MK UNIVERSITY

PATAN, GUJARAT

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

MK University, Patan
Faculty of Engineering Technology,
Department of Electronics & Communication Engineering (ECE)

B. TECH (ELCETRONICS & COMMUNICATION 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	BTECE101	ENGINEERING MATHEMATICS-I	4	0	4	40	60	100
2	MAJOR	BTECE102	PROGRAMING FOR ENGINEERS (PYTHON)	4	2	6	90	60	150
3	MAJOR	BTECE103	BASIC ELECTRONICS	4	2	6	90	60	150
4	MINOR	BTECE104	ENGINEERING PHYSICS	4	0	4	40	60	100
5	VAC	BTECE105	COMMUNICATION SKILL-I	2	0	2	0	50	50
TOTAL				18	4	22	260	290	550

B. TECH (ELCETRONICS & COMMUNICATION 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	BTECE201	ENGINEERING MATHEMATICS-II	4	0	4	40	60	100
2	MAJOR	BTECE202	DIGITAL LOGIC DESIGN	4	2	6	90	60	150
3	MAJOR	BTECE203	NETWORK ANALYSIS	4	2	6	90	60	150
4	MINOR	BTECE204	ENGINEERING CHEMISTRY	4	0	4	40	60	100
5	VAC	BTECE205	ENVIRONMENTAL SCIENCE	2	0	2	0	50	50
TOTAL				18	4	22	260	290	550

B. TECH (ELCETRONICS & COMMUNICATION ENGINEERING) SEM-III

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTECE301	ELECTRONIC DEVICES & CIRCUITS	4	2	6	90	60	150
2	MAJOR	BTECE302	SIGNALS & SYSTEMS	4	0	4	40	60	100
3	MAJOR	BTECE303	ELECTROMAGNETIC THEORY	4	0	4	40	60	100
4	MINOR	BTECE304	DATA STRUCTURES & ALGORITHMS	4	2	6	90	60	150
5	SEC	BTECE305	PCB DESIGN & FABRICATION	0	2	2	00	50	50
TOTAL				16	6	22	260	290	550

B. TECH (ELCETRONICS & COMMUNICATION ENGINEERING) SEM-IV

SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTECE401	ANALOG AND DIGITAL COMMUNICATION	4	2	6	90	60	150
2	MAJOR	BTECE402	MICRPROCESSORS & MICRCONTROLLERS	4	2	6	90	60	150
3	MAJOR	BTECE403	CONTROL SYSTEMS	4	0	4	40	60	100
4	MINOR	BTECE404	COMPUTER NETWORKS	4	0	4	40	60	100
5	SEC	BTECE405	Indian Constitution	2	0	2	0	50	50
TOTAL				18	4	22	260	290	550

B. TECH (ELCETRONICS & COMMUNICATION ENGINEERING) SEM-V

SR NO.	COURSE TYPE	COURSE CODE	CUORSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	BTECEE501	DIGITAL SIGNAL PROCESSING	4	2	6	90	60	150
2	MAJOR	BTECE502	VLSI DESIGN	4	2	6	90	60	150
3	MAJOR	BTECE503	ANTTNA & WAVE PROPOGATION	4	0	4	40	60	100
4	MINOR	BTECE504	IOT & SENSOR NETWORKS	4	0	4	40	60	100
5	VAC	BTECE505	MINI-PROJECT	0	4	4	50	00	50
TOTAL				16	8	24	310	240	550

B. TECH (ELCETRONICS & COMMUNICATION 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	BTECE601	WIRELESS COMMUNICATION	4	0	4	40	60	100
2	MAJOR	BTECE602	OPTICAL COMMUNICATION	4	2	6	90	60	150
3	MAJOR	BTECE603	RF & MICROWAVE ENGINEERING	4	2	6	90	60	150
4	MINOR	BTECE604	MACHINE LEARNING FOR ECE	4	0	4	40	60	100
5	SEC	BTECE605	APTITUDE & CARRER SKILLS	0	2	2	50	0	50
TOTAL				16	6	22	250	300	550

B. TECH (ELCETRONICS & COMMUNICATION 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	BTECE701	SATELLITE COMMUNICATION	4	2	6	90	60	150
2	MAJOR	BTECE702	ADVANCED VLSI DESIGN	4	2	6	90	60	150
3	MINOR	BTECE703	AI IN ECE	4	0	4	40	60	100
4	SEC	BTECE704	INDUSTRY 4.O & AUTOMATION	0	2	2	00	50	50
5	VAC	BTECE705	Project Phase-I	0	4	4	100	00	100
TOTAL				12	10	22	220	230	550

B. TECH (ELCETRONICS & COMMUNICATION ENGINEERING) SEM-VIII

SR NO.	COURSE TYPE	COURSE CODE	CUORSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERN AL	EXTERNAL	
1	MAJOR	BTECE801	RESEARCH METHDOLOGY IN ECE	4	0	4	40	60	100
2	MAJOR	BTECE802	TELECOM NETWORK MANAGEMENT	4	2	6	90	60	150
3	MINOR	BTECE803	EMBEDDED SYSTEMS DESIGN	4	2	6	90	60	150
4	SEC	BTECE804	Project Phase-II	0	10	10	100	100	200
TOTAL				12	14	26	320	280	600

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SUBJECT CODE: BTECE101

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: BTECE102

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

- To introduce Python as the primary programming language for ECE.
- 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 ECE 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	1	25%

	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.		
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.

SUBJECT CODE: BTECE103

SUBJECT NAME: BASIC ELECTRONICS

Course Objectives:

- To introduce fundamental concepts of electronic components, circuits, and systems.
- To develop an understanding of semiconductor devices, diodes, transistors, and their applications.
- To analyse and design basic analog and digital electronic circuits.
- To provide hands-on experience in building, testing, and troubleshooting electronic circuits.

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 design rectifier, amplifier, and oscillator circuits using diodes and transistors.
C03	Understand the fundamentals of operational amplifiers and their linear/non-linear applications.
C04	Build, test, and debug basic electronic circuits in a laboratory environment.

Unit	Content	Credit	Weightage
I	**Semiconductor Devices & Diodes** • **Introduction to Semiconductors:** Energy bands, intrinsic & extrinsic semiconductors, PN junction. • **PN Junction Diode:** Forward & reverse bias, VI characteristics, breakdown mechanisms. • **Diode Applications:** Half-wave & full-wave rectifiers, filters, clippers, clampers. • **Special Diodes:** Zener diode, LED, photodiode, varactor diode.	1	25%
II	**Bipolar Junction Transistors (BJTs)** • **BJT Structure & Operation:** NPN & PNP transistors, current components, configurations (CE, CB, CC). • **Biasing & Stabilization:** Fixed bias, voltage divider	1	25%

	bias, thermal runaway. • **Small Signal Analysis:** Hybrid model, h-parameters, CE amplifier analysis. • **Applications:** Switch, amplifier basics.		
III	**Field Effect Transistors (FETs) & Amplifiers** • **JFET & MOSFET:** Structure, operation, characteristics (drain & transfer). • **Biasing of FETs:** Fixed bias, self-bias, voltage divider bias. • **FET Amplifiers:** Common source amplifier, small signal model. • **Differential Amplifiers & Op-Amps:** Introduction, ideal characteristics.	1	25%
IV	**Operational Amplifiers & Applications** • **Op-Amp Basics:** Ideal vs practical, open-loop & closed-loop configurations. • **Linear Applications:** Inverting & non-inverting amplifiers, summing, differential, integrator, differentiator. • **Non-linear Applications:** Comparator, zero-crossing detector, Schmitt trigger. • **Oscillators:** Feedback concept, RC phase shift, Wein bridge oscillators.	1	25%

Textbooks:

- Electronic Devices and Circuit Theory – Robert L. Boylestad & Louis Nashelsky
- Microelectronic Circuits – Adel S. Sedra & Kenneth C. Smith
- Basic Electronics and Linear Circuits – N. N. Bhargava, D. C. Kulshreshtha, S. C. Gupta

Reference books:

- Electronic Principles – Albert Paul Malvino & David J. Bates
- Fundamentals of Electronic Devices and Circuits – David A. Bell
- Principles of Electronics – V. K. Mehta & Rohit Mehta
- Electronics: Fundamentals and Applications – John D. Ryder

Online Platforms:

- NPTEL: *Basic Electronics* by IIT Madras
- Coursera: *Introduction to Electronics* – Georgia Tech
- edX: *Electronics for Everyone* – MIT

PRACTICAL LIST:

- Lab 1: Study of PN junction diode VI characteristics.
- Lab 2: Design and testing of half-wave and full-wave rectifiers.
- Lab 3: Zener diode as voltage regulator.
- Lab 4: Clipper and clamper circuits.
- Lab 5: BJT characteristics (input & output) in CE configuration.
- Lab 6: BJT biasing circuits (fixed bias & voltage divider bias).
- Lab 7: Single-stage CE amplifier – frequency response.
- Lab 8: BJT as a switch (driving LED/relay).
- Lab 9: JFET/MOSFET drain and transfer characteristics.
- Lab 10: Common source FET amplifier.

- Lab 11: MOSFET as a switch.
- Lab 12: Differential amplifier using BJTs.
- Lab 13: Op-amp inverting & non-inverting amplifiers.
- Lab 14: Op-amp summing amplifier and integrator.
- Lab 15: Op-amp comparator and Schmitt trigger.
- Lab 16: RC phase shift oscillator using op-amp.

SUBJECT CODE: BTECE104

SUBJECT NAME: ENGINEERING PHYSICS

Course Objectives:

- To provide a foundation in fundamental physics concepts relevant to electronics and communication engineering.
- To understand wave optics, quantum mechanics, semiconductor physics, and electromagnetism.
- To apply physical principles in the design and analysis of electronic devices and communication systems.
- To develop problem-solving skills through theoretical and practical applications of physics in engineering**.**

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

CO1	Explain wave optics phenomena and their applications in communication systems.
CO2	Apply quantum mechanical principles to understand semiconductor behavior and device physics.
C03	Analyze electromagnetic wave propagation, transmission lines, and waveguides.
C04	Relate material science concepts to the performance of electronic and photonic devices.

Unit	Content	Credit	Weightage
I	**Wave Optics & Laser Physics** • **Interference:** Young's double slit, interference in thin films, Newton's rings. • **Diffraction:** Fresnel and Fraunhofer diffraction, single slit, diffraction grating. • **Polarization:** Types, Malus's law, Brewster's law, optical activity. • **Lasers:** Spontaneous vs stimulated emission, population inversion, He-Ne & semiconductor lasers. • **Applications in ECE:** Fiber optics, holography, optical communication.	1	25%
II	**Quantum Mechanics & Semiconductor Physics** • **Quantum Basics:** de Broglie hypothesis, uncertainty principle, Schrödinger equation (time-independent). • **Energy Bands in Solids:** Conductors, insulators, semiconductors, Fermi level. • **Semiconductor Physics:** Intrinsic & extrinsic semiconductors, carrier concentration, mobility. • **PN Junction:** Formation, energy band diagram,	1	25%

	diode equation. • **Photoelectric Effect & Photonic Devices:** Photodiodes, solar cells.		
III	**Electromagnetic Theory & Transmission Lines** • **Maxwell's Equations:** Integral and differential forms, wave equation. • **EM Wave Propagation:** Plane waves, polarization, Poynting vector. • **Transmission Lines:** Line equations, characteristic impedance, VSWR, Smith chart basics. • **Waveguides:** Rectangular waveguides, modes, cut-off frequency. • **Antenna Basics:** Radiation pattern, gain, directivity.	1	25%
IV	**Materials Science for Electronics** • **Crystal Structure:** Bravais lattices, Miller indices, X-ray diffraction. • **Dielectric Materials:** Polarization mechanisms, dielectric constant, losses. • **Magnetic Materials:** Dia-, para-, ferro-, ferri-magnetism, hysteresis. • **Superconductivity:** Meissner effect, Type I & II superconductors, applications. • **Nanomaterials & Thin Films:** Basic concepts, quantum dots, applications in ECE.	1	25%

Textbooks:

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

Reference books:

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

Online Platforms:

- NPTEL:
  - *Engineering Physics* – IIT Madras
  - *Semiconductor Physics* – IIT Kanpur
  - *Electromagnetic Theory* – IIT Bombay
- Coursera:
  - *Introduction to Quantum Mechanics for Engineers* – University of Colorado
  - *Optics and Photonics* – MIT

SEMESTER-II

SUBJECT CODE: BTECE201

SUBJECT NAME: ENGINEERING MATHEMATICS-II

Course Objectives:

- To provide a strong foundation in advanced mathematical concepts essential for electronics and communication engineering.
- To develop skills in solving differential equations, complex variables, transforms, and numerical methods.
- To apply mathematical techniques to model, analyse, and solve engineering problems in circuits, signals, and systems.
- To enhance analytical and computational thinking required for advanced ECE courses.

