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B.TECH. - ELECTRONICS & COMMUNICATION ENGINEERING
Course Structure R-25

SEMESTER III

S.No.	Course Classification	Course Code	Name of the subject	L	T	P	C	CIE	SEE	Total Marks
1	**BS**	5BS3DA	Numerical methods and Complex variables	3	0	0	3	40	60	100
2	**PC**	5PC3DB	Digital Logic Design	3	0	0	3	40	60	100
3	**PC**	5PC3DC	Pulse and Digital Circuits	3	0	0	3	40	60	100
4	**PC**	5PC3DD	Electronic Circuit Analysis	3	0	0	3	40	60	100
5	**PC**	5PC3DE	Signals and Systems	3	0	0	3	40	60	100
6	**BS**	5BS341	Computational Mathematics lab	0	0	2	1	40	60	100
7	**PC**	5PC342	Digital Logic Design Lab	0	0	2	1	40	60	100
8	**PC**	5PC343	Electronic Circuit Analysis Lab	0	0	2	1	40	60	100
9	**PC**	5PC344	Pulse and Digital Circuits Lab	0	0	2	1	40	60	100
10	**PC**	5PC345	Basic Simulation Lab	0	0	2	1	40	60	100
11	**SDC-1**	5PC346	Linux and Shell Programming	0	0	2	1	40	60	100
		Total Credits		**15**	**00**	**12**	**21**	**440**	**660**	**1100**

SEMESTER IV

S.No.	Course Classification	Course Code	Name of the subject	L	T	P	C	CIE	SEE	Total Marks
1	**PC**	5PC4DA	Probability Theory and Stochastic Processes	3	0	0	3	40	60	100
2	**PC**	5PC4DB	Analog and Digital Communications	3	0	0	3	40	60	100
3	**HS**	5HS4DC	Innovation and Entrepreneurship	3	0	0	3	40	60	100
4	**PC**	5PC4DD	Linear and Digital IC Applications	3	0	0	3	40	60	100
5	**PC**	5PC4DE	Control systems	2	0	0	2	40	60	100
6	**PC**	5PC4DF	Electromagnetic Theory and Transmission Lines	3	0	0	3	40	60	100
7	**PC**	5PC441	Analog and Digital communications Lab	0	0	2	1	40	60	100
8	**PC**	5PC442	Linear and Digital IC Applications Lab	0	0	2	1	40	60	100
9	**SDC-2**	5SD443	PCB Design and Fabrication	0	0	2	1	40	60	100
10	MC	5MC444	Environmental Science	0	0	2	1	40	60	100
		Total Credits		**17**	**0**	**08**	**21**	**400**	**600**	**1000**

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B.TECH. ELECTRONICS & COMMUNICATION ENGINEERING

NUMERICAL METHODS AND COMPLEX VARIABLES

B.Tech.IIISemester **L/T/P/C**
3/0/0/3

Pre-requisites: Mathematics courses of first year of study.
Course Objectives: To learn

1. Understand numerical methods for solving equations and interpolation using finite differences and Lagrange's formula.
2. Learn numerical integration techniques and methods for solving first-order ordinary
3. differential equations.
4. Understand Fourier series and Fourier transforms for representing and analyzing functions.
5. Learn the concepts of complex differentiation, analyticity, and properties of elementary
6. analytic functions.
7. Understand complex integration techniques and apply Cauchy's theorems, series expansions, and residue methods.

Course outcomes: Upon completion of the Course, the students will be able to:
CO1: Apply numerical methods to solve equations and perform interpolation using finite difference and Lagrange techniques
CO2: Apply numerical integration techniques and solve first-order ordinary differential equations
using Taylor's, Euler's, and Runge–Kutta methods
CO3: Apply Fourier series and Fourier transform to represent and analyze periodic and non-periodic functions.
CO4: Analyze complex functions for analyticity, determine harmonic conjugates, and apply properties of elementary analytic functions
CO5: Analyze and evaluate complex integrals using Cauchy's theorems, series expansions, and
residue methods

COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	3		2									
CO2	3	3	2	3									
CO3	3	3	2	2									
CO4	3	2		2									
CO5	3	3		3									

UNIT-I: Numerical Methods-I

Solution of polynomial and transcendental equations: Bisection method – Iteration Method – Newton- Raphson method and Regula-Falsi method. Finite differences: forward differences — backward differences –Interpolation using Newton's forward and backward difference formulae – Lagrange's method of interpolation.

UNIT-II: Numerical Methods-II

Numerical integration: Trapezoidal rule - Simpson's $1/3^{rd}$ and $3/8^{th}$ rules.

