analyze solar PV and wind energy conversion systems.
C03	Evaluate the integration of renewable energy into existing power grids.
C04	Assess the economic, environmental, and societal impacts of renewable energy systems.

Unit	Content	Credit	Weightage
I	**Introduction to Renewable Energy** • **Energy Scenario:** Global and national energy demand, fossil fuel depletion, climate change. • **Renewable Energy Sources:** Solar, wind, biomass, hydro, geothermal, tidal, and ocean energy. • **Energy Fundamentals:** Power, energy, capacity	1	25%

	factor, load factor, energy storage needs. • **Environmental Impact:** Carbon footprint, sustainability, life cycle assessment. • **Policy and Incentives:** National and international policies, subsidies, feed-in tariffs, net metering.		
II	**Solar Energy Systems** • **Solar Radiation:** Measurement, solar geometry, irradiance, solar time. • **Photovoltaic (PV) Technology:** PV cell types (mono, poly, thin-film), I-V characteristics, efficiency factors. • **PV System Design:** Stand-alone, grid-connected, hybrid systems, component sizing (PV array, battery, inverter). • **Solar Thermal Systems:** Flat plate collectors, concentrating collectors, solar water heating, solar power plants. • **Performance Analysis:** Losses, degradation, performance ratio, economic evaluation.	1	25%
III	**Wind Energy Systems** • **Wind Resource Assessment:** Wind speed distribution, Weibull statistics, wind maps, site selection. • **Wind Turbine Technology:** Horizontal axis and vertical axis turbines, components, power curve, Betz limit. • **Wind Energy Conversion:** Aerodynamics, generator types (induction, synchronous, PMSG), power electronics interface. • **Grid Integration:** Power quality issues, fault ride-through, grid codes. • **Offshore Wind Farms:** Challenges, advantages, and current trends.	1	25%
IV	**Other Renewable Sources & Integration** • **Biomass Energy:** Types of biomass, conversion technologies (combustion, gasification, anaerobic digestion), biogas plants. • **Hydro and Geothermal Energy:** Small hydro, pumped storage, geothermal power plants. • **Energy Storage:** Batteries, pumped hydro, flywheels, supercapacitors, hydrogen storage. • **Hybrid Systems:** Solar-wind, wind-diesel, microgrids, smart grid integration. • **Future Trends:** Green hydrogen, floating solar, agrivoltaics, community-based renewable energy projects.	1	25%

Textbooks:

- *Renewable Energy: Power for a Sustainable Future* – Godfrey Boyle (Oxford University Press)
- *Renewable Energy Systems* – David M. Buchla, Thomas E. Kissell, Thomas L. Floyd (Pearson)
- *Solar Photovoltaics: Fundamentals, Technologies and Applications* – Chetan Singh Solanki (PHI Learning)

Reference books:

- *Wind Energy Explained: Theory, Design and Application* – J. F. Manwell, J. G. McGowan, A. L. Rogers (Wiley)
- *Renewable and Efficient Electric Power Systems* – Gilbert M. Masters (Wiley)
- *Integration of Renewable Energy Sources with Smart Grid* – A. Keyhani & M. Marwali (Wiley)
- *Biomass for Renewable Energy, Fuels, and Chemicals* – Donald L. Klass (Academic Press)

Online Platforms:

- NPTEL:
  - *Solar Energy* – IIT Bombay
  - *Wind Energy* – IIT Guwahati
  - *Renewable Energy Engineering* – IIT Kharagpur
- Coursera:
  - *Renewable Energy and Green Building Entrepreneurship* – Duke University
  - *Solar Energy Basics* – The State University of New York

SEMESTER-VI

SUBJECT CODE: BTEE601

SUBJECT NAME: HIGH VOLTAGE ENGINEERING

Course Objectives:

- To understand the principles of high voltage generation, measurement, and testing.
- To study the breakdown mechanisms in gases, liquids, and solid insulating materials.
- To analyze insulation coordination, overvoltages, and protection in high voltage systems.
- To design and evaluate high voltage equipment and insulation systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the mechanisms of electrical breakdown in different dielectric media.
CO2	Generate and measure high AC, DC, and impulse voltages.
C03	Analyze over voltages and design insulation coordination for power systems.
C04	Evaluate high voltage equipment and insulation testing techniques.

Unit	Content	Credit	Weightage
I	**Dielectric Breakdown in Gases, Liquids, and Solids** • **Introduction to High Voltage Engineering:** Applications, challenges, and standards. • **Breakdown in Gases:** Ionization processes, Townsend's theory, streamer theory, corona discharge, Paschen's law. • **Breakdown in Liquid Dielectrics:** Purification, breakdown mechanisms, suspended particles theory. • **Breakdown in Solid Dielectrics:** Intrinsic breakdown, thermal breakdown, partial discharges, tracking and erosion. • **Composite Insulation Systems:** Oil-paper, SF6 gas, vacuum insulation.	1	25%
II	**Generation of High Voltages** • **High AC Voltage Generation:** Cascaded transformers, resonant transformers, Tesla coils. • **High DC Voltage Generation:** Half-wave and full-wave rectifier circuits, voltage multipliers (Cockcroft-Walton). • **Impulse Voltage Generation:** Single-stage and multi-stage impulse generators (Marx circuit), standard lightning and switching impulses. • **High Current Impulse Generation:** For testing circuit breakers and protective devices. • **Testing Transformers and Reactors** for high voltage applications.	1	25%
III	**Measurement of High Voltages** • **Measurement of High AC Voltages:** Series	1	25%

	impedance voltmeters, capacitive voltage dividers, potential transformers. • **Measurement of High DC Voltages:** Resistive dividers, generating voltmeters (field mill). • **Measurement of Impulse Voltages:** Resistive and capacitive dividers, CRO and digital storage oscilloscopes. • **Measurement of High Currents:** Rogowski coils, current transformers, Hall effect sensors. • **Calibration and Standards** for high voltage measurements.		
IV	**Over voltages, Insulation Coordination & Testing** • **Over voltages in Power Systems:** Lightning over voltages, switching over voltages, temporary over voltages. • **Insulation Coordination:** Principles, statistical approach, coordination between protective devices and insulation. • **High Voltage Testing:** Routine tests, type tests, and acceptance tests for transformers, cables, and insulators. • **Non-Destructive Testing:** Partial discharge measurement, dielectric loss measurement (tan δ), insulation resistance. • **Applications:** HVDC transmission, substation insulation, cable testing, outdoor insulation design.	1	25%

Textbooks:

- *High Voltage Engineering* – M. S. Naidu & V. Kamaraju (McGraw Hill)
- *High Voltage Engineering: Fundamentals* – E. Kuffel, W. S. Zaengl, J. Kuffel (Elsevier)
- *High Voltage Insulation Engineering* – Ravindra Arora & Wolfgang Mosch (New Age International)

Reference books:

- *High Voltage and Electrical Insulation Engineering* – Ravindra Arora & Wolfgang Mosch (IEEE Press)
- *Electrical Power Systems Quality* – Roger C. Dugan, Mark F. McGranaghan, Surya Santoso (McGraw Hill) – relevant sections.
- *Insulation Coordination for Power Systems* – Andrew R. Hileman (CRC Press)
- *High Voltage Test and Measuring Techniques* – Wolfgang Hauschild & Eberhard Lemke (Springer)

Online Platforms:

- NPTEL:
  - *High Voltage Engineering* – IIT Kharagpur
  - *Electrical Insulation and High Voltage Engineering* – IIT Madras
- Coursera:
  - *High Voltage Engineering* – Technical University of Munich (TUM)

MK UNIVERSITY

PATAN, GUJARAT

ESTABLISHED BY THE GUJARAT GOVT. RECOGNIZED BY UGC UNDER SECTION 2(f) OF UGC ACT,1956

SUBJECT CODE: BTEE602

SUBJECT NAME: DIGITAL SIGNAL PROCESSING

Course Objectives:

- To introduce fundamental concepts of discrete-time signals and systems.
- To analyse signals and systems using Z-transform, Discrete Fourier Transform (DFT), and Fast Fourier Transform (FFT).
- To design and implement digital filters (FIR and IIR) for signal processing applications.
- To apply DSP techniques in communication, audio processing, image processing, and embedded systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Represent and analyze discrete-time signals and systems in time and frequency domains.
CO2	Apply DFT/FFT for spectral analysis and understand the effects of windowing.
C03	Design and implement FIR and IIR digital filters using various techniques.
C04	Implement DSP algorithms using software tools (MATLAB/Python) and embedded platforms.

Unit	Content	Credit	Weightage
I	**Discrete-Time Signals & Systems** • **Discrete-Time Signals:** Sequences, elementary signals, operations (shifting, scaling, folding). • **Classification of Systems:** Linear, time-invariant, causal, stable, FIR/IIR. • **Linear Time-Invariant (LTI) Systems:** Convolution sum, impulse response, stability, causality. • **Frequency Domain Representation:** Discrete-time Fourier Transform (DTFT), properties. • **Introduction to Sampling:** A/D and D/A conversion, quantization effects.	1	25%
II	**Z-Transform & Discrete Fourier Transform (DFT)** • **Z-Transform:** Definition, ROC, properties, inverse Z-transform. • **System Function:** Poles and zeros, stability in Z-domain. • **Discrete Fourier Transform (DFT):** Definition, properties, circular convolution. • **Fast Fourier Transform (FFT):** Radix-2 algorithms (DIT, DIF), computational complexity. • **Spectral Analysis:** Leakage, windowing techniques, frequency resolution.	1	25%
III	**Digital Filter Design** • **Filter Specifications:** Passband, stopband, ripple, transition band.	1	25%

	• **FIR Filter Design:** Windowing method, frequency sampling method, optimal design (Parks-McClellan). • **IIR Filter Design:** Analog filter approximations (Butterworth, Chebyshev, Elliptic), bilinear transformation, impulse invariance. • **Filter Structures:** Direct, cascade, parallel, lattice structures. • **Finite Word Length Effects:** Quantization noise, limit cycles, scaling.		
IV	**DSP Applications & Real-Time Implementation** • **Multi rate Signal Processing:** Decimation, interpolation, polyphase structures. • **Introduction to Adaptive Filters:** LMS algorithm. • **DSP in Communications:** Digital modulation, channel equalization. • **Audio & Image Processing Applications:** Echo cancellation, noise reduction, edge detection. • **Real-Time Implementation:** DSP processors (TMS320C67x/ARM), embedded implementation using C/MATLAB.	1	25%

Textbooks:

- Digital Signal Processing: Principles, Algorithms, and Applications – John G. Proakis & Dimitris G. Manolakis
- Discrete-Time Signal Processing – Alan V. Oppenheim & Ronald W. Schafer
- Digital Signal Processing: A Practical Approach – Emmanuel C. Ifeachor & Barrie W. Jervis

Reference books:

- Understanding Digital Signal Processing – Richard G. Lyons
- Digital Signal Processing Using MATLAB – Vinay K. Ingle & John G. Proakis
- Theory and Application of Digital Signal Processing – Lawrence R. Rabiner & Bernard Gold
- Real-Time Digital Signal Processing – Sen M. Kuo, Bob H. Lee, & Wenshun Tian

Online Platforms:

- NPTEL:
  - *Digital Signal Processing* – IIT Kharagpur
  - *Digital Signal Processing and Applications* – IIT Madras
  - *Advanced Digital Signal Processing* – IIT Delhi
- Coursera:
  - *Digital Signal Processing* – École Polytechnique Fédérale de Lausanne (EPFL)
  - *Digital Signal Processing 1: Basic Concepts and Algorithms* – Rice University

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Generation and operations on discrete-time signals (unit step, ramp, exponential, sinusoidal).
- Lab 2: Linear convolution of two sequences (manual and using MATLAB/Python).
- Lab 3: Verification of LTI system properties (linearity, time-invariance).
- Lab 4: A/D and D/A conversion simulation (sampling and reconstruction).

Module 2 Practicals

- Lab 5: Z-transform and inverse Z-transform using partial fraction expansion.
- Lab 6: Computation of DFT and IDFT of given sequences.
- Lab 7: Implementation of FFT algorithm (DIT or DIF) and comparison with DFT.
- Lab 8: Spectral analysis of signals using FFT and windowing (Hamming, Hanning).

Module 3 Practicals

- Lab 9: Design of FIR filter using windowing method (low-pass, high-pass).
- Lab 10: Design of IIR filter using bilinear transformation (Butterworth, Chebyshev).
- Lab 11: Implementation of filter structures (direct, cascade).
- Lab 12: Study of finite word length effects in filter implementation.

Module 4 Practicals

- Lab 13: Multirate processing: Decimation and interpolation of signals.
- Lab 14: Adaptive filter implementation using LMS algorithm (noise cancellation).
- Lab 15: Audio signal processing: Echo addition and removal.
- Lab 16: Mini-project – Real-time implementation of a digital filter on a DSP processor or ARM Cortex-M.

SUBJECT CODE: BTEE603

SUBJECT NAME: ELECTRIC DRIVES

Course Objectives:

- To understand the principles, operation, and control of electric drives for various applications.
- To analyze the characteristics of DC and AC motor drives and their control methods.
- To study power electronic converters used in drive systems and their control strategies.
- To design, simulate, and test electric drive systems for industrial and traction applications.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the components, configurations, and dynamics of electric drive systems.
CO2	Analyze and design control schemes for DC and AC motor drives.
C03	Select appropriate power converters and control strategies for specific drive applications.
C04	Simulate, implement, and test electric drive systems in laboratory settings.