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

CO1	Solve ordinary and partial differential equations relevant to circuit analysis and signal processing.
CO2	Apply complex analysis techniques to evaluate integrals and analyze AC circuits.
C03	Utilize Laplace and Fourier transform for system analysis and signal representation.
C04	Implement numerical methods to approximate solutions for engineering problems.

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

	• **Inverse Laplace Transform:** Partial fraction expansion, convolution. • **Solution of ODEs & Systems:** Using Laplace transforms. • **Transfer Functions:** Poles and zeros, stability analysis. • **Applications:** Circuit analysis, control systems, communication systems.		
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. • **Applications:** Solving circuit equations, signal approximation, system simulation.	1	25%

Textbooks:

- Advanced Engineering Mathematics – Erwin Kreyszig
- Higher Engineering Mathematics – B. S. Grewal
- Engineering Mathematics – H. K. Dass

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: BTECE202

SUBJECT NAME: DIGITAL LOGIC DESIGN

Course Objectives:

- To introduce fundamental concepts of digital systems, binary logic, and number systems.
- To design and analyse combinational and sequential logic circuits.
- To develop skills in using Boolean algebra, K-maps, and state machines for digital circuit design.
- To provide hands-on experience with logic gates, flip-flops, counters, and registers using hardware and simulation tools.

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

CO1	Apply number systems, codes, and Boolean algebra to solve digital logic problems.
CO2	Design and optimize combinational circuits such as adders, multiplexers, and decoders.
C03	Analyze and design sequential circuits including flip-flops, counters, and registers.
C04	Implement and verify digital logic circuits using hardware kits and simulation software.

Unit	Content	Credit	Weightage
I	**Number Systems & Boolean Algebra** • **Number Systems:** Binary, octal, hexadecimal; conversions. • **Binary Arithmetic:** Addition, subtraction (1's & 2's complement), multiplication. • **Codes:** BCD, Gray, ASCII, error detection and correction (parity, Hamming codes). • **Boolean Algebra:** Laws, theorems, SOP and POS forms. • **Logic Gates:** AND, OR, NOT, NAND, NOR, XOR, XNOR; truth tables; universal gates.	1	25%
II	**Combinational Logic Design** • **Minimization Techniques:** Karnaugh maps (2-4 variables), Quine-McCluskey method. • **Combinational Circuits:** o Arithmetic circuits: Half adder, full adder, subtractor, BCD adder. o Data processing circuits: Multiplexers, demultiplexers, encoders, decoders. • **Code Converters:** Binary to Gray, BCD to 7-segment. • **Hazards:** Static and dynamic hazards, elimination techniques.	1	25%
III	**Sequential Logic Fundamentals** • **Latches:** SR latch, D latch. • **Flip-Flops:** SR, JK, D, T; master-slave, edge-triggered. • **Flip-Flop Conversions:** One type to another. • **Registers:** Shift registers (SISO, SIPO, PISO, PIPO), universal shift register. • **Counters:** Asynchronous (ripple), synchronous; up/down, MOD-N counters; ring, Johnson counters.	1	25%
IV	**Finite State Machines & Introduction to HDL** • **Finite State Machines (FSM):** Mealy and Moore models. • **State Diagrams & Tables:** State minimization, state assignment. • **Design of Sequential Circuits:** Sequence detectors, counters, registers. • **Introduction to HDL:** Basics of Verilog/VHDL	1	25%

	(structure, data types, operators). • **Simple Implementations:** Combinational and sequential circuits in HDL.		

Textbooks:

- Digital Design – M. Morris Mano & Michael D. Ciletti
- Digital Logic and Computer Design – M. Morris Mano
- Fundamentals of Digital Logic with Verilog Design – Stephen Brown & Zvonko Vranesic

Reference books:

- Digital Electronics – R. P. Jain
- Introduction to Logic Design – Alan B. Marcovitz
- Verilog HDL: A Guide to Digital Design and Synthesis – Samir Palnitkar
- Digital Circuits and Design – S. Salivahanan & S. Arivazhagan

Online Platforms:

- NPTEL:
  - *Digital Circuits* – IIT Madras
  - *Digital Systems Design* – IIT Kharagpur
- Coursera:
  - *Digital Systems: From Logic Gates to Processors* – University Autònoma de Barcelona
  - *Hardware Description Languages for FPGA Design* – University of Colorado Boulder

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Verification of truth tables for basic and universal gates.
- Lab 2: Implementation of Boolean functions using logic gates.
- Lab 3: Binary arithmetic operations (addition, subtraction using 2's complement).
- Lab 4: Code converters (Binary to Gray, Gray to Binary).

Module 2 Practicals

- Lab 5: Design and implementation of half adder and full adder.
- Lab 6: 4-bit binary adder/subtractor using ICs.
- Lab 7: Multiplexer (8:1) and demultiplexer (1:8) implementation.
- Lab 8: BCD to 7-segment decoder with display.

Module 3 Practicals

- Lab 9: Verification of truth tables for SR, JK, D, and T flip-flops.
- Lab 10: Design of 4-bit shift register (SISO, SIPO).
- Lab 11: Asynchronous (ripple) up/down counter.
- Lab 12: Synchronous MOD-10 counter.

Module 4 Practicals

- Lab 13: Sequence detector (Mealy/Moore machine) using flip-flops.
- Lab 14: Design and implementation of a digital clock (hours, minutes, seconds).
- Lab 15: Introduction to HDL – simple gate-level simulation in Verilog/VHDL.
- Lab 16: Mini-project – 4-bit ALU design and implementation.

SUBJECT CODE: BTECE203

SUBJECT NAME: NETWORK ANALYSIS

Course Objectives:

- To provide a fundamental understanding of electric circuit theory and network theorems.
- To analyse linear time-invariant (LTI) networks using various techniques.
- To study transient and steady-state behaviour of circuits with DC and AC excitation.
- To develop skills in analysing two-port networks and applying network theorems to practical circuits.
- To prepare students for advanced courses in signals, systems, and communication networks.

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

CO1	Apply network theorems (Thevenin, Norton, Superposition, etc.) to analyze linear circuits.
CO2	Analyze transient and steady-state responses of RLC circuits under DC and AC excitation.
C03	Solve circuit problems using Laplace transform and frequency domain techniques.
C04	Characterize and analyze two-port networks using various parameter sets (Z, Y, h, ABCD).

Unit	Content	Credit	Weightage
I	**Basic Circuit Concepts & Network Theorems** • **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, Tellegen's theorem. • **DC Circuit Analysis:** Mesh and nodal analysis. • **AC Fundamentals:** Phasor representation, impedance, admittance.	1	25%
II	**Transient Analysis & Frequency Response** • **Transient Response:** First-order RC and RL circuits (step and impulse response). • **Second-Order Circuits:** Series and parallel RLC circuits, damping conditions. • **Sinusoidal Steady-State Analysis:** Phasor diagrams, power in AC circuits (real, reactive, apparent power), power factor. • **Resonance:** Series and parallel resonance, bandwidth, Q-factor. • **Three-Phase Circuits:** Balanced star and delta connections.	1	25%
III	**Laplace Transform & S-Domain Analysis** • **Laplace Transform Review:** Properties, transforms of basic signals. • **Circuit Analysis in S-Domain:** Impedance and admittance in s-domain.	1	25%

	• **Network Functions:** Transfer function, poles and zeros, stability. • **Frequency Response:** Bode plots, magnitude and phase plots. • **Filter Concepts:** Low-pass, high-pass, band-pass, band-stop filters.		
IV	**Two-Port Networks & Network Synthesis** • **Two-Port Parameters:** Z, Y, h, ABCD parameters, interrelationships. • **Interconnection of Two-Ports:** Series, parallel, cascade connections. • **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 analysis.	1	25%

Textbooks:

- Network Analysis – M. E. Van Valkenburg
- Engineering Circuit Analysis – William H. Hayt, Jack E. Kemmerly, & Steven M. Durbin
- Electric Circuits – James W. Nilsson & Susan Riedel

Reference books:

- Fundamentals of Electric Circuits – Charles K. Alexander & Matthew N. O. Sadiku
- Network Theory: Analysis and Synthesis – S. P. Ghosh & A. K. Chakraborty
- Circuit Theory (Analysis and Synthesis) – A. Chakrabarti
- Linear Networks and Systems – B. D. O. Anderson & R. W. Newcomb

Online Platforms:

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

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Verification of Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL).
- Lab 2: Verification of Thevenin's and Norton's theorems.
- Lab 3: Verification of Superposition theorem.
- Lab 4: Maximum Power Transfer theorem and its verification.

Module 2 Practicals

- Lab 5: Transient response of RC circuit (charging and discharging).
- Lab 6: Transient response of RL circuit.
- Lab 7: Series and parallel resonance in RLC circuits.
- Lab 8: Power measurement in AC circuits – determination of power factor.

Module 3 Practicals

- Lab 9: Frequency response of RC low-pass and high-pass filters.

- Lab 10: Bode plots for first and second-order systems.
- Lab 11: Step response of second-order RLC circuits.
- Lab 12: Design and testing of active filters (using op-amps).

Module 4 Practicals

- Lab 13: Determination of Z and Y parameters for a two-port network.
- Lab 14: Determination of h and ABCD parameters for a two-port network.
- Lab 15: Cascade connection of two-port networks.
- Lab 16: Mini-project – Design and analysis of a passive filter network for a given specification.

SUBJECT CODE: BTECE204

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,	1	25%

	solder joints, and connectors.		
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: BTECE301

SUBJECT NAME: ELECTRONIC DEVICES AND CIRCUITS

Course Objectives:

- To introduce the physics, characteristics, and applications of semiconductor devices.
- To analyse and design amplifier circuits using BJTs and FETs.
- To understand feedback, stability, and frequency response in amplifier circuits.
- To provide hands-on experience in testing, analysing, and designing electronic circuits.

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

CO1	Explain the working principles and characteristics of diodes, BJTs, and FETs.
CO2	Analyze and design biasing circuits and small-signal amplifiers using BJTs and FETs.
C03	Evaluate the performance of feedback amplifiers and oscillators.
C04	Build, test, and troubleshoot amplifier and oscillator circuits in the laboratory.