Ordinary differential equations: Taylor's series – Euler's method – Runge-Kutta method of fourth order for first order ODE.

UNIT-III: Fourier Series & Fourier Transforms

Fourier series — Dirichlet's Conditions — Half-range Fourier series — Fourier Transforms: Fourier Integral Theorem (Only statements), Fourier Sine and Cosine transforms (Elementary illustrations)

UNIT-IV: Complex Differentiation

Differentiation of Complex functions — Analyticity — Cauchy-Riemann equations (without proof) — Harmonic Functions – Finding harmonic conjugate – Milne-Thomson method – Elementary analytic functions (exponential, trigonometric, logarithm) and their properties.

UNIT-V: Complex Integration

Line integral — Cauchy's theorem — Cauchy's Integral formula — Zeros of analytic functions — Singularities – Taylor's series – Laurent's series. Residues – Cauchy Residue theorem (All theorems without Proof).

TEXT BOOKS

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36^{th} Edition, 201
2. S.S. Sastry, Introductory methods of numerical analysis, PHI, 4th Edition, 2005.

REFERENCE BOOKS

1. Murray R. Spiegel, Ph.D., Seymour Lipschutz, Ph.D., John J. Schiller, Ph.D., Dennis Spellman, Ph.D., Complex Variables (Schaum's outline).
2. M. K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical methods for Scientific and Engineering Computations, New Age International publishers.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 9^{th}Edition, John Wiley &Sons, 2006.
4. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7^{th} Edition, Mc-Graw Hill, 2004.

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ELECTRONICS AND COMMUNICATION ENGINEERING
DIGITAL LOGIC DESIGN

B.Tech. III Semester **L/T/P C**
3/0/0/3

Course Objective

1. To learn basic techniques for the design of Digital Circuits and fundamental concepts used in the design of Digital Systems.
2. To understand common forms of number representation in Digital Electronic Circuits and to be able to convert between different representations.
3. To implement simple Logical operations using Combinational Logic Circuits
4. To impart students the concepts of Sequential Circuits.

Course Outcomes

Upon completion of the Course, the students will be able to:
CO1: Analyze the Conversion of numeric information of different forms, e.g. different Analyze the Conversion of numeric information of different forms, e.g. different bases, signed integers, various codes such as ASCII, Gray, and BCD.
CO2: Analyzing the Realized simple Boolean expressions and to minimize Combinational Functions.
CO3: Design and analyze of combinational functions/building blocks for building larger more complex circuits.
CO4: Design of Sequential Logic circuits and synthesizing of threshold functions.
CO5: Design and analyze small Sequential circuits and devices and to use standard sequential functions/building blocks to build larger more Complex Circuits.

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1
CO1	3	2										2
CO2	3	3	2									3
CO3	3	3	3									3
CO4	3	3	3									3
CO5	3	3	3									3

UNIT I

Number System and Switching Functions: Number Systems, Base Conversion Methods, Complements of Numbers, Codes- Binary Codes, Binary Coded Decimal Code and its Properties, Unit Distance Codes, Error Detecting and Correcting Codes.

UNIT II

Boolean Algebra: Basic Theorems and Properties, Switching Functions, Canonical and Standard Form, Algebraic Simplification of Digital Logic Gates, Properties of XOR Gates, Universal Gates, Multilevel NAND/NOR realizations.

Minimization of Boolean Functions: Introduction, The Minimization with theorem, The Karnaugh Map Method, Five and Six Variable Maps, Prime and Essential Implications, Don't Care Map conditions, Tabular Method.

UNIT III

Combinational Circuits: Introduction, Adders, Subtractors, Multiplexers, Demultiplexers, Encoders, Decoders, code converters, Comparators and Hazards.

UNIT IV

Sequential Circuits I: Introduction, Basic Differences between Combinational and Sequential circuits, the Binary Cell, Latch, Flip-Flop-Types, and Race around condition, Excitation tables and characteristic equations. Conversion from one type of Flip-Flop to another, preset and Clear inputs, Timing and Triggering Consideration, Clock Skew.

UNIT V

Sequential Circuits II: Introduction, Register-Types, Counter –Types, Design of Ripple (mod-N) Counter, Ring Counter.

Text Books:

1. Digital Design- Morris Mano, PHI, 3rd Edition.
2. Switching and Finite Automata Theory- Zvi Kohavi & Niraj K. Jha, 3rd Edition, Cambridge.

References Books:

1. Anand Kumar, “Switching Theory and Logic Design” PHI, 2008.
2. Charles H. Roth, “Fundamentals of Logic Design” Thomson Publications, 5th Edition, 2004.