Unit	Content	Credit	Weightage
I	**Introduction to Electric Drives & DC Motor Drives** • **Introduction:** Elements of electric drives, types of loads, multi-quadrant operation. • **DC Motor Drives:** Characteristics of separately excited, series, and shunt DC motors. • **Control of DC Drives:** Single-phase and three-phase controlled rectifier drives. • **Chopper-controlled DC Drives:** Step-up and step-down choppers, four-quadrant operation. • **Closed-loop Control:** Speed and torque control, current limiting, PI controllers.	1	25%
II	**Induction Motor Drives**	1	25%

	• **Induction Motor Characteristics:** Torque-speed curves, starting, braking, and speed control methods. • **Voltage Control:** AC voltage controllers for induction motor speed control. • **Variable Frequency Drives (VFD):** V/f control, constant torque and constant power operation. • **Vector Control:** Field-oriented control (FOC) principles, direct and indirect methods. • **Slip Power Recovery:** Static rotor resistance control, Kramer and Scherbius drives.		
III	**Synchronous & Special Motor Drives** • **Synchronous Motor Drives:** Starting methods, self-controlled and load-commutated inverter drives. • **Brushless DC (BLDC) Motor Drives:** Construction, operation, electronic commutation, control. • **Stepper Motor Drives:** Types, drive circuits, microstepping, applications. • **Switched Reluctance Motor (SRM) Drives:** Operation, power converters, control strategies. • **Servo Drives:** AC and DC servo motors, position and speed control.	1	25%
IV	**Drive Applications & Advanced Topics** • **Industrial Applications:** Pumps, fans, compressors, conveyors, machine tools. • **Traction Drives:** Electric vehicles, locomotives, battery management, regenerative braking. • **Energy Efficiency in Drives:** Energy-saving techniques, standards, and audits. • **Protection & Maintenance:** Overload, overcurrent, thermal protection, drive maintenance. • **Modern Trends:** IoT in drives, predictive maintenance, smart drives, digital twins.	1	25%

Textbooks:

- *Fundamentals of Electric Drives* – G. K. Dubey (Narosa Publishing)
- *Electric Drives: Concepts and Applications* – Vedam Subrahmanyam (McGraw Hill)
- *Power Electronics and Motor Drives* – Bimal K. Bose (Elsevier)

Reference books:

- *Modern Power Electronics and AC Drives* – Bimal K. Bose (Pearson)
- *Electric Drives* – Ion Boldea & Syed A. Nasar (CRC Press)
- *Control of Electric Machine Drive Systems* – Seung-Ki Sul (Wiley)
- *Electric Motor Drives: Modeling, Analysis, and Control* – R. Krishnan (Pearson)

Online Platforms:

- NPTEL:
  - *Electric Drives* – IIT Kharagpur
  - *Industrial Drives and Power Electronics* – IIT Roorkee
- Coursera:
  - *Electric Vehicles and Mobility* – École des Ponts ParisTech
  - *Motor and Motor Control Circuits* – University of Colorado Boulder

PRACTICAL LIST:

Module 1: DC Motor Drives

- Speed Control of DC Shunt Motor using armature voltage control (chopper).
- Four-Quadrant Operation of DC Motor using dual converter/chopper.
- Closed-Loop Speed Control of DC motor using PI controller.
- Study of DC Drive Parameters – current limit, acceleration control.

Module 2: Induction Motor Drives

- V/f Control of Three-Phase Induction Motor using VFD.
- Soft Starting of Induction Motor using AC voltage controller.
- Braking Methods – Dynamic braking and regenerative braking in induction motor.
- Vector Control Simulation using MATLAB/Simulink.

Module 3: Special Motor Drives

- Speed Control of BLDC Motor using Hall sensors and electronic commutation.
- Stepper Motor Control – full-step, half-step, and microstepping.
- Switched Reluctance Motor Drive – current control and speed regulation.
- Servo Motor Position Control using PID controller.

Module 4: Applications & Integration

- Traction Drive Simulation for electric vehicle (EV) using battery and motor model.
- Energy Audit of an Industrial Drive System – efficiency calculation.
- Fault Diagnosis in Drive System – overcurrent, overtemperature protection.
- Final Project: Design and implementation of a complete drive system for a given application (e.g., conveyor belt, pump, or EV prototype).

SUBJECT CODE: BTEE604

SUBJECT NAME: MACHINE LEARNING FOR EE

Course Objectives:

- To introduce fundamental concepts of machine learning (ML) and their relevance to electrical engineering (EE) applications.
- To develop skills in implementing supervised and unsupervised learning algorithms for EE problems.
- To apply ML techniques to signal processing, power systems, control, and embedded systems.
- To integrate ML models with hardware systems and understand deployment challenges in real-time EE applications.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain core ML concepts, learning paradigms, and the bias-variance tradeoff.
CO2	Implement and evaluate supervised learning models for regression and classification in EE tasks.
C03	Apply unsupervised learning and deep learning for signal analysis, clustering, and feature extraction.
C04	Deploy ML models on embedded platforms and evaluate performance in real-world EE applications.

Unit	Content	Credit	Weightage
I	**Foundations of Machine Learning for EE**	1	25%

	• **Introduction to ML in EE:** Applications in signal processing, power systems, communications, IoT, and robotics. • **ML Pipeline:** Data collection, preprocessing, feature engineering, model selection, evaluation metrics. • **Mathematical Foundations:** Linear algebra, probability, statistics review for ML. • **Data Preprocessing for EE Data:** Handling missing values, normalization, encoding, feature scaling. • **Model Evaluation Metrics:** Accuracy, precision, recall, F1-score, MSE, R^2, ROC-AUC.		
II	**Supervised Learning for EE Applications** • **Linear Regression:** Simple and multiple regression, regularization (Ridge, Lasso). • **Classification Algorithms:** Logistic regression, k-NN, decision trees, SVM. • **Ensemble Methods:** Random forest, gradient boosting, AdaBoost. • **Model Selection & Hyperparameter Tuning:** Cross-validation, grid search, random search. • **Case Studies in EE:** Load forecasting, fault detection in circuits, modulation classification, channel estimation.	1	25%
III	**Unsupervised Learning & Deep Learning Basics** • **Unsupervised Learning:** Clustering (k-means, hierarchical), dimensionality reduction (PCA, t-SNE). • **Introduction to Neural Networks:** Perceptron, multi-layer perceptron (MLP), activation functions. • **Deep Learning Architectures:** CNN for image/signal processing, RNN/LSTM for sequential data. • **Transfer Learning:** Using pre-trained models for EE tasks. • **Applications:** Signal denoising, anomaly detection in sensor data, spectrum sensing.	1	25%

IV	**ML Deployment & EE-Specific Applications**
	• **Edge AI:** Deploying ML models on microcontrollers (ARM Cortex, Raspberry Pi, Jetson Nano).
	• **Model Optimization:** Pruning, quantization, knowledge distillation.
	• **Real-Time ML Systems:** Latency, power consumption, memory constraints.
	• **EE-Specific Applications:**
	    ○ **Power Systems:** Load forecasting, fault diagnosis, renewable energy prediction.
	    ○ **Signal Processing:** EEG/ECG analysis, speech recognition, image processing.
		1	25%