Unit	Content	Credit	Weightage
I	**Semiconductor Diodes & Applications** • **PN Junction Diode:** Static and dynamic resistance, VI characteristics, temperature effects. • **Diode Models:** Piecewise linear, small-signal model. • **Rectifiers:** Half-wave, full-wave (center-tapped, bridge), filters (C, L, π). • **Clippers & Clampers:** Series, parallel configurations. • **Special Diodes:** Zener diode (regulation), LED, photodiode, varactor diode.	1	25%
II	**Bipolar Junction Transistor (BJT) Circuits** • **BJT Characteristics:** Input/output characteristics in CE, CB, CC configurations. • **Biasing Techniques:** Fixed bias, collector-to-base bias, voltage divider bias, emitter bias. • **DC Load Line & Q-point Stabilization:** Thermal runaway, stability factors. • **Small-Signal Analysis:** Hybrid model, h-parameters, CE amplifier analysis (gain, input/output impedance). • **Frequency Response:** Low and high-frequency analysis of CE amplifier.	1	25%
III	**Field Effect Transistors (FETs) & Amplifiers** • **JFET & MOSFET:** Construction, operation, VI characteristics (drain & transfer). • **Biasing of FETs:** Fixed bias, self-bias, voltage divider bias.	1	25%

	• **Small-Signal Models:** Common Source (CS) amplifier analysis. • **MOSFET Amplifiers:** CS, CD (source follower), CG configurations. • **FET vs. BJT:** Comparison and applications.		
IV	**Feedback Amplifiers & Oscillators** • **Feedback Concepts:** Types of feedback (voltage/current, series/shunt), effect on gain, impedance, bandwidth. • **Stability & Frequency Compensation:** Nyquist criterion, Bode plots, phase margin. • **Oscillators:** Barkhausen criterion, RC phase shift, Wien bridge, Hartley, Colpitts oscillators. • **Power Amplifiers:** Class A, B, AB, and C amplifiers; efficiency, distortion. • **Tuned Amplifiers:** Single and double-tuned amplifiers.	1	25%

Textbooks:

- Electronic Devices and Circuit Theory – Robert L. Boylestad & Louis Nashelsky
- Microelectronic Circuits – Adel S. Sedra & Kenneth C. Smith
- Electronic Principles – Albert Paul Malvino

Reference books:

- Fundamentals of Microelectronics – Behzad Razavi
- Electronic Circuit Analysis and Design – Donald A. Neamen
- Electronic Devices: Conventional Current Version – Thomas L. Floyd
- Analog Electronics – J. B. Gupta

Online Platforms:

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

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: VI characteristics of PN junction and Zener diodes.
- Lab 2: Half-wave and full-wave rectifiers with and without filters.
- Lab 3: Clipper circuits (positive, negative, and biased clippers).
- Lab 4: Clamper circuits and voltage multiplier (doubler).

Module 2 Practicals

- Lab 5: Input and output characteristics of BJT in CE configuration.
- Lab 6: Design and testing of voltage divider bias circuit for BJT.
- Lab 7: Single-stage CE amplifier – gain and frequency response.
- Lab 8: Emitter follower (CC amplifier) – input/output impedance measurement.

Module 3 Practicals

- Lab 9: Drain and transfer characteristics of JFET.

- Lab 10: MOSFET characteristics (enhancement and depletion modes).
- Lab 11: Common Source JFET amplifier – gain measurement.
- Lab 12: MOSFET as a switch (driving LED/relay).

Module 4 Practicals

- Lab 13: Negative feedback amplifier – effect on gain and bandwidth.
- Lab 14: RC phase shift oscillator using BJT.
- Lab 15: Wien bridge oscillator using op-amp.
- Lab 16: Class B push-pull amplifier – crossover distortion and efficiency.

SUBJECT CODE: BTECE302

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.	1	25%

	• **Parseval's Theorem:** Energy and power spectral density. • **Applications:** Filtering, modulation, spectral analysis.		
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. • **Discrete Fourier Transform (DFT):** Introduction and basic properties. • **Applications:** Digital filters, DT signal processing, introduction to DSP.	1	25%

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: BTECE303

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. • **Maxwell's Equations:** Integral and differential forms, physical interpretation. • **Boundary Conditions:** Dielectric-dielectric,	1	25%

	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: BTECE304

SUBJECT NAME: DATA STRUCTURES AND ALGORITHMS

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,	1	25%

	longest common subsequence. • **Algorithmic Thinking for ECE:** Space-time trade-offs in embedded systems, real-time constraints.		

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: BTECE305

SUBJECT NAME: PCB DESIGN AND FABRICATION

Course Objectives:

- To introduce the fundamentals of printed circuit board (PCB) design, layout, and fabrication.
- To develop skills in using industry-standard PCB design software (Eagle/KiCad/Altium).
- To understand design rules, component placement, routing, and manufacturing considerations.
- To provide hands-on experience in PCB fabrication, soldering, assembly, and testing.

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

CO1	Explain PCB terminology, layers, materials, and manufacturing processes.
CO2	Design schematics and convert them into PCB layouts using CAD tools.
C03	Apply design rules, component placement strategies, and routing techniques for single/double-layer PCBs.
C04	Fabricate, assemble, solder, and test a functional PCB prototype.

PRACTICAL LIST:

Module 1: Introduction to PCB Design & Software Tools

- Lab 1: Introduction to PCB terminology, types (single/double/multi-layer), and materials.
- Lab 2: Installation and overview of PCB design software (KiCad/Eagle).
- Lab 3: Creating a simple schematic (LED circuit with resistor) using schematic editor.
- Lab 4: Generating netlists and importing components into PCB layout editor.

Module 2: Schematic Design & Component Libraries

- Lab 5: Designing a power supply circuit schematic (rectifier, filter, regulator).
- Lab 6: Creating custom schematic symbols and footprints for uncommon components.
- Lab 7: Schematic design for a microcontroller-based system (Arduino/ESP32).
- Lab 8: Electrical Rule Check (ERC) and netlist generation.

Module 3: PCB Layout & Routing

- Lab 9: Board outline creation, layer stack-up configuration.
- Lab 10: Component placement strategies for optimal routing and thermal management.
- Lab 11: Manual routing for single and double-layer boards.
- Lab 12: Auto-routing, design rule check (DRC), and error resolution.

Module 4: Fabrication, Assembly & Testing

- Lab 13: Generating Gerber files, drill files, and assembly drawings.
- Lab 14: PCB fabrication using UV exposure/etching method (in-lab fabrication).
- Lab 15: Soldering through-hole and surface-mount components.
- Lab 16: Testing and debugging the assembled PCB using multimeter, oscilloscope.

SEMESTER-IV

SUBJECT CODE: BTECE401

SUBJECT NAME: ANALOG AND DIGITAL COMMUNICATION

Course Objectives:

- To introduce fundamental principles of analog and digital communication systems.
- To analyse modulation techniques (AM, FM, PM) and their performance in noisy environments.
- To understand digital modulation schemes (ASK, FSK, PSK, QAM) and pulse modulation techniques.
- To study information theory, source coding, channel coding, and modern communication standards.

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

CO1	Explain analog modulation techniques and analyze their spectral characteristics.
CO2	Compare digital modulation schemes and evaluate their performance in terms of BER and bandwidth.
C03	Apply sampling theorem and pulse modulation techniques in digital communication systems.
C04	Design and simulate basic analog and digital communication systems using software tools.

Unit	Content	Credit	Weightage
I	**Introduction to Communication Systems & Analog Modulation** • **Communication System Model:** Transmitter, channel, receiver, noise sources. • **Amplitude Modulation (AM):** DSB-FC, DSB-SC, SSB, VSB; generation and detection. • **Angle Modulation:** Frequency Modulation (FM) and Phase Modulation (PM); bandwidth, Carson's rule. • **Noise in Analog Systems:** SNR, noise figure, noise temperature. • **Analog Modulation Comparisons:** AM vs FM, applications in broadcasting.	1	25%
II	**Pulse Modulation & Digital Modulation Techniques** • **Sampling Theorem:** Nyquist rate, aliasing, reconstruction. • **Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM).** • **Pulse Code Modulation (PCM):** Sampling, quantization, encoding; companding (μ-law, A-law). • **Delta Modulation (DM) & Adaptive Delta Modulation (ADM).** • **Digital Modulation:** ASK, FSK, PSK, DPSK, QPSK, QAM.	1	25%
III	**Digital Transmission & Performance Analysis** • **Baseband Transmission:** Line coding (RZ, NRZ, Manchester, AMI), ISI, Nyquist criterion.	1	25%

	• **Matched Filter & Correlation Receiver.** • **Error Probability:** BER calculation for ASK, FSK, PSK in AWGN. • **Digital Modulation Schemes Comparison:** Bandwidth efficiency, power efficiency. • **Spread Spectrum Techniques:** DSSS, FHSS.		
IV	**Information Theory & Coding** • **Information Theory:** Entropy, mutual information, channel capacity (Shannon's theorem). • **Source Coding:** Huffman coding, Lempel-Ziv algorithm. • **Channel Coding:** Error detection and correction codes (parity, Hamming, cyclic, convolutional codes). • **Modern Communication Systems Overview:** OFDM, MIMO, 5G basics. • **Case Studies:** GSM, Wi-Fi, Bluetooth.	1	25%

Textbooks:

- Communication Systems – Simon Haykin
- Principles of Communication Systems – Herbert Taub, Donald L. Schilling, & Goutam Saha
- Digital Communications – John G. Proakis & Masoud Salehi

Reference books:

- Modern Digital and Analog Communication Systems – B. P. Lathi & Zhi Ding
- Analog and Digital Communication – K. Sam Shanmugam
- Digital Communication – R. P. Singh & S. D. Sapre
- Wireless Communications – Andrea Goldsmith

Online Platforms:

- NPTEL:
  - *Analog Communication* – IIT Roorkee
  - *Digital Communication* – IIT Kharagpur
  - *Principles of Communication* – IIT Bombay
- Coursera:
  - *Digital Signal Processing* – École Polytechnique Fédérale de Lausanne (EPFL)
  - *Fundamentals of Communication Systems* – Rice University

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Amplitude Modulation and Demodulation using IC/Kit.
- Lab 2: Frequency Modulation and Demodulation (using PLL/Kit).
- Lab 3: Spectrum analysis of AM and FM signals using spectrum analyzer/software.
- Lab 4: Noise measurement in analog systems – SNR calculation.

Module 2 Practicals

- Lab 5: Sampling and reconstruction of analog signals (verification of sampling theorem).
- Lab 6: Pulse Code Modulation (PCM) encoding and decoding.
- Lab 7: Delta Modulation and Adaptive Delta Modulation.
- Lab 8: Generation and detection of ASK, FSK, and PSK signals.

Module 3 Practicals

- Lab 9: Line coding techniques (RZ, NRZ, Manchester) generation and analysis.
- Lab 10: Matched filter implementation for signal detection.
- Lab 11: BER measurement for ASK/FSK/PSK in simulated noisy channel.
- Lab 12: Spread spectrum modulation (DSSS/FHSS) simulation.

Module 4 Practicals

- Lab 13: Huffman coding implementation for data compression.
- Lab 14: Error detection and correction using Hamming codes.
- Lab 15: Convolutional coding and Viterbi decoding simulation.
- Lab 16: Mini-project – Design and simulation of a complete digital communication link (e.g., QPSK transceiver).

SUBJECT CODE: BTECE402

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.	1	25%

	• **Assembly & Embedded C Programming:** Programming timers, interrupts, I/O ports. • **Development Tools:** Keil µVision, simulators, programmers. • **Comparison:** Microprocessor vs Microcontroller.		
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, I^2C basics. • **Memory Interfacing:** RAM, ROM, EEPROM with 8051. • **Case Study:** Interfacing sensors (temperature, IR) with microcontrollers.	1	25%
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* –

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.

SUBJECT CODE: BTECE403

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.	1	25%

	• **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.		
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: BTECE404

SUBJECT NAME: COMPUTER NETWORKS

Course Objectives:

- To introduce the fundamental concepts, architectures, and protocols of computer networks.
- To understand the layered communication models (OSI and TCP/IP) and their functions.
- To analyse data link, network, transport, and application layer protocols.
- To introduce wireless, mobile, and emerging network technologies relevant to ECE applications.

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

CO1	Explain network architectures, topologies, and the OSI/TCP/IP reference models.
CO2	Analyze data link layer protocols, error control, flow control, and medium access control.
C03	Describe routing algorithms, IP addressing, subnetting, and transport layer protocols (TCP/UDP).
C04	Understand application layer protocols, network security basics, and emerging network trends.

Unit	Content	Credit	Weightage
I	**Introduction to Computer Networks & Physical Layer** • **Network Fundamentals:** Uses, types (LAN, MAN, WAN), topologies, network hardware. • **Network Models:** OSI reference model, TCP/IP protocol suite. • **Transmission Media:** Guided (twisted pair, coaxial, fiber) and unguided (radio, microwave, satellite). • **Switching Techniques:** Circuit switching, packet switching, message switching. • **Introduction to IoT Networks:** Concepts and relevance to ECE.	1	25%
II	**Data Link Layer & Medium Access Control** • **Data Link Layer Design Issues:** Framing, error control (parity, CRC), flow control (stop-and-wait, sliding window). • **Data Link Layer Protocols:** HDLC, PPP. • **Medium Access Control (MAC):** CSMA/CD,	1	25%

	CSMA/CA, token passing. • **LAN Technologies:** Ethernet (IEEE 802.3), wireless LANs (IEEE 802.11). • **Switching:** Bridges, switches, VLANs.		
III	**Network Layer & Routing** • **Network Layer Design Issues:** Logical addressing, routing, fragmentation. • **IP Addressing:** IPv4 addressing, subnetting, CIDR, IPv6 basics. • **Routing Algorithms:** Distance vector (RIP), link state (OSPF), path vector (BGP). • **Network Layer Protocols:** IP, ICMP, ARP, RARP. • **Internetworking:** Routers, gateways.	1	25%
IV	**Transport & Application Layers** • **Transport Layer:** Services, multiplexing, demultiplexing. • **Transport Protocols:** UDP (connectionless), TCP (connection-oriented, flow control, congestion control). • **Application Layer Protocols:** HTTP, FTP, SMTP, DNS, SNMP. • **Network Security Basics:** Cryptography, firewalls, VPNs. • **Emerging Trends:** Software Defined Networking (SDN), 5G networks, cloud networking.	1	25%

Textbooks:

- Computer Networks – Andrew S. Tanenbaum & David J. Wetherall
- Data Communications and Networking – Behrouz A. Forouzan
- TCP/IP Protocol Suite – Behrouz A. Forouzan

Reference books:

- Computer Networking: A Top-Down Approach – James F. Kurose & Keith W. Ross
- Internetworking with TCP/IP – Douglas E. Comer
- Data and Computer Communications – William Stallings
- Wireless Communications and Networks – William Stallings

Online Platforms:

- NPTEL:
  - *Computer Networks* – IIT Kharagpur
  - *Data Communication* – IIT Delhi
  - *Advanced Computer Networks* – IIT Bombay
- Coursera:
  - *Computer Networking* – University of Washington
  - *The Bits and Bytes of Computer Networking* – Google

SEMESTER-V

SUBJECT CODE: BTECE501

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,	1	25%

	transition band. • **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: BTECE502

SUBJECT NAME: VLSI DESIGN

Course Objectives:

- To introduce the fundamentals of Very Large-Scale Integration (VLSI) technology and design methodologies.
- To understand MOS transistor theory, CMOS fabrication processes, and design rules.
- To design and analyse combinational and sequential CMOS digital circuits.
- To develop skills in HDL-based design, simulation, and verification using industry-standard EDA tools.

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

CO1	Explain MOS transistor characteristics, CMOS fabrication steps, and design rules.
CO2	Design and optimize combinational and sequential CMOS logic circuits.
C03	Model digital systems using Hardware Description Languages (Verilog/VHDL).
C04	Simulate, synthesize, and verify digital designs using EDA tools.

Unit	Content	Credit	Weightage
I	**Introduction to VLSI & MOS Transistor Theory** • **VLSI Design Flow:** Overview of front-end and back-end design. • **MOS Transistor:** Structure, operation, I-V characteristics, MOSFET scaling. • **CMOS Fabrication Process:** Basic steps (oxidation, diffusion, ion implantation, lithography, etching). • **Design Rules:** Lambda-based design rules, stick diagrams, layout diagrams. • **CMOS Inverter:** Static and dynamic characteristics, noise margins, power dissipation.	1	25%

II	**CMOS Circuit Design** • **Combinational Logic Design:** CMOS logic gates (NAND, NOR, XOR), pass transistor logic, transmission gates. • **Sequential Logic Design:** Latches, flip-flops (SR, D, JK), timing parameters (setup/hold time). • **Dynamic Logic Circuits:** Precharge-evaluate logic, domino logic. • **Arithmetic Circuits:** Adders (ripple carry, carry look-ahead), multipliers. • **Memory Elements:** SRAM, DRAM basics, ROM.	1	25%
III	**HDL-Based Digital Design (Verilog/VHDL)** • **Introduction to HDL:** Verilog/VHDL syntax, data types, operators. • **Modeling Styles:** Structural, dataflow, behavioral. • **Design Examples:** Combinational circuits (MUX, decoder, adder), sequential circuits (counters, FSMs). • **Simulation & Testbenches:** Writing testbenches for verification. • **Introduction to Synthesis:** RTL to gate-level synthesis basics.	1	25%
IV	**VLSI Testing & Advanced Topics** • **VLSI Testing:** Fault models (stuck-at, bridging), test generation, scan-path testing. • **Low-Power Design Techniques:** Clock gating, power gating, multi-Vdd design. • **Programmable Logic Devices:** FPGA architecture, CPLD basics. • **System-on-Chip (SoC) Concepts:** IP cores, bus architectures (AMBA, AXI). • **Emerging Trends:** Nanoelectronics, 3D ICs, AI accelerators.	1	25%

Textbooks:

- CMOS VLSI Design: A Circuits and Systems Perspective – Neil H. E. Weste & David M. Harris
- Digital Integrated Circuits: A Design Perspective – Jan M. Rabaey, Anantha Chandrakasan, & Borivoje Nikolic
- Principles of CMOS VLSI Design – Neil H. E. Weste & Kamran Eshraghian

Reference books:

- VLSI Design – K. Lal Kishore & V. S. V. Prabhakar
- Introduction to VLSI Systems – Carver Mead & Lynn Conway
- Verilog HDL: A Guide to Digital Design and Synthesis – Samir Palnitkar
- VHDL: Programming by Example – Douglas L. Perry

Online Platforms:

- NPTEL:
  - *VLSI Design* – IIT Madras
  - *Digital VLSI Testing* – IIT Kharagpur
  - *CMOS Digital VLSI Design* – IIT Roorkee

- Coursera:
    - *VLSI CAD: Logic to Layout* – University of Illinois at Urbana-Champaign
    - *Hardware Description Languages for FPGA Design* – University of Colorado Boulder

PRACTICAL LIST:

- Lab 1: Study of MOSFET characteristics using LTspice/Simulation tool.
- Lab 2: Layout design of CMOS inverter using CAD tools (Microwind/DSCH).
- Lab 3: Stick diagram and layout design of basic gates (NAND, NOR).
- Lab 4: Analysis of CMOS inverter: voltage transfer characteristics and noise margins.
- Lab 5: Design and simulation of CMOS combinational circuits (XOR, MUX).
- Lab 6: Design of sequential circuits (D flip-flop, JK flip-flop).
- Lab 7: Simulation of adder circuits (half adder, full adder) in CMOS.
- Lab 8: Design and analysis of a 4-bit counter using CMOS logic.
- Lab 9: Introduction to Verilog/VHDL: writing and simulating a simple gate.
- Lab 10: Structural modeling of a 4-bit ripple carry adder.
- Lab 11: Behavioural modeling of a finite state machine (sequence detector).
- Lab 12: Testbench writing and simulation of a 4-bit ALU.
- Lab 13: Synthesis of a Verilog design using Xilinx Vivado/Synopsys tools.
- Lab 14: FPGA implementation of a digital system (e.g., traffic light controller).
- Lab 15: Introduction to scan-path testing and fault simulation.
- Lab 16: Mini-project – Design of a simple 8-bit microprocessor data path.

SUBJECT CODE: BTECE503

SUBJECT NAME: ANTEENA AND WAVE PROPAGATION

Course Objectives:

- To introduce fundamental principles of antenna theory, parameters, and radiation mechanisms.
- To analyse various types of antennas and their design considerations.
- To understand wave propagation mechanisms in different media and frequency bands.
- To apply antenna and propagation concepts in wireless communication, radar, and satellite systems.

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

CO1	Explain antenna fundamentals, radiation patterns, and key antenna parameters.
CO2	Analyze and design common antenna types (dipoles, arrays, reflectors, microstrip).
C03	Understand wave propagation mechanisms (ground wave, sky wave, space wave).
C04	Apply antenna and propagation knowledge to wireless communication system design.

Unit	Content	Credit	Weightage
I	**Antenna Fundamentals & Parameters** • **Introduction to Antennas:** History, functions, types of antennas. • **Antenna Parameters:** Radiation pattern, beamwidth, directivity, gain, efficiency,	1	25%

	polarization, input impedance, bandwidth. • **Radiation Mechanisms:** Current distribution on thin wire antennas. • **Antenna Arrays:** Array factor, pattern multiplication, uniform linear arrays, broadside and end-fire arrays. • **Friis Transmission Equation:** Link budget calculation.		
II	**Wire Antennas & Antenna Arrays** • **Dipole Antennas:** Infinitesimal dipole, half-wave dipole, folded dipole. • **Monopole Antennas:** Quarter-wave monopole, ground plane effects. • **Loop Antennas:** Small loop, radiation resistance. • **Antenna Arrays:** Binomial arrays, Dolph-Chebyshev arrays, phased arrays. • **Feeding Techniques:** Baluns, matching networks.	1	25%
III	**Aperture Antennas & Modern Antennas** • **Aperture Antennas:** Huygens' principle, horn antennas, parabolic reflector antennas, cassegrain feed. • **Microstrip Antennas:** Rectangular patch, feeding methods, design considerations. • **Broadband Antennas:** Log-periodic antennas, spiral antennas. • **Special Antennas:** Yagi-Uda antenna, helical antenna, slot antenna. • **Antenna Measurements:** Pattern measurement, gain measurement, impedance measurement.	1	25%
IV	**Wave Propagation** • **Propagation Mechanisms:** Ground wave, sky wave, space wave. • **Ground Wave Propagation:** Characteristics, frequency range, applications. • **Sky Wave Propagation:** Ionospheric layers, critical frequency, MUF, LUF, skip distance. • **Space Wave Propagation:** Line-of-sight (LOS), Fresnel zones, diffraction, scattering. • **Propagation Effects:** Multipath, fading, Doppler shift, path loss models (Free-space, Two-ray). • **Applications:** Mobile communication, satellite communication, radar.	1	25%

Textbooks:

- Antenna Theory: Analysis and Design – Constantine A. Balanis
- Antennas and Wave Propagation – John D. Kraus & Ronald J. Marhefka
- Antennas and Wave Propagation – Harish & Sachidananda

Reference books:

- Electromagnetic Waves and Radiating Systems – Edward C. Jordan & Keith G. Balmain
- Wireless Communications: Principles and Practice – Theodore S. Rappaport
- Foundations of Antenna Engineering: A Unified Approach for Line-of-Sight and Multipath –

Per-Simon Kildal
- Antenna Engineering Handbook – John L. Volakis (Editor)

Online Platforms:

- NPTEL:
  - *Antenna and Wave Propagation* – IIT Roorkee
  - *Antenna Theory* – IIT Kharagpur
  - *Wireless Communication* – IIT Madras
- Coursera:
  - *Antenna Basics* – University of Colorado Boulder
  - *RF and Microwave Engineering* – Eindhoven University of Technology

SUBJECT CODE: BTECE504

SUBJECT NAME: IOT AND SENSOR

Course Objectives:

- To understand IoT architecture, sensor technologies, and data acquisition methods for smart systems.
- To develop skills in processing, analysing, and visualizing time-series sensor data.
- To apply machine learning and deep learning techniques for anomaly detection, predictive maintenance, and real-time analytics.
- To design and implement end-to-end IoT data pipelines from edge to cloud.