	○ **Communications:** MIMO detection, beamforming, network optimization. ○ **Embedded Vision:** Object detection, facial recognition in embedded systems. • **Ethics & Fairness in ML for EE.**		

Textbooks:

- *Pattern Recognition and Machine Learning* – Christopher M. Bishop (Springer)
- *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow* – Aurélien Géron (O'Reilly)
- *Machine Learning: A Probabilistic Perspective* – Kevin P. Murphy (MIT Press)

Reference books:

- *The Elements of Statistical Learning* – Trevor Hastie, Robert Tibshirani, Jerome Friedman (Springer)
- *Deep Learning* – Ian Goodfellow, Yoshua Bengio, Aaron Courville (MIT Press)
- *Machine Learning for Signal Processing* – Max A. Little (Oxford University Press)
- *Embedded Machine Learning for IoT and Edge Computing* – Mohamed Abdel-Basset, Nour Moustafa (Springer)

Online Platforms:

- NPTEL:
  - *Machine Learning* – IIT Kharagpur
  - *Deep Learning* – IIT Madras
  - *Machine Learning for Wireless Communication* – IIT Hyderabad
- Coursera:
  - *Machine Learning* – Stanford University (Andrew Ng)
  - *Deep Learning Specialization*
  - *TensorFlow for AI, ML, and DL*

SEMESTER-VII

SUBJECT CODE: BTEE701

SUBJECT NAME: POWER SYSTEM PROTECTION

Course Objectives:

- To understand the principles, requirements, and philosophy of power system protection.
- To analyze and design protection schemes for generators, transformers, transmission lines, and busbars.
- To study different types of relays, circuit breakers, and their coordination.
- To develop skills in testing, setting, and maintaining protection systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the fundamentals of protection systems, relay characteristics, and coordination.
CO2	Design protection schemes for generators, transformers, and transmission lines.
C03	Apply knowledge of overcurrent, distance, differential, and pilot protection in power systems.
C04	Perform relay testing, setting calculations, and fault analysis in laboratory environments.

Unit	Content	Credit	Weightage
I	**Fundamentals of Power System Protection** • **Need for Protection:** System security, reliability, fault types and effects. • **Protection Philosophy:** Zones of protection, primary and backup protection, selectivity, sensitivity, speed. • **Relay Classification:** Electromechanical, static, digital/numerical relays. • **Relay Characteristics:** Time-current characteristics (IDMT, definite time), plug setting, time multiplier. • **Instrument Transformers:** CTs and PTs – construction, ratio, errors, burden, saturation.	1	25%
II	**Overcurrent & Distance Protection** • **Overcurrent Protection:** Principles, directional overcurrent relays, coordination in radial and ring systems. • **Distance Protection:** Impedance relays (MHO, reactance, offset MHO), three-zone step distance protection. • **Pilot Protection:** Transfer trip schemes, power line carrier communication (PLCC), fiber optic pilots. • **Protection of Feeders and Distribution Lines:** Fuse-recloser coordination, sectionalizers. • **Case Studies:** Protection of radial and interconnected systems.	1	25%
III	**Transformer, Generator & Busbar Protection** • **Transformer Protection:** Differential protection,	1	25%

	percentage differential relay, restricted earth fault protection, Buchholz relay. • **Generator Protection:** Stator and rotor faults, loss of excitation, negative sequence protection, over/under frequency. • **Busbar Protection:** High-impedance and low-impedance differential schemes. • **Motor Protection:** Overload, locked rotor, single-phasing, earth fault protection. • **Capacitor Bank and Reactor Protection.**		
IV	**Advanced Protection & Testing** • **Numerical Relays:** Architecture, advantages, communication capabilities (IEC 61850). • **Auto re closing:** Single-shot and multi-shot reclosing, high-speed reclosing. • **Protection Coordination Studies:** Software tools (ETAP, CAPE). • **Relay Testing:** Primary and secondary injection testing, commissioning, maintenance. • **Modern Trends:** Wide-area protection, adaptive relaying, AI/ML in protection.	1	25%

Textbooks:

- *Power System Protection and Switchgear* – B. Ravindranath & M. Chander (Wiley)
- *Protective Relaying: Principles and Applications* – J. Lewis Blackburn & Thomas J. Domin (CRC Press)
- *Power System Protection* – P. M. Anderson (Wiley)

Reference books:

- *Fundamentals of Power System Protection* – Y. G. Paithankar & S. R. Bhide (PHI Learning)
- *Digital Protection for Power Systems* – A. T. Johns & S. K. Salman (IET)
- *Protective Relaying Theory and Applications* – Walter A. Elmore (ABB)
- *Switchgear and Protection* – S. Rao (Khanna Publishers)

Online Platforms:

- NPTEL:
  - *Power System Protection* – IIT Kharagpur
  - *Digital Protection of Power Systems* – IIT Bombay
- Coursera:
  - *Power System Protection and Control* – University at Buffalo

Practical List:

Module 1: Relay Characteristics & CT/PT Testing

- Study of Electromechanical Overcurrent Relay – IDMT curve plotting.
- CT Testing – Ratio, polarity, and saturation tests.
- PT Testing – Ratio and phase angle error measurement.
- Time-Current Characteristic Verification of a relay using secondary injection.

Module 2: Overcurrent & Distance Protection

- Coordination of Overcurrent Relays in a radial distribution system.
- Directional Overcurrent Relay Testing for forward/reverse faults.
- Distance Relay Testing – impedance measurement and zone setting.

- Simulation of Three-Zone Distance Protection using MATLAB/ETAP.

Module 3: Transformer & Generator Protection

- Differential Protection of Transformer using relay test kit.
- Buchholz Relay Testing and gas analysis simulation.
- Generator Protection – loss of excitation and negative sequence relay testing.
- Restricted Earth Fault Protection for transformer/generator.

Module 4: Advanced Testing & System Studies

- Numerical Relay Programming and setting using relay software (e.g., SEL AcSELerator).
- Auto-Reclosing Scheme Testing for transmission line protection.
- Protection Coordination Study for a small power system using software.
- Final Project: Design and testing of a complete protection scheme for a microgrid or substation.

SUBJECT CODE: BTEE702

SUBJECT NAME: SMART GRID TECHNOLOGIES

Course Objectives:

- To introduce the concepts, architecture, and components of smart grids.
- To analyze the integration of renewable energy, energy storage, and electric vehicles into smart grids.
- To study communication technologies, data management, and cybersecurity in smart grids.
- To develop skills in designing, simulating, and managing smart grid systems.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the architecture, components, and functionalities of smart grids.
CO2	Analyze the integration of distributed energy resources (DERs) and energy storage systems.
C03	Apply communication protocols and data analytics for smart grid operation.
C04	Design and simulate smart grid systems with focus on automation and cybersecurity.