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

CO1	Explain IoT architecture, sensor types, communication protocols, and edge computing concepts.
CO2	Preprocess, clean, and visualize time-series sensor data for analysis.
C03	Apply ML/DL models for sensor data tasks like classification, forecasting, and anomaly detection.
C04	Design and deploy scalable IoT data pipelines integrating edge devices, cloud platforms, and dashboards.

Unit	Content	Credit	Weightage
I	**IoT Fundamentals & Sensor Data Acquisition** • **Introduction to IoT:** Architecture (sensors, connectivity, edge, cloud), applications (smart cities, health, industry). • **Sensors & Actuators:** Types (temperature, motion, pressure, image), specifications, calibration. • **IoT Communication Protocols:** MQTT, CoAP, HTTP, Bluetooth Low Energy (BLE), LoRaWAN. • **Edge Computing:** Edge devices (Raspberry Pi, Arduino), preprocessing at edge, fog computing. • **Data Acquisition Systems:** Sampling, quantization, data logging, streaming from sensors.	1	25%
II	**Sensor Data Processing & Time-Series Analysis** • **Time-Series Data Characteristics:** Seasonality, trends, noise, stationarity. • **Preprocessing Sensor Data:** Handling missing values, outliers, smoothing (moving average, median	1	25%

	filter). • **Feature Engineering:** Lag features, rolling statistics, Fourier transforms, wavelet transforms. • **Dimensionality Reduction:** PCA, t-SNE for high-dimensional sensor data. • **Visualization:** Time-series plots, heatmaps, spectrograms, dashboarding (Grafana, Plotly Dash).		
III	**Machine Learning for Sensor Data** • **Classification:** Activity recognition using accelerometer/gyroscope data. • **Regression:** Predictive maintenance (remaining useful life estimation). • **Clustering:** Sensor grouping, fault detection. • **Anomaly Detection:** Statistical methods (IQR, Z-score), ML methods (Isolation Forest, One-Class SVM). • **Deep Learning for Sensor Data:** 1D CNNs, RNNs/LSTMs for sequence modeling, attention mechanisms.	1	25%
IV	**IoT Data Systems & Deployment** • **IoT Cloud Platforms:** AWS IoT Core, Google Cloud IoT, Azure IoT Hub. • **Stream Processing:** Real-time analytics with Kafka, Spark Streaming, Flink. • **Data Storage:** Time-series databases (Influx DB, Time scale DB), NoSQL (Cassandra), data lakes. • **End-to-End Pipeline:** Edge data collection → MQTT broker → cloud processing → visualization. • **Case Studies:** Smart agriculture, industrial IoT, wearable health monitoring, environmental sensing.	1	25%

Textbooks:

- IoT and Edge Computing for Architects by Perry Lea
- Sensor Data Analysis and Management by Akiyoshi Wachi
- Time Series Analysis and Its Applications by Robert H. Shumway and David S. Stoffer

Reference books:

- Internet of Things: A Hands-On Approach by Arshdeep Bahga and Vijay Madisetti
- Applied Sensor Data Analytics with IoT by K. G. Srinivasa and G. M. Siddesh
- Deep Learning for Time Series Forecasting by Jason Brownlee
- IoT System Design: Project-Based Approach by Alice James and Avinash Gupta

Online Platforms:

- Coursera: “IoT Sensors and Devices” (University of California, Irvine)
- edX: “IoT Programming and Big Data” (Curtin University)
- YouTube: Andreas Spiess (The Swiss Guy), IoT for Everyone
- Kaggle Datasets: Sensor time-series datasets (e.g., accelerometer, temperature)
- Google Colab / Jupyter: For data analysis and ML modeling

SEMESTER-VI

SUBJECT CODE**: BTECE601**

SUBJECT NAME: WIRELESS COMMUNICATION

Course Objectives:

- To understand the fundamentals of wireless communication systems and cellular networks.
- To analyse wireless channel characteristics, fading, and multipath effects.
- To study modern wireless technologies, multiple access techniques, and standards (4G/5G, Wi-Fi, Bluetooth).
- To design and simulate wireless systems and evaluate their performance.

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

CO1	Explain cellular network concepts, frequency reuse, and handoff strategies.
CO2	Analyze wireless channel models, fading, and diversity techniques.
C03	Compare multiple access techniques (FDMA, TDMA, CDMA, OFDMA).
C04	Design and simulate wireless communication systems using software tools.

Unit	Content	Credit	Weightage
I	**Introduction to Wireless Systems & Cellular Fundamentals** • **Wireless Communication Overview:** Evolution, applications, challenges. • **Cellular Network Architecture:** Cells, frequency reuse, cluster size, co-channel interference. • **Handoff Strategies:** Hard handoff, soft handoff, handoff algorithms. • **Capacity and Coverage:** Trunking theory, Erlang formulas, cell splitting, sectoring. • **Introduction to 1G, 2G, 3G, 4G, and 5G Networks.**	1	25%
II	**Wireless Channel Characteristics & Fading** • **Wireless Channel Models:** Path loss models (Free-space, Two-ray, Okumura, Hata). • **Multipath Propagation:** Delay spread, coherence bandwidth, Doppler spread, coherence time. • **Fading:** Large-scale fading (shadowing), small-scale fading (Rayleigh, Rician). • **Diversity Techniques:** Time, frequency, space diversity; MIMO basics. • **Equalization:** Linear and adaptive equalizers.	1	25%
III	**Multiple Access Techniques & Wireless Standards** • **Multiple Access:** FDMA, TDMA, CDMA (DS-CDMA, FH-CDMA), OFDMA. • **Spread Spectrum:** DSSS, FHSS. • **Wireless Standards:**	1	25%

	○ GSM: Architecture, channels, frame structure. ○ Wi-Fi (IEEE 802.11 a/b/g/n/ac/ax). ○ Bluetooth (IEEE 802.15.1). ○ LTE/4G and 5G NR overview. • **Wireless Network Security Basics.**		
IV	**Modern Wireless Technologies & System Design** • **MIMO Systems:** Spatial multiplexing, beamforming, capacity of MIMO channels. • **Cognitive Radio & Software Defined Radio (SDR) concepts.** • **Wireless Sensor Networks (WSN) & IoT Communication.** • **Satellite Communication:** Orbits, link budget, VSAT. • **System Design Case Studies:** Designing a small cell network, IoT deployment.	1	25%

Textbooks:

- Wireless Communications: Principles and Practice – Theodore S. Rappaport
- Wireless Communication – Andreas F. Molisch
- Principles of Wireless Networks – Kaveh Pahlavan & Prashant Krishnamurthy

Reference books:

- Fundamentals of Wireless Communication – David Tse & Pramod Viswanath
- Mobile Cellular Telecommunications – William C. Y. Lee
- Introduction to 5G Mobile Communications – Mosa Ali Abu-Rgheff
- Wireless Communications and Networking – Vijay K. Garg

Online Platforms:

- NPTEL:
  - *Wireless Communication* – IIT Bombay
  - *Advanced 3G and 4G Wireless Mobile Communications* – IIT Kharagpur
  - *Cellular Mobile Communications* – IIT Madras
- Coursera:
  - *Wireless Communications for Everybody* – Yonsei University
  - *5G for Everyone* – Qualcomm

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Study of cellular network architecture and frequency reuse patterns.
- Lab 2: Handoff simulation (hard vs. soft handoff) using MATLAB/NS3.
- Lab 3: Capacity analysis using Erlang B and Erlang C calculators.
- Lab 4: Cell splitting and sectoring performance analysis.

Module 2 Practicals

- Lab 5: Path loss modeling (Free-space, Hata model) using MATLAB.
- Lab 6: Simulation of Rayleigh and Rician fading channels.
- Lab 7: Diversity combining techniques (selection, maximal ratio combining).
- Lab 8: BER performance analysis in fading channels with and without diversity.

Module 3 Practicals

- Lab 9: Implementation and comparison of FDMA, TDMA, CDMA.
- Lab 10: OFDM simulation: IFFT/FFT, cyclic prefix, BER performance.
- Lab 11: Wi-Fi network setup and analysis using packet analyzer (Wireshark).
- Lab 12: Bluetooth communication between devices (using HC-05 module and Arduino).

Module 4 Practicals

- Lab 13: MIMO system simulation: Spatial multiplexing and Alamouti STBC.
- Lab 14: Software Defined Radio (SDR) experiment using GNU Radio (FM receiver).
- Lab 15: Link budget calculation for satellite communication.
- Lab 16: Mini-project – Design of a small-scale wireless sensor network for temperature monitoring.

SUBJECT CODE**: BTECE602**

SUBJECT NAME: OPTICAL COMMUNICATION

Course Objectives:

- To understand the principles of optical fiber communication systems and components.
- To analyse optical fiber characteristics, signal degradation, and dispersion effects.
- To study optical sources, detectors, amplifiers, and modulation techniques.
- To design and evaluate optical communication links for modern networks (WDM, SONET/SDH).

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

CO1	Explain the principles of light propagation in optical fibers and fiber types.
CO2	Analyze signal attenuation, dispersion, and nonlinear effects in optical fibers.
C03	Characterize optical sources (LEDs, lasers), detectors (PIN, APD), and amplifiers.
C04	Design point-to-point optical links and understand WDM and optical network architectures.

Unit	Content	Credit	Weightage
I	**Introduction to Optical Fiber Communication** • **Evolution of Optical Communication:** Advantages, applications, and system block diagram. • **Light Propagation Basics:** Ray optics, wave optics, Snell's law, total internal reflection. • **Optical Fiber Types:** Step-index, graded-index fibers; single-mode vs multimode fibers. • **Fabrication Techniques:** MCVD, OVD, VAD methods. • **Numerical Aperture (NA), Acceptance Angle, and V-number.**	1	25%
II	**Optical Fiber Characteristics & Signal Degradation** • **Attenuation in Fibers:** Absorption, scattering (Rayleigh, Mie), bending losses. • **Dispersion:** Chromatic dispersion (material, waveguide), polarization mode dispersion (PMD). • **Intermodal Dispersion:** Modal delay in multimode	1	25%

	fibers. • **Nonlinear Effects:** SPM, XPM, FWM, SBS, SRS. • **Fiber Optic Measurements:** OTDR, insertion loss, bandwidth measurement.		
III	**Optical Sources, Detectors & Amplifiers** • **Optical Sources:** LEDs (surface emitting, edge emitting), semiconductor lasers (Fabry-Perot, DFB, DBR), laser characteristics. • **Optical Detectors:** PIN photodiodes, avalanche photodiodes (APD), responsivity, quantum efficiency. • **Optical Amplifiers:** EDFA, Raman amplifiers, SOA. • **Modulation Techniques:** Direct modulation, external modulation (MZM, EAM). • **Noise in Optical Receivers:** Shot noise, thermal noise, SNR, BER.	1	25%
IV	**Optical Communication Systems & Networks** • **Point-to-Point Link Design:** Power budget, rise time budget, link margin. • **Wavelength Division Multiplexing (WDM):** CWDM, DWDM, components (MUX/DEMUX, OADM). • **Optical Network Architectures:** SONET/SDH, OTN, optical access networks (PON, FTTH). • **Advanced Topics:** Coherent optical communication, optical switching, optical CDMA. • **Emerging Trends:** Space division multiplexing, quantum communication.	1	25%

Textbooks:

- Optical Fiber Communications – Gerd Keiser
- Fiber-Optic Communication Systems – Govind P. Agrawal
- Optical Communications – John M. Senior

Reference books:

- Fundamentals of Photonics – Bahaa E. A. Saleh & Malvin Carl Teich
- Introduction to Fiber Optics – Ajoy Ghatak & K. Thyagarajan
- Optical Networks: A Practical Perspective – Rajiv Ramaswami & Kumar N. Sivarajan
- Optical Communication Systems – John Gowar

Online Platforms:

- NPTEL:
  - *Optical Fiber Communication* – IIT Delhi
  - *Optical Communication* – IIT Kharagpur
  - *Photonics* – IIT Madras
- Coursera:
  - *Optical Communications* – University of Colorado Boulder
  - *Fundamentals of Optical Engineering* – University of Colorado Boulder

SUBJECT CODE: **BTECE603**

SUBJECT NAME: RF AND MICROWAVE ENGINEERING

Course Objectives:

- To introduce the fundamentals of RF and microwave engineering and their applications in communication systems.
- To analyse transmission lines, waveguides, and microwave network parameters (S-parameters).
- To design and characterize microwave passive components, filters, and amplifiers.
- To provide hands-on experience in microwave measurement techniques and simulation tools.

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

CO1	Analyze transmission lines, waveguides, and impedance matching techniques.
CO2	Characterize microwave networks using S-parameters and Smith chart.
C03	Design microwave passive components (couplers, filters, resonators) and amplifiers.
C04	Perform microwave measurements and simulate RF circuits using industry-standard tools.

Unit	Content	Credit	Weightage
I	**Transmission Lines & Waveguides** • **Introduction to RF & Microwaves:** Frequency bands, applications in wireless and satellite systems. • **Transmission Line Theory:** Telegrapher's equations, reflection coefficient, VSWR, impedance transformation. • **Smith Chart:** Construction, impedance matching (single stub, double stub). • **Waveguides:** Rectangular waveguide modes, cutoff frequency, TE/TM modes. • **Microstrip Lines:** Characteristics, design equations, losses.	1	25%
II	**Microwave Network Analysis** • **Impedance Matching:** L-section, quarter-wave transformer, matching networks. • **Network Parameters:** Z, Y, ABCD parameters, scattering parameters (S-parameters). • **Signal Flow Graphs:** Mason's gain formula. • **Microwave Junctions:** E-plane, H-plane, magic tee, directional couplers. • **Power Dividers & Combiners:** Wilkinson power divider, rat-race coupler.	1	25%
III	**Microwave Passive Components & Filters** • **Resonators:** Cavity resonators, dielectric resonators, Q-factor. • **Filters:** Low-pass, high-pass, band-pass, band-stop filter design (Butterworth, Chebyshev). • **Couplers:** Bethe-hole coupler, branch-line coupler. • **Ferrite Devices:** Isolators, circulators.	1	25%

	• **Microwave Antennas:** Horn, patch antenna basics.		
IV	**Microwave Active Devices & Measurements** • **Microwave Transistors:** MESFET, HEMT, HBT characteristics. • **Microwave Amplifiers:** Small-signal amplifier design, stability, gain, noise figure. • **Oscillators & Mixers:** DRO, YIG-tuned oscillators; mixer fundamentals. • **Microwave Measurements:** Power, frequency, VSWR, S-parameter measurement using VNA. • **RFIC & MMIC Basics:** Introduction to monolithic microwave integrated circuits.	1	25%

Textbooks:

- Microwave Engineering – David M. Pozar
- Foundations for Microwave Engineering – Robert E. Collin
- RF Microelectronics – Behzad Razavi

Reference books:

- Microwave Devices and Circuits – Samuel Y. Liao
- RF Circuit Design: Theory and Applications – Reinhold Ludwig & Gene Bogdanov
- Microwave and RF Design: A Systems Approach – Michael Steer
- Planar Microwave Engineering – Thomas H. Lee

Online Platforms:

- NPTEL:
  - *Microwave Engineering* – IIT Kharagpur
  - *RF and Microwave Engineering* – IIT Bombay
  - *Microwave Integrated Circuits* – IIT Madras
- Coursera:
  - *RF and Microwave Engineering* – University of Colorado Boulder
  - *Microwave Engineering and antennas* – Eindhoven University of Technology

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Measurement of VSWR and reflection coefficient using slotted line.
- Lab 2: Impedance matching using single stub tuner (simulation and hardware).
- Lab 3: Smith chart exercises: impedance transformation and matching.
- Lab 4: Characterization of rectangular waveguide modes.

Module 2 Practicals

- Lab 5: S-parameter measurement of a two-port network using Vector Network Analyzer (VNA).
- Lab 6: Design and testing of a directional coupler.
- Lab 7: Wilkinson power divider design and analysis.
- Lab 8: Magic tee (hybrid tee) characteristics measurement.

Module 3 Practicals

- Lab 9: Design and simulation of a microstrip low-pass filter.
- Lab 10: Design of a band-pass filter using coupled lines.
- Lab 11: Cavity resonator Q-factor measurement.
- Lab 12: Microstrip patch antenna design and radiation pattern measurement.

Module 4 Practicals

- Lab 13: Small-signal amplifier design (biasing, stability, gain measurement).
- Lab 14: Noise figure measurement of an LNA.
- Lab 15: Dielectric Resonator Oscillator (DRO) frequency measurement.
- Lab 16: Mini-project – Design of a complete RF front-end for a given specification (e.g., 2.4 GHz receiver).

SUBJECT CODE**: BTECE604**

SUBJECT NAME: MACHINE LEARNING FOR ECE

Course Objectives:

- To introduce fundamental concepts of machine learning and its applications in electronics and communication engineering.
- To develop skills in implementing supervised and unsupervised learning algorithms for ECE-specific problems.
- To apply ML techniques in signal processing, communication systems, and embedded applications.
- To integrate ML models with hardware systems and understand deployment challenges.

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 tasks in ECE.
C03	Apply unsupervised learning and deep learning techniques for signal analysis, clustering, and feature extraction.
C04	Deploy ML models on embedded platforms and evaluate performance in real-world ECE applications.

Unit	Content	Credit	Weightage
I	**Foundations of Machine Learning & Data Preprocessing** • **Introduction to ML in ECE:** Applications in signal processing, communications, IoT, and robotics. • **ML Pipeline:** Data collection, preprocessing, feature engineering, model selection, evaluation. • **Mathematical Foundations:** Linear algebra, probability, and statistics review. • **Data Preprocessing:** Handling missing values, normalization, encoding, feature scaling. • **Model Evaluation Metrics:** Accuracy, precision, recall, F1-score, MSE, R^2.	1	25%
II	**Supervised Learning for ECE** • **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.	1	25%

	• **Case Studies:** Channel estimation, modulation classification, fault detection in circuits.		
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, activation functions. • **Deep Learning Architectures:** CNN for image/signal processing, RNN/LSTM for sequential data. • **Transfer Learning:** Using pre-trained models for ECE tasks. • **Applications:** Signal denoising, anomaly detection in sensor data, spectrum sensing.	1	25%

IV	**ML Deployment & ECE-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.
	• **Applications:**
	  ○ Wireless communications: ML for MIMO detection, beamforming.
	  ○ Signal processing: Speech recognition, EEG/ECG analysis.
	  ○ Embedded vision: Object detection, facial recognition.
	• **Ethics & Fairness in ML for ECE.**
		1	25%

Textbooks:

- Pattern Recognition and Machine Learning – Christopher M. Bishop
- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow – Aurélien Géron
- Machine Learning: A Probabilistic Perspective – Kevin P. Murphy

Reference books:

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

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*

SEMESTER-VII

SUBJECT CODE: **BTECE701**

SUBJECT NAME: SATELLITE COMMUNICATION

Course Objectives:

- To introduce the principles, architecture, and applications of satellite communication systems.
- To understand orbital mechanics, link budget analysis, and satellite subsystems.
- To study multiple access techniques, earth station technology, and satellite networks.
- To analyse modern satellite systems, including VSAT, GPS, and satellite-based IoT.

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

CO1	Explain satellite orbits, orbital mechanics, and satellite subsystems.
CO2	Perform link budget calculations and analyze satellite communication parameters.
C03	Compare multiple access techniques and earth station technologies.
C04	Design and simulate basic satellite communication links and understand modern applications.

Unit	Content	Credit	Weightage
I	**Introduction to Satellite Systems & Orbits** • **Overview of Satellite Communication:** History, applications (broadcasting, navigation, remote sensing), advantages and limitations. • **Orbital Mechanics:** Kepler's laws, orbital parameters (apogee, perigee, inclination, RAAN), types of orbits (LEO, MEO, GEO, HEO, Molniya, sun-synchronous). • **Satellite Subsystems:** Power, propulsion, attitude control, thermal control, telemetry and command (TTC). • **Launch Vehicles & Station Keeping:** Launch procedures, orbital perturbations, station-keeping maneuvers. • **Frequency Bands:** L, S, C, X, Ku, Ka bands, frequency allocation (ITU).	1	25%
II	**Satellite Link Design & Modulation** • **Link Budget Analysis:** EIRP, free-space path loss, antenna gain, system noise temperature, G/T ratio. • **Satellite Link Equations:** Uplink and downlink calculations, CNR, SNR, BER. • **Modulation Techniques:** BPSK, QPSK, 8PSK, QAM in satellite systems. • **Coding & Forward Error Correction:** Convolutional codes, turbo codes, LDPC codes. • **Rain Attenuation & Atmospheric Effects:** Tropospheric and ionospheric impairments,	1	25%

	mitigation techniques.		
III	**Multiple Access & Earth Station Technology** • **Multiple Access Techniques:** FDMA, TDMA, CDMA, SDMA, OFDMA. • **DAMA & Aloha Protocols.** • **Earth Station Architecture:** Antenna types (parabolic, phased array), low-noise amplifier (LNA), high-power amplifier (HPA), up/down converters. • **VSAT Systems:** Architecture, network topologies (star, mesh), applications. • **Satellite Tracking:** Antenna pointing, tracking systems.	1	25%
IV	**Satellite Networks & Modern Applications** • **Satellite Networks:** INTELSAT, INMARSAT, DVB-S2, DVB-RCS. • **Navigation Systems:** GPS, GLONASS, Galileo, BeiDou. • **Satellite-based IoT & M2M Communication.** • **Mobile Satellite Systems:** Iridium, Globalstar, Thuraya. • **Emerging Trends:** High-throughput satellites (HTS), NGSO constellations (Starlink, OneWeb), satellite 5G integration.	1	25%

Textbooks:

- Satellite Communications – Timothy Pratt, Charles W. Bostian, & Jeremy E. Allnutt
- Fundamentals of Satellite Communications – K. N. Raja Rao
- Satellite Communication Systems – B. G. Evans

Reference books:

- Satellite Communications – Dennis Roddy
- Understanding GPS: Principles and Applications – Elliott D. Kaplan & Christopher J. Hegarty
- Mobile Satellite Communications – Shingo Ohmori, Hiromitsu Wakana, & Seiichiro Kawase
- Satellite Technology: Principles and Applications – Anil K. Maini & Varsha Agrawal

Online Platforms:

- NPTEL:
  - *Satellite Communication* – IIT Kharagpur
  - *Satellite Communications and Networks* – IIT Bombay
  - *Space Communications* – ISRO/IIST
- Coursera:
  - *Satellite Communications* – École Polytechnique Fédérale de Lausanne (EPFL)
  - *GPS and GNSS for Geospatial Professionals* – University of California, Davis

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Study of orbital parameters and satellite orbits using STK/NASA Eyes.
- Lab 2: Calculation of orbital period and velocity for LEO, MEO, GEO satellites.
- Lab 3: Introduction to satellite tracking software (SatPC32/Gpredict).
- Lab 4: Study of satellite subsystems through block diagrams and datasheets.