Unit	Content	Credit	Weightage
I	**Introduction to Smart Grid** • **Evolution of Power Grids:** Traditional grid vs. smart grid, drivers for smart grid. • **Smart Grid Architecture:** Layers (physical, communication, application), interoperability. • **Key Components:** Smart meters, sensors, actuators, Phasor Measurement Units (PMUs), IoT devices. • **Smart Grid Standards:** IEEE, IEC, NIST framework. • **Benefits and Challenges:** Reliability, efficiency, sustainability, cost, privacy, and security.	1	25%
II	**Renewable Integration & Energy Management** • **Distributed Energy Resources (DERs):** Solar PV, wind, microgrids, virtual power plants. • **Energy Storage Systems:** Batteries, flywheels, supercapacitors, pumped hydro.	1	25%

	• **Demand Response (DR) & Demand-Side Management (DSM):** Load shifting, peak shaving, dynamic pricing. • **Electric Vehicles (EVs) and V2G (Vehicle-to-Grid):** Charging infrastructure, grid impact, V2G technology. • **Microgrids:** Operation, control, islanding, and grid-tied modes.		
III	**Communication & Data Management in Smart Grid** • **Communication Technologies:** Wired (PLC, fiber) and wireless (Zigbee, Wi-Fi, LoRaWAN, 5G). • **Protocols:** IEC 61850, DNP3, Modbus, MQTT. • **SCADA & Advanced Metering Infrastructure (AMI):** Architecture, smart metering, data collection. • **Big Data & Analytics:** Data acquisition, processing, predictive maintenance, fault detection. • **Cybersecurity:** Threats, encryption, authentication, intrusion detection systems (IDS).	1	25%
IV	**Smart Grid Operation, Automation & Future Trends** • **Wide-Area Monitoring Systems (WAMS):** PMUs, synchrophasors, state estimation. • **Distribution Automation:** Fault location, isolation, and service restoration (FLISR). • **Smart Grid Control:** Volt/VAR optimization, frequency regulation, grid resilience. • **Smart Cities & IoT Integration:** Smart homes, smart lighting, intelligent transportation. • **Future Trends:** Blockchain for energy trading, AI/ML in grid management, digital twins, grid modernization initiatives	1	25%

Textbooks:

- *Smart Grid: Fundamentals of Design and Analysis* – James Momoh (Wiley-IEEE Press)
- *Smart Grids: Infrastructure, Technology, and Solutions* – Stuart Borlase (CRC Press)
- *Smart Grid: Technology and Applications* – Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, et al. (Wiley)

Reference books:

- *The Smart Grid: Enabling Energy Efficiency and Demand Response* – Clark Gellings (CRC Press)
- *Renewable and Efficient Electric Power Systems* – Gilbert M. Masters (Wiley)
- *Smart Grids: Advanced Technologies and Solutions* – Stephen F. Bush (Springer)
- *Cybersecurity for Smart Grids* – Eric D. Knapp & Raj Samani (Syngress)

Online Platforms:

- NPTEL:
  - *Smart Grid Technology* – IIT Kharagpur
  - *Microgrids and Distributed Generation* – IIT Madras
- Coursera:
  - *Smart Grids* – University at Buffalo
  - *Electric Power Systems* – University at Buffalo

Practical List:

Module 1: Smart Grid Components & Architecture

- Study of Smart Meter Architecture and data communication (using a smart meter simulator).
- Phasor Measurement Unit (PMU) Setup and real-time data visualization.
- Interfacing IoT Sensors (voltage, current, temperature) with a microcontroller (Raspberry Pi/Arduino).
- Design of a Basic Smart Grid Architecture using simulation software.

Module 2: Renewable Integration & Energy Storage

- Simulation of a PV-Wind Hybrid System integrated with the grid using MATLAB/Simulink.
- Battery Energy Storage System (BESS) Modeling and charge/discharge control.
- Demand Response Simulation – load shifting using dynamic pricing models.
- EV Charging Station Integration and impact analysis on distribution grid.

Module 3: Communication & Cybersecurity

- Implementation of a Smart Grid Communication Network using Zigbee/LoRa modules.
- SCADA System Simulation for remote monitoring and control of a microgrid.
- Cybersecurity Attack Simulation on a smart grid network (using tools like Wireshark).
- Data Analytics for Fault Detection using machine learning (Python/MLlib).

Module 4: Automation & Smart Applications

- Distribution Automation (FLISR) Simulation using OpenDSS or ETAP.
- Volt/VAR Optimization in a distribution feeder with capacitor banks and voltage regulators.
- Smart Home Energy Management System design using IoT and cloud platforms (e.g., ThingSpeak, AWS IoT).
- Final Project: Design and simulation of a campus microgrid with renewable integration, storage, demand response, and cybersecurity measures.

SUBJECT CODE: BTEE703

SUBJECT NAME: IOT FOR ELECTRICAL SYSTEMS

Course Objectives:

- To introduce Internet of Things (IoT) concepts and their applications in electrical engineering.
- To understand IoT architecture, sensors, communication protocols, and cloud platforms for electrical systems.
- To develop skills in designing, implementing, and managing IoT-based monitoring and control systems for power systems, smart grids, and electrical appliances.
- To analyze data from IoT devices for predictive maintenance, energy management, and fault detection.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain IoT architecture and its components relevant to electrical systems.
CO2	Design IoT-based systems for monitoring and controlling electrical parameters.
C03	Implement communication protocols and cloud integration for IoT-enabled electrical applications.
C04	Analyze IoT data for energy optimization, fault diagnosis, and predictive maintenance.

Unit	Content	Credit	Weightage

I	**Introduction to IoT in Electrical Systems** • **IoT Fundamentals:** Definition, architecture (perception, network, application layers), and enabling technologies. • **IoT in Electrical Engineering:** Applications in smart grids, energy management, industrial automation, and home automation. • **Sensors and Actuators for Electrical Systems:** Voltage, current, temperature, humidity, power quality sensors; relays, contactors. • **IoT Hardware Platforms:** Arduino, Raspberry Pi, ESP32, NodeMCU for electrical applications. • **Case Studies:** IoT in substation monitoring, smart meters, and renewable energy systems.	1	25%
II	**IoT Communication Protocols & Networking** • **Wired and Wireless Communication Protocols:** MQTT, CoAP, HTTP, AMQP. • **Wireless Technologies:** Wi-Fi, Bluetooth (BLE), Zigbee, LoRaWAN, NB-IoT for electrical systems. • **Network Topologies:** Star, mesh, hybrid topologies for IoT networks. • **Data Acquisition and Edge Computing:** Local data processing, edge devices, fog computing. • **IoT Gateways:** Role, architecture, and implementation for electrical systems.	1	25%
III	**Cloud Platforms & Data Management** • **IoT Cloud Platforms:** AWS IoT, Google Cloud IoT, Azure IoT Hub, ThingSpeak, Ubidots. • **Data Storage and Management:** Time-series databases (InfluxDB), SQL/NoSQL databases. • **Data Visualization:** Dashboards using Grafana, Node-RED, custom web interfaces. • **IoT Security:** Encryption, authentication, secure boot, cybersecurity threats and mitigation. • **Scalability and Reliability:** Handling large-scale IoT deployments in electrical grids.	1	25%
IV	**Applications & Implementation** • **Smart Metering and Energy Monitoring:** Real-time energy consumption tracking, billing automation. • **Predictive Maintenance:** Condition monitoring of transformers, motors, and switchgear using IoT. • **Fault Detection and Diagnosis:** IoT-based systems for detecting faults in power lines and equipment. • **Integration with Smart Grids:** Demand response, load forecasting, grid stability using IoT data. • **Project Development:** End-to-end IoT system design for a specific electrical engineering application.	1	25%

Textbooks:

- *Internet of Things: A Hands-On Approach* – Arshdeep Bahga & Vijay Madisetti (VPT)

- *IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things* – David Hanes, Gonzalo Salgueiro, Patrick Grossetete, et al. (Cisco Press)
- *Building IoT with ESP32 and MQTT: A Hands-On Guide* – Vedat Ozan Oner (Packt)

Reference books:

- *IoT and Edge Computing for Architects* – Perry Lea (Packt)
- *Smart Grids: Infrastructure, Technology, and Solutions* – Stuart Borlase (CRC Press) – IoT sections.
- *Practical Industrial Internet of Things Security* – Sravani Bhattacharjee (Packt)
- *The Internet of Things: Enabling Technologies, Platforms, and Use Cases* – Pethuru Raj & Anupama C. Raman (CRC Press)

Online Platforms:

- NPTEL:
  - *Internet of Things* – IIT Kharagpur
  - *IoT and Applications* – IIT Bombay
- Coursera:
  - *IoT (Internet of Things) Specialization* – University of California, Irvine
  - *Introduction to the Internet of Things and Embedded Systems* – University of California, Irvine

SUBJECT CODE**: BTEE704**

SUBJECT NAME: INDUSTRY 4.0 AND AUTOMATION

Course Objectives:

- To introduce the core concepts, technologies, and frameworks of Industry 4.0.
- To understand smart manufacturing, industrial IoT (IIoT), and cyber-physical systems (CPS).
- To develop skills in designing, simulating, and implementing automation systems using sensors, PLCs, and robotics.
- To apply data analytics, AI, and cloud computing in industrial automation scenarios.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the pillars of Industry 4.0 and their impact on manufacturing and automation.
CO2	Design and interface industrial sensors, actuators, and PLC-based control systems.
C03	Implement IIoT solutions for data acquisition, monitoring, and control.
C04	Develop AI-driven automation systems and simulate smart factory workflows.

PRACTICAL LIST:

Module 1: Introduction to Industry 4.0 & Smart Sensors

- Lab 1: Study of Industry 4.0 architecture: CPS, IoT, cloud, and AI integration.
- Lab 2: Interfacing industrial sensors (temperature, proximity, pressure) with Arduino/Raspberry Pi.
- Lab 3: Data acquisition from multiple sensors using DAQ modules (e.g., NI USB-6000).
- Lab 4: Wireless sensor network setup using Zigbee/LoRa for industrial monitoring.

Module 2: PLC Programming & Industrial Automation

- Lab 5: Introduction to PLC ladder logic programming (using Siemens/Allen-Bradley simulators).
- Lab 6: Design of a conveyor belt control system with sensors and actuators using PLC.
- Lab 7: Motor control (AC/DC) using VFD and PLC interface.
- Lab 8: HMI (Human-Machine Interface) design for monitoring industrial processes.

Module 3: Industrial IoT (IIoT) & Cloud Integration

- Lab 9: Setting up an IIoT node with ESP32/Arduino for temperature and vibration monitoring.
- Lab 10: Data transmission to cloud platforms (AWS IoT/Thing Speak/Ubidots).
- Lab 11: Real-time dashboard creation for industrial data visualization (Grafana/Node-RED).
- Lab 12: MQTT/HTTP-based communication between edge devices and cloud.

Module 4: Robotics, AI & Smart Factory Simulation

- Lab 13: Programming a robotic arm (e.g., Dobot/UR simulator) for pick-and-place tasks.
- Lab 14: Machine vision for quality inspection using OpenCV/Python (defect detection).
- Lab 15: Predictive maintenance using vibration analysis and machine learning (scikit-learn).
- Lab 16: Mini-project – Design and simulate a smart factory cell integrating PLC, IIoT, and robotics.

TOOLS & EQUIPMENT REQUIRED

Hardware:

- PLC Trainer Kits (Siemens S7-1200/Allen-Bradley MicroLogix)
- Industrial Sensors (Temperature, Pressure, Proximity, Vibration)
- Actuators (Solenoid valves, DC/Stepper motors, relays)
- Microcontrollers (Arduino, Raspberry Pi, ESP32)
- Robotic Arm Kit (Dobot Magician/UR simulator)
- DAQ Modules (NI USB-6000, Advantech)
- Wireless Modules (Zigbee, LoRa, Wi-Fi, Bluetooth)

Software:

- PLC Simulators: Siemens TIA Portal, RSLogix 500/5000, CODESYS
- IIoT Platforms: AWS IoT Core, Thing Speak, Ubidots
- Visualization: Node-RED, Grafana, MATLAB Dashboard
- Automation & Simulation: Factory I/O, MATLAB/Simulink, RoboDK
- AI/ML Tools: Python (OpenCV, scikit-learn, TensorFlow Lite)
- Communication Protocols: MQTT, OPC-UA, Modbus TCP/IP

SEMESTER-VIII

SUBJECT CODE: BTEE801

SUBJECT NAME: RESEARCH METHDOLOGY IN EE

Course Objectives:

- To introduce the principles, processes, and ethics of scientific research in electrical engineering.
- To develop skills in formulating research problems, conducting literature reviews, and designing experiments.
- To apply statistical and computational methods for data analysis, validation, and interpretation in EE research.
- To prepare and present research findings through technical writing, visualization, and academic publishing.

Course Outcomes: At the end of the course students shall be able to

CO1	Formulate clear, researchable problems and design valid experimental studies in EE.
CO2	Conduct systematic literature reviews, identify research gaps, and synthesize existing work.
C03	Apply statistical and computational methods for hypothesis testing and result validation in EE research.
C04	Communicate research findings effectively through reports, papers, and presentations following academic and ethical standards.