Module 2 Practicals

- Lab 5: Link budget calculation for a GEO satellite communication link.
- Lab 6: Simulation of satellite modulation schemes (BPSK, QPSK) using MATLAB/GNURadio.
- Lab 7: BER performance analysis in satellite channel with AWGN and rain fade.
- Lab 8: Atmospheric attenuation modeling for Ku and Ka bands.

Module 3 Practicals

- Lab 9: Implementation and comparison of FDMA and TDMA in a simulated satellite network.
- Lab 10: Design of a VSAT earth station: antenna gain and system noise temperature calculation.
- Lab 11: SDR-based reception of satellite signals (NOAA/APT, Cubesat).
- Lab 12: Measurement of antenna radiation pattern and pointing accuracy.

Module 4 Practicals

- Lab 13: GPS signal reception and position calculation using U-blox/SDR.
- Lab 14: Simulation of a DVB-S2 link using MATLAB/Simulink.
- Lab 15: Study of LEO satellite constellations (Iridium/Starlink) and handover simulation.
- Lab 16: Mini-project – Design of a satellite-based IoT sensor data transmission system.

SUBJECT CODE: **BTECE702**

SUBJECT NAME: ADVANCED VLSI DESIGN

Course Objectives:

- To understand deep-submicron CMOS technology, scaling effects, and advanced fabrication processes.
- To analyse and design low-power, high-speed digital and mixed-signal VLSI circuits.
- To develop skills in system-level design, verification, and testing methodologies.
- To introduce advanced topics such as SoC design, hardware-software co-design, and emerging technologies.

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

CO1	Analyze deep-submicron effects and design CMOS circuits for nanoscale technologies.
CO2	Design and optimize low-power and high-performance digital VLSI circuits.
C03	Implement mixed-signal circuits and memory systems using advanced design techniques.
C04	Apply system-level design, verification, and testing methodologies for complex VLSI systems.

Unit	Content	Credit	Weightage
I	**Deep-Submicron CMOS Technology & Scaling** • **Technology Scaling:** Moore's Law, Dennard scaling, challenges in nanoscale CMOS. • **Deep-Submicron Effects:** Short-channel effects (DIBL, velocity saturation, hot carriers), leakage currents (subthreshold, gate tunneling). • **Advanced Fabrication Processes:** Fin FET, FD-SOI, GAA transistors. • **Interconnect Issues:** RC delay, crosstalk, IR drop,	1	25%

	electromigration. • **Design for Manufacturing (DFM) & Yield Enhancement.**		
II	**Low-Power VLSI Design Techniques** • **Power Dissipation Sources:** Dynamic, short-circuit, leakage power. • **Low-Power Design Techniques:** ○ Clock gating, power gating, multi-Vdd, multi-Vth design. ○ Dynamic voltage and frequency scaling (DVFS). ○ Adiabatic logic, subthreshold circuit design. • **Power Estimation & Analysis:** Gate-level and RTL power estimation. • **Low-Power Memory Design:** SRAM, DRAM, and non-volatile memory power optimization.	1	25%
III	**High-Speed & Mixed-Signal VLSI Design** • **High-Speed Digital Design:** Timing analysis, clock distribution networks, PLL/DLL. • **Mixed-Signal Design:** Data converters (ADC/DAC), PLLs, oscillators, filters. • **Signal Integrity:** Noise coupling, substrate noise, shielding techniques. • **RF CMOS Design:** LNAs, mixers, VCOs for wireless applications. • **On-Chip Sensors:** Thermal, process variation sensors.	1	25%
IV	**System-Level Design & Advanced Topics** • **System-on-Chip (SoC) Design:** IP integration, bus architectures (AMBA AXI, AHB, APB), network-on-chip (NoC). • **Hardware-Software Co-Design:** Co-simulation, co-verification, embedded processors in SoC. • **Verification Methodologies:** UVM, formal verification, assertion-based verification. • **Testing & DFT:** Built-in self-test (BIST), scan chains, JTAG. • **Emerging Technologies:** 3D ICs, quantum-dot cellular automata, neuromorphic computing.	1	25%

Textbooks:

- CMOS VLSI Design: A Circuits and Systems Perspective – Neil H. E. Weste & David M. Harris
- Digital Integrated Circuits: A Design Perspective – Jan M. Rabaey, Anantha Chandrakasan, & Borivoje Nikolic
- Low Power CMOS VLSI Circuit Design – Kaushik Roy & Sharat C. Prasad

Reference books:

- Design of Analog CMOS Integrated Circuits – Behzad Razavi
- VLSI Test Principles and Architectures – Laung-Terng Wang, Cheng-Wen Wu, & Xiaoqing Wen
- System Verilog for Verification – Chris Spear & Greg Tumbush

- Network-on-Chip – Axel Jantsch & Hannu Tenhunen

Online Platforms:

- NPTEL:
  - *Advanced VLSI Design* – IIT Madras
  - *Low Power VLSI Circuits & Systems* – IIT Kharagpur
  - *VLSI Testing* – IIT Delhi
- Coursera:
  - *VLSI CAD Part II: Layout* – University of Illinois at Urbana-Champaign
  - *Hardware Security* – University of Maryland

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Simulation of short-channel effects in 45nm/28nm CMOS using SPICE.
- Lab 2: Layout design of a FinFET-based inverter using Cadence Virtuoso.
- Lab 3: Analysis of interconnect parasitics (RC extraction) and delay calculation.
- Lab 4: DFM exercise: Design rule checking (DRC) and layout vs. schematic (LVS).

Module 2 Practicals

- Lab 5: Power analysis of a digital circuit using Synopsys Prime Time PX.
- Lab 6: Design and simulation of a clock-gated sequential circuit.
- Lab 7: Implementation of multi-Vth design for leakage reduction.
- Lab 8: Low-power SRAM cell design and characterization.

Module 3 Practicals

- Lab 9: Design of a phase-locked loop (PLL) for clock generation.
- Lab 10: Simulation of a 8-bit SAR ADC in mixed-signal environment.
- Lab 11: RF LNA design and noise figure analysis.
- Lab 12: Signal integrity analysis: Crosstalk and IR drop simulation.

Module 4 Practicals

- Lab 13: SoC design with AMBA AXI bus using System Verilog.
- Lab 14: UVM-based testbench for verification of an IP core.
- Lab 15: Built-in self-test (BIST) implementation for a memory module.
- Lab 16: Mini-project – Design of a low-power IoT sensor node SoC (sensor interface, processor, memory).

SUBJECT CODE**: BTECE703**

SUBJECT NAME: AI IN ECE

Course Objectives:

- To introduce the integration of Artificial Intelligence techniques in Electronics and Communication Engineering domains.
- To apply machine learning and deep learning methods to solve ECE-specific problems.
- To design AI-driven systems for communication networks, signal processing, embedded systems, and robotics.
- To explore ethical considerations and deployment challenges of AI in hardware and real-time systems.

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

CO1	Explain AI fundamentals and their relevance to ECE

	applications.
CO2	Apply ML/DL techniques for signal processing, communication, and control systems.
C03	Design AI-enabled embedded and IoT systems using edge computing.
C04	Evaluate AI solutions for ECE problems considering performance, ethics, and deployment constraints.

Unit	Content	Credit	Weightage
I	**Foundations of AI for ECE** • **Introduction to AI in ECE:** Overview, motivation, and applications in communication, robotics, IoT, and signal processing. • **Machine Learning Basics:** Supervised vs unsupervised learning, regression, classification, clustering. • **Neural Networks & Deep Learning:** Perceptron, MLP, CNN, RNN, LSTM fundamentals. • **ECE Data Representation:** Time-series, spectral, image, and sensor data for AI. • **Tools & Frameworks:** Python, TensorFlow, PyTorch, MATLAB for ECE applications.	1	25%
II	**AI in Communication & Signal Processing** • **AI for Wireless Communication:** ○ Channel estimation and equalization using neural networks. ○ Modulation classification with CNNs. ○ Beamforming and MIMO optimization with reinforcement learning. • **AI in Signal Processing:** ○ Speech/audio signal enhancement and separation. ○ Image/video processing: denoising, super-resolution, compression. ○ Biomedical signal analysis (ECG/EEG) using AI. • **Cognitive Radio & Intelligent Spectrum Management.**	1	25%
III	**AI in Embedded Systems & IoT** • **Edge AI & TinyML:** Deploying AI models on microcontrollers (ARM Cortex, ESP32, Raspberry Pi). • **Hardware-aware AI:** Model compression, pruning, quantization for embedded deployment. • **AI for Sensor Networks:** Anomaly detection, predictive maintenance, smart sensing. • **Real-Time AI Systems:** Latency, power, and memory optimization. • **Case Studies:** AI-driven wearable devices, smart agriculture, industrial automation.	1	25%
IV	**Advanced AI Applications & Ethics in ECE**	1	25%

	• **AI in Robotics & Control Systems:** Path planning, computer vision for robotics, reinforcement learning for control. • **AI for VLSI & Hardware Design:** Automated circuit design, fault detection, yield prediction. • **AI in Network Security:** Intrusion detection, anomaly detection in cyber-physical systems. • **Ethical AI in ECE:** Bias, fairness, transparency, and security in AI-driven systems. • **Future Trends:** Neuromorphic computing, quantum machine learning, AI-5G integration.		

Textbooks:

- Artificial Intelligence: A Modern Approach – Stuart Russell & Peter Norvig
- Deep Learning – Ian Goodfellow, Yoshua Bengio, & Aaron Courville
- Machine Learning for Signal Processing – Max A. Little

Reference books:

- AI for Electronics and Communication Engineering – Edited volume (Emerging reference)
- Pattern Recognition and Machine Learning – Christopher M. Bishop
- Embedded Machine Learning for IoT and Edge Computing – Mohamed Abdel-Basset et al.
- Reinforcement Learning: An Introduction – Richard S. Sutton & Andrew G. Barto

Online Platforms:

- NPTEL:
  - *Artificial Intelligence* – IIT Kharagpur
  - *Machine Learning for Wireless Communication* – IIT Hyderabad
  - *Deep Learning for Computer Vision* – IIT Ropar
- Coursera:
  - *AI for Everyone*
  - *AI in Wireless Communication* – Yonsei University
  - *TinyML* – Harvard University

SUBJECT CODE: **BTECE704**

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**: BTECE801**

SUBJECT NAME: RESEARCH METHDOLOY IN ECE

Course Objectives:

- To introduce the principles, processes, and ethics of scientific research in Electronics and Communication 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 ECE 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 ECE problems and design valid experimental studies.
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 ECE.
C04	Communicate research findings effectively through reports, papers, and presentations following academic and ethical standards.