Unit	Content	Credit	Weightage
I	**Foundations of Research in EE** • **Introduction to Research:** Types of research (fundamental, applied, experimental, simulation-based) in electrical engineering. • **Research Ethics in EE:** Data integrity, plagiarism, authorship, intellectual property rights (IPR), responsible conduct of research. • **Literature Review & Survey:** Searching databases (IEEE Xplore, Scopus, Google Scholar), citation management (Zotero, Mendeley). • **Research Problem Formulation:** Defining objectives, hypotheses, variables (independent, dependent, control). • **Research Funding & Grants:** Overview of funding agencies (SERB, DST, IEEE, industry grants.	1	25%
II	**Research Design & Experimental Methods** • **Experimental Design in EE:** Between-subjects, within-subjects, factorial designs, quasi-experiments. • **Sampling & Data Collection:** Probability vs. non-probability sampling, sample size determination (power analysis). • **Data Sources for EE Research:** Public datasets (UCI, Kaggle), simulation data (MATLAB, PSCAD, HFSS), hardware testbeds. • **Statistical Methods for EE:** Descriptive statistics, inferential statistics (t-test, ANOVA, chi-square), Bayesian methods.	1	25%

	• **Tools for Experimentation:** MATLAB, Python (SciPy, StatsModels), LabVIEW, simulation tools.		
III	**EE Research Techniques & Implementation** • **Model Development & Validation:** Cross-validation, hyperparameter tuning, benchmarking. • **Reproducibility in EE Research:** Code sharing (GitHub), containerization (Docker), environment replication. • **Advanced Research Methods:** Ablation studies, counterfactual analysis, causal inference in ML for EE. • **Simulation & Hardware Testbeds:** NS-3 for networks, HFSS/CST for EM, FPGA/ARM for embedded research. • **Human-Centered EE Research:** User studies, A/B testing, qualitative analysis in HCI and wearable tech.	1	25%
IV	**Dissemination & Future Trends** • **Technical Writing:** Structure of research papers (abstract, introduction, methodology, results, discussion). • **Academic Publishing:** Journal/conference selection (IEEE, IET, Elsevier), submission process, peer review. • **Research Presentation:** Conference talks, poster sessions, demo presentations. • **EE Research Trends:** AI/ML in communications, 6G, quantum computing, neuromorphic engineering, sustainable electronics. • **Career Paths in EE Research:** Academia vs. industry, research internships, PhD preparation.	1	25%

Textbooks:

- *Research Methodology: A Step-by-Step Guide for Beginners* – Ranjit Kumar (Sage)
- *Doing Your Research Project: A Guide for First-Time Researchers* – Judith Bell (Open University Press)
- *The Craft of Research* – Wayne C. Booth, Gregory G. Colomb, & Joseph M. Williams (University of Chicago Press)

Reference books:

- *Research Methods in Engineering* – A. Srinivasan (Cambridge University Press)
- *Experimental Methods for Engineers* – J. P. Holman (McGraw Hill)
- *How to Write and Publish a Scientific Paper* – Barbara Gastel & Robert A. Day (Cambridge University Press)
- *Design and Analysis of Experiments* – Douglas C. Montgomery (Wiley)

Online Platforms:

- NPTEL:
  - *Research Methodology* – IIT Madras
  - *Technical Writing* – IIT Bombay
  - *Data Analysis for Engineers* – IIT Kanpur
- Coursera:

- *Writing and Editing: Word Choice and Word Order* – University of Michigan
- *Introduction to Systematic Review and Meta-Analysis* – Johns Hopkins University

SUBJECT CODE: BTEE802

SUBJECT NAME: ELECTRICAL SYSTEM DESIGN

Course Objectives:

- To understand the principles, standards, and methodologies for designing electrical systems for residential, commercial, and industrial applications.
- To develop skills in load estimation, equipment selection, protection design, and compliance with electrical codes and standards.
- To design power distribution systems, lighting systems, earthing, and lightning protection.
- To prepare electrical drawings, specifications, and project documentation using modern design tools.

Course Outcomes: At the end of the course students shall be able to

CO1	Estimate electrical loads and design electrical systems as per standards (IS, NEC, IEC).
CO2	Select appropriate cables, switchgear, transformers, and protective devices for given applications.
C03	Design lighting, earthing, and lightning protection systems.
C04	Create electrical drawings, specifications, and project documentation using CAD tools.

Unit	Content	Credit	Weightage
I	**Fundamentals of Electrical System Design** • **Introduction to Electrical Design:** Scope, objectives, stages of design (concept to commissioning). • **Electrical Codes and Standards:** IS, NEC, IEC, IEEE standards for design and safety. • **Load Estimation and Calculation:** Diversity factor, demand factor, load types (lighting, power, HVAC), load scheduling. • **Single-Line Diagrams (SLD):** Symbols, layout, interpretation, and creation. • **Design Software Overview:** AutoCAD Electrical, ETAP, Dialux, Revit MEP.	1	25%
II	**Power Distribution System Design** • **Distribution System Layout:** Radial, ring, network systems for LV and MV distribution. • **Cable Selection and Sizing:** Current carrying capacity, voltage drop, short-circuit rating, derating factors. • **Switchgear Selection:** MCBs, MCCBs, ACBs, isolators, contactors, selection criteria. • **Transformer Sizing and Selection:** Rating, impedance, losses, cooling, protection. • **Protection Coordination:** Overcurrent, earth fault,	1	25%

	differential protection settings.		
III	**Illumination Design & Special Systems** • **Illumination Fundamentals:** Luminous flux, illuminance, glare, color rendering index (CRI). • **Lighting Design:** Indoor (offices, industries) and outdoor (street lighting) using lumen method, point-by-point method. • **Energy-Efficient Lighting:** LED, CFL, control systems (sensors, dimmers). • **Earthing System Design:** Types of earthing (TT, TN, IT), earth resistance calculation, electrode design. • **Lightning Protection:** Risk assessment, air terminals, down conductors, earthing for lightning.	1	25%
IV	**System Integration & Project Documentation** • **Substation Design:** Layout, equipment arrangement, clearances, safety. • **Emergency and Standby Systems:** UPS, generators, battery banks, ATS design. • **Power Quality and Harmonics:** Mitigation techniques, filters, power factor correction. • **Project Documentation:** Bill of materials (BOM), cost estimation, tender documents, as-built drawings. • **Case Studies:** Design of electrical systems for a residential building, commercial complex, and industrial plant.	1	25%

Textbooks:

- *Electrical Design Estimating and Costing* – K. B. Raina (McGraw Hill)
- *Electrical Power System Design* – M. K. Giridharan (IK International)
- *Wiring Regulations in Brief* – Ray Tricker (Routledge)

Reference books:

- *Handbook of Electrical Design Details* – Neil Sclater & John E. Traister (McGraw Hill)
- *Industrial Power Distribution* – Ralph E. Fehr (Wiley-IEEE Press)
- *Lighting Design Basics* – Mark Karlen & Christina Spangler (Wiley)
- *IEEE Red Book* (IEEE Std 141) – Recommended Practice for Electric Power Distribution for Industrial Plants.