Unit	Content	Credit	Weightage
I	**Foundations of Research in ECE** • **Introduction to Research:** Types of research (fundamental, applied, experimental, simulation-based) in ECE. • **Research Ethics in ECE:** Data integrity, plagiarism, authorship, IPR, responsible conduct of research. • **Literature Review & Survey:** Searching databases (IEEE Xplore, ACM, 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 ECE:** Between-subjects, within-subjects, factorial designs, quasi-experiments. • **Sampling & Data Collection:** Probability vs. non-probability sampling, sample size determination (power analysis). • **Data Sources for ECE Research:** Public datasets (UCI, Kaggle), simulation data (MATLAB, NS3, HFSS), hardware testbeds. • **Statistical Methods for ECE:** Descriptive	1	25%

	statistics, inferential statistics (t-test, ANOVA, chi-square), Bayesian methods. • **Tools for Experimentation:** MATLAB, Python (SciPy, StatsModels), LabVIEW, simulation tools.		
III	**ECE Research Techniques & Implementation** • **Model Development & Validation:** Cross-validation, hyperparameter tuning, benchmarking. • **Reproducibility in ECE Research:** Code sharing (GitHub), containerization (Docker), environment replication. • **Advanced Research Methods:** Ablation studies, counterfactual analysis, causal inference in ML for ECE. • **Simulation & Hardware Testbeds:** NS3 for networks, HFSS/CST for EM, FPGA/ARM for embedded research. • **Human-Centered ECE 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, ACM, Elsevier), submission process, peer review. • **Research Presentation:** Conference talks, poster sessions, demo presentations. • **ECE Research Trends:** AI/ML in communications, 6G, quantum computing, neuromorphic engineering, sustainable electronics. • **Career Paths in ECE Research:** Academia vs. industry, research internships, PhD preparation.	1	25%

Textbooks:

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

Reference books:

- Research Methods in Engineering – A. Srinivasan
- Experimental Methods for Engineers – J. P. Holman
- How to Write and Publish a Scientific Paper – Barbara Gastel & Robert A. Day
- Design and Analysis of Experiments – Douglas C. Montgomery

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: **BTECE802**

SUBJECT NAME: TELECOM NETWORK MANAGEMENT

Course Objectives:

- To introduce the principles, architectures, and protocols of telecom network management.
- To understand network management models (FCAPS, TMN), standards, and protocols (SNMP, NETCONF, YANG).
- To develop skills in monitoring, configuring, troubleshooting, and securing telecom networks.
- To apply network management tools for performance analysis, fault detection, and service assurance in modern telecom networks.

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

CO1	Explain telecom network management architectures, models, and standards.
CO2	Implement network management protocols (SNMP, NETCONF) for device monitoring and configuration.
C03	Analyze network performance, detect faults, and ensure QoS in telecom networks.
C04	Design and manage secure, scalable telecom networks using modern management tools and platforms.

Unit	Content	Credit	Weightage
I	**Introduction to Telecom Network Management** • **Telecom Networks Overview:** PSTN, mobile networks, NGN, IMS, SDN/NFV. • **Network Management Models:** FCAPS (Fault, Configuration, Accounting, Performance, Security), TMN (Telecom Management Network). • **Management Architectures:** Centralized vs distributed, agent-manager model. • **Standards & Organizations:** ITU-T, ISO, IETF, TMF. • **Introduction to OSS/BSS:** Operations Support Systems / Business Support Systems.	1	25%
II	**Network Management Protocols & Technologies** • **SNMP (Simple Network Management Protocol):** Versions (v1, v2c, v3), MIB, traps, polling. • **NETCONF/YANG:** Configuration management, data modeling, RESTCONF. • **Telecom Protocols for Management:** TR-069, CORBA, TL1. • **Network Monitoring Tools:** Wireshark, Nmap, SolarWinds, Nagios. • **SDN & NFV in Network Management:** SDN controllers (Open Day light, ONOS), VNF management.	1	25%

III	**Fault, Performance & Security Management** • **Fault Management:** Alarm correlation, root cause analysis, trouble ticket systems. • **Performance Management:** QoS parameters (delay, jitter, packet loss), SLA monitoring, KPI/KQI. • **Accounting Management:** Billing systems, CDR (Call Detail Record) analysis. • **Security Management:** Threats in telecom networks, firewalls, IDS/IPS, secure management access. • **Case Studies:** Mobile network fault analysis, VoIP QoS monitoring.	1	25%
IV	**Advanced Topics & Future Trends** • **5G Network Management:** Network slicing, zero-touch network management, AI/ML for automation. • **Cloud-based Management:** Managing hybrid and multi-cloud telecom networks. • **IoT Network Management:** Managing massive IoT device connectivity, LPWAN management. • **Automation & Orchestration:** Ansible, Chef, Puppet for telecom network automation. • **Career Paths:** Telecom network engineer, NOC engineer, network architect.	1	25%

Textbooks:

- Network Management: Principles and Practice – Mani Subramanian
- Fundamentals of Telecommunications Network Management – Lakshmi G. Raman
- Telecommunications Network Management – Salah Aidarous & Thomas Plevyak

Reference books:

- SNMP, SNMPv2, SNMPv3, and RMON 1 and 2 – William Stallings
- SDN and NFV Simplified – Jim Doherty
- 5G Mobile Networks: A Systems Approach – Larry Peterson & Oguz Sunay
- Telecom for Dummies – Stephen P. Olejniczak

Online Platforms:

- NPTEL:
  - *Telecommunication Network Management* – IIT Kharagpur
  - *Mobile Communication Networks* – IIT Bombay
- Coursera:
  - *Network Management and Operations* – Cisco
  - *5G Network Fundamentals* – Institut Mines-Télécom

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Study of telecom network architectures (PSTN, NGN, IMS) using diagrams and simulators.
- Lab 2: Introduction to OSS/BSS systems – demo of a telecom billing/CRM platform.
- Lab 3: FCAPS model implementation – setting up a simple fault and performance monitoring system.
- Lab 4: Case study on TMN architecture and its layers.

Module 2 Practicals

- Lab 5: SNMP-based network monitoring: Configuring SNMP agents and managers, querying MIBs.
- Lab 6: NETCONF/YANG lab: Configuring network devices using YANG models and NETCONF.
- Lab 7: Traffic analysis using Wireshark – capturing and analyzing SIP, RTP, and Diameter protocols.
- Lab 8: SDN controller setup (OpenDaylight/ONOS) and flow configuration.

Module 3 Practicals

- Lab 9: Fault management simulation – alarm generation, correlation, and ticketing system.
- Lab 10: QoS measurement in VoIP networks – measuring delay, jitter, and packet loss.
- Lab 11: SLA monitoring and KPI calculation for a simulated telecom service.
- Lab 12: Security management – configuring firewall and IDS for a telecom network.

Module 4 Practicals

- Lab 13: 5G network slicing simulation using open-source tools (OpenAirInterface).
- Lab 14: IoT device management platform (e.g., AWS IoT, ThingsBoard) for telecom IoT.
- Lab 15: Network automation using Ansible – automating router/switch configuration.
- Lab 16: Mini-project – Designing a network management system for a small telecom operator.

SUBJECT CODE**: BTECE803**

SUBJECT NAME: EMBEDDED SYSTEMS DESIGN

Course Objectives:

- To introduce the architecture, design, and development of embedded systems.
- To develop skills in programming microcontrollers (ARM Cortex-M, AVR) using embedded C.
- To understand real-time operating systems (RTOS), interfacing, and communication protocols.
- To design, simulate, and implement embedded systems for real-world applications.

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

CO1	Explain embedded system architecture, processors, and design methodologies.
CO2	Program ARM Cortex-M microcontrollers using embedded C and assembly.
C03	Interface sensors, actuators, and peripherals using SPI, I2C, UART, and CAN.
C04	Design and implement real-time embedded applications using RTOS and debugging tools.

Unit	Content	Credit	Weightage
I	**Embedded System Fundamentals** • **Introduction:** Definition, characteristics, applications, and design challenges. • **Embedded System Architecture:** Harvard vs. von Neumann, RISC vs. CISC, microcontrollers vs. microprocessors. • **ARM Cortex-M Architecture:** Registers, memory map, exception handling, CMSIS. • **Embedded Development Cycle:** Requirements, design, implementation, testing, debugging.	1	25%

	• **Introduction to Embedded C:** Data types, memory mapping, bit manipulation, pointers.		
II	**Embedded Programming & Peripherals** • **ARM Cortex-M Programming:** Assembly basics, embedded C programming, inline assembly. • **GPIO Programming:** Input/output configuration, push-pull, open-drain modes. • **Timers & Counters:** SysTick timer, PWM generation, input capture, output compare. • **Interrupts:** NVIC, interrupt service routines (ISR), priority management. • **Low-Power Modes:** Sleep, deep sleep, wake-up mechanisms.	1	25%
III	**Embedded Communication Protocols** • **Serial Communication:** UART/USART, RS-232, RS-485. • **Synchronous Protocols:** SPI (master/slave), I2C (master/slave). • **Advanced Protocols:** CAN bus, Ethernet, USB basics. • **Wireless Communication:** Bluetooth Low Energy (BLE), Wi-Fi, Zigbee basics. • **Sensor Interfacing:** Analog sensors (ADC), digital sensors (I2C/SPI), motor control.	1	25%
IV	**RTOS & Advanced Embedded Design** • **Real-Time Operating Systems (RTOS):** Tasks, scheduling, semaphores, queues, mutex. • **Free RTOS:** Task creation, inter-task communication, memory management. • **Embedded Linux Basics:** Boot process, device drivers, cross-compilation. • **Embedded System Security:** Secure boot, firmware encryption, secure communication. • **Design Project:** Complete embedded system design (e.g., smart home controller, IoT node).	1	25%

Textbooks:

- Embedded Systems: Introduction to ARM Cortex-M Microcontrollers – Jonathan W. Valvano
- Making Embedded Systems – Elecia White
- The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors – Joseph Yiu

Reference books:

- Embedded C Programming and the Atmel AVR – Richard H. Barnett, Sarah Cox, & Larry O'Cull
- Real-Time Concepts for Embedded Systems – Qing Li & Carolyn Yao
- Programming Embedded Systems in C and C++ – Michael Barr
- ARM System Developer's Guide – Andrew N. Sloss, Dominic Symes, & Chris Wright

Online Platforms:

- NPTEL:
    - *Embedded Systems Design* – IIT Delhi
    - *ARM Based Development* – IIT Kharagpur
    - *Real-Time Systems* – IIT Bombay

- Coursera:
  - *Embedded Systems Essentials with ARM* – ARM Education
  - *Real-Time Embedded Systems* – University of Colorado Boulder

PRACTICAL LIST:

Module 1 Practicals

- Lab 1: Setting up STM32CubeIDE and blinking an LED using STM32.
- Lab 2: Memory-mapped I/O programming – accessing registers directly.
- Lab 3: Embedded C programming – writing and debugging a simple program.
- Lab 4: Study of ARM Cortex-M memory map and linker script.

Module 2 Practicals

- Lab 5: GPIO programming – interfacing switches, LEDs, and buzzers.
- Lab 6: Timer programming – generating PWM for servo motor control.
- Lab 7: Interrupt programming – external interrupt for button press.
- Lab 8: Low-power mode implementation – wake-up from sleep.

Module 3 Practicals

- Lab 9: UART communication between STM32 and PC (using PuTTY).
- Lab 10: I2C communication with temperature sensor (LM75, BMP280).
- Lab 11: SPI communication with OLED display or SD card.
- Lab 12: CAN bus communication between two microcontrollers.

Module 4 Practicals

- Lab 13: Free RTOS – creating multiple tasks and semaphores.
- Lab 14: Inter-task communication using queues and mailboxes.
- Lab 15: Embedded Linux – cross-compilation and running Hello World on Raspberry Pi.
- Lab 16: Mini-project – Design a smart weather station with sensors, display, and cloud connectivity.