Online Platforms:

- NPTEL:
  - *Electrical System Design* – IIT Kharagpur
  - *Power System Design and Analysis* – IIT Bombay
- Coursera:
  - *Electrical Power Distribution* – University at Buffalo

Practical List:

Module 1: Load Estimation & Single-Line Diagram

- Load Estimation for a Residential Building – preparation of load schedule.
- Design of Single-Line Diagram (SLD) for a small industry using AutoCAD Electrical.
- Calculation of Diversity Factor and Demand Factor for a commercial complex.

- Study of Electrical Symbols and Standards (IS, IEC).

Module 2: Cable & Protection Design

- Cable Sizing for a Three-Phase Motor considering current rating and voltage drop.
- Selection of Protective Devices (MCB, MCCB, Fuse) for a distribution board.
- Transformer Sizing for a given load and calculation of losses.
- Protection Coordination Study using ETAP or manual calculation.

Module 3: Lighting & Earthing Design

- Illumination Design for a Classroom/Office using lumen method and Dialux software.
- Design of Street Lighting System for a 500m road stretch.
- Earthing Design for a substation – calculation of earth resistance and electrode layout.
- Lightning Protection System Design for a high-rise building.

Module 4: Integrated Project

- Complete Electrical Design of a Small Workshop – SLD, lighting, earthing, cable schedule.
- Design of an LT Panel with protection devices and metering.
- Cost Estimation and Bill of Materials (BOM) preparation for the designed system.
- Final Project: Comprehensive electrical system design for a 3-storey commercial building including distribution, lighting, earthing, and protection.

SUBJECT CODE: BTEE803

SUBJECT NAME: EMBEDDED SYSTEMS FOR EE

Course Objectives:

- To introduce the architecture, design, and development of embedded systems for electrical engineering applications.
- To develop skills in programming microcontrollers and interfacing sensors, actuators, and communication modules.
- To design and implement embedded solutions for power systems, motor control, instrumentation, and IoT in EE.
- To integrate embedded systems with real-time operating systems (RTOS) and cloud platforms.

Course Outcomes: At the end of the course students shall be able to

CO1	Explain the architecture and components of embedded systems and microcontrollers.
CO2	Program microcontrollers in C/Embedded C for data acquisition, control, and communication.
C03	Interface sensors, actuators, and communication modules with embedded platforms.
C04	Design and deploy embedded systems for EE applications such as smart metering, motor control, and grid monitoring.

Unit	Content	Credit	Weightage
I	**Introduction to Embedded Systems for EE** • **Embedded Systems Basics:** Definition, characteristics, applications in electrical engineering. • **Microcontroller Architecture:** 8051, PIC, AVR, ARM Cortex-M series overview. • **Embedded Development Tools:** IDEs (Keil,	1	25%

	MPLAB, STM32Cube), compilers, debuggers, simulators. • **Embedded C Programming:** Syntax, memory management, pointers, bitwise operations. • **Case Studies:** Embedded systems in smart meters, protection relays, power quality monitors.		
II	**Interfacing and Communication Protocols** • **Sensors and Actuators Interfacing:** Temperature, current, voltage sensors; relays, motors, displays. • **Analog and Digital I/O:** ADC, DAC, PWM generation for motor control. • **Communication Protocols:** UART, SPI, I2C, CAN, Modbus for industrial applications. • **Wireless Communication:** Bluetooth, Wi-Fi, Zigbee, LoRa for remote monitoring. • **Real-Time Clock and Timers:** Scheduling, interrupt handling, time-critical operations.	1	25%
III	**Embedded System Design for EE Applications** • **Power System Monitoring:** Embedded-based data loggers, fault recorders, energy meters. • **Motor Control Systems:** Speed control of DC/AC motors using microcontrollers. • **Protection and Automation:** Implementation of overcurrent, undervoltage protection in embedded systems. • **Grid-Tied Systems:** Inverter control, MPPT for solar systems using embedded controllers. • **Human-Machine Interface (HMI):** LCD, touchscreen interfacing for control panels.	1	25%
IV	**Advanced Topics and System Integration** • **Real-Time Operating Systems (RTOS):** Task scheduling, semaphores, message queues using Free RTOS. • **Embedded Linux:** Basics for high-performance applications (Raspberry Pi, BeagleBone). • **IoT Integration:** Connecting embedded systems to cloud platforms (AWS IoT, Thing Speak). • **Security in Embedded Systems:** Encryption, secure boot, firmware updates. • **Project Lifecycle:** Design, prototyping, testing, and deployment of an embedded EE system.	1	25%

Textbooks:

- *Embedded Systems: Architecture, Programming and Design* – Raj Kamal (McGraw Hill)
- *Introduction to Embedded Systems: Using Microcontrollers and the MSP430* – Manuel Jiménez, Rogelio Palomera, Isidoro Couvertier (Springer)
- *Making Embedded Systems: Design Patterns for Great Software* – Elecia White (O'Reilly)

Reference books:

- Embedded C Programming and the Microchip PIC – Richard H. Barnett, Sarah Cox, Larry O'Cull (Cengage)
- ARM System Developer's Guide – Andrew N. Sloss, Dominic Symes, Chris Wright (Morgan

Kaufmann)
- Real-Time Concepts for Embedded Systems – Qing Li, Caroline Yao (CMP Books)
- Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C – Yifeng Zhu (E-Man Press)

Online Platforms:
- NPTEL:
  - *Embedded Systems* – IIT Delhi
  - *Microprocessors and Microcontrollers* – IIT Kharagpur
- Coursera:
  - *Embedded Systems Essentials with ARM* – ARM Education
  - *Introduction to Embedded Systems Software and Development Environments* – University of Colorado Boulder

Practical List:

Module 1: Microcontroller Programming & Basic I/O
- LED Blinking and Pattern Generation using GPIO on Arduino/STM32.
- Interfacing LCD Display (16x2) to display sensor data.
- ADC Programming – reading analog voltage from a potentiometer.
- PWM Generation for LED dimming or motor speed simulation.

Module 2: Sensor Interfacing & Communication
- Temperature Monitoring System using LM35 and microcontroller.
- Current and Voltage Sensing using ACS712 and voltage divider.
- UART Communication between microcontroller and PC (serial monitor).
- I2C Communication – interfacing RTC (DS1307) with microcontroller.

Module 3: Control Applications in EE
- Speed Control of DC Motor using PWM and L298 motor driver.
- Relay-Based Load Control – switching AC loads using microcontroller.
- Energy Meter Simulation – pulse counting from a sensor to calculate kWh.
- Overcurrent Protection Simulation using current sensor and relay.

Module 4: Advanced Integration & IoT
- Wi-Fi Based Data Logging – sending sensor data to ThingSpeak using ESP32.
- RTOS Implementation – multi-tasking for sensor reading and motor control using FreeRTOS.
- CAN Bus Communication between two microcontrollers (simulating automotive/grid communication).
- Final Project: Design an embedded system for smart energy monitoring with local display, cloud connectivity, and relay control.