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ELECTRONICS AND COMMUNICATION ENGINEERING

PULSE AND DIGITAL CIRCUITS

B.Tech. III Semester **L/T/P/C**
3/0/0/3

COURSE OBJECTIVES:

1. To explain the complete response of R-C and R-L-C transient circuits, clippers, clampers, switching characteristics of transistors and sampling gates.
2. To construct various multivibrators using transistors, design of sweep circuits, sampling gates and realization of logic gates using diodes and transistors Study the concepts of distortion less transmission through LTI Systems, convolution and correlation properties.

COURSE OUTCOMES:

Upon completion of the Course, the students will be able to:

CO1: Analyze the response of RLC circuits excited by linear signals.

CO2: Design Non Linear wave shaping circuits.

CO3: Illustrate the working of time base generators with help of nonlinear switching devices.

CO4: Analysis and design of various Multi-vibrators.

CO5: Realize of logic gates in various logic families.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3									
CO2	3	3									
CO3	2	2									
CO4	3	3									
CO5	3	3									

UNIT- I:

Linear Wave Shaping: High pass and low pass RC circuits and their response for Sinusoidal, Step, Pulse, Square, & Ramp inputs, High pass RC network as Differentiator, Low pass RC circuit as an Integrator, Attenuators and its application as a CRO Probe, RL and RLC Circuits and their response for Step Input, Ringing circuit, Illustrative Problems.

UNIT-II:

Non-Linear Wave Shaping: Diode clippers, Transistor clippers, Clipping at two independent levels, Emitter coupled clipper, Comparators, Applications of Voltage comparators. Clamping Operation, Clamping circuit taking Source and Diode resistances into account, Clamping Circuit Theorem, Practical Clamping circuits effect of Diode characteristics on clamping

voltage

UNIT-III:

Switching Characteristics of Devices: Diode as a Switch, Piecewise Linear Diode Characteristics, Diode Switching times, Transistor as a Switch, Transistor switching times.

Time Base Generators: General features of a Time base Signal, Methods of Generating Time Base Waveform, Transistor Miller Time Base generator, Transistor Bootstrap, Time Base Generator, Transistor Current Time Base Generators.

UNIT-IV:

Multivibrators: Analysis and Design of Bistable, Monostable, Astable Multivibrators and Schmitt trigger using transistors, Commutating Capacitor, Monostable Multivibrator (collector Coupled only), Astable Multivibrator (collector Coupled only) and Applications of Multivibrators.

UNIT - V:

Realization of Logic Gates: AND, OR and NOT gates using Diodes and transistors, DCTL, RTL, DTL, TTL, CML (ECL) and CMOS Logic Families and its Comparison, Sampling Gates.

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TEXT BOOKS

1. J. Millman, H. Taub and Mothiki S. Prakash Rao, “Pulse Digital and Switching Waveforms”, 3 rd Edition, McGraw Hill, 2017.
2. David A. Bell, “Pulse, Switching and Digital Circuits”, 5th Edition, Oxford University Press, 2015

REFERENCE BOOKS

1. Venkata Rao K, Rama Sudha K, Manmadha rao G, “Pulse and Digital Circuits”, Pearson Education, 2010.

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ELECTRONICS AND COMMUNICATION ENGINEERING
ELECTRONIC CICUIT ANALYSIS

B.Tech. III Semester **L/T/P/ C**
3/0/0/ 3

Prerequisite: Electronic Devices and Circuits.

COURSE OBJECTIVE:

To give understanding of various types of amplifier such as small signal, Cascaded, Large Signal, tuned or un tuned circuits and to know the concept of feedback in amplifiers and Oscillators.

COURSE OUTCOMES:

Upon completion of the Course, the students will be able to
CO-1:Analyze Small signal Analysis of different transistor amplifier circuits such as single stage or multistage amplifiers using hybrid parameters. L4
CO-2: Analyze the high frequency response of transistor circuits. L4
CO-3: Analyze the gain of JFET and MOSFET amplifier using small signal model. L4
CO-4: Design various Feedback Amplifiers and Oscillator circuits. L5
CO-5: Analyze and Compare the efficiency and distortion of various Power Amplifiers. L4

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO-1	3	3	3								
CO-2		3									
CO-3	3	3									
CO-4		3	3								
CO-5		3									

UNIT-I:

Analysis and Design of Small Signal Low Frequency BJT Amplifiers: Classification of Amplifiers, h-parameter analysis, small signal equivalent circuit of a transistor, Analysis of CE, CB, CC amplifiers using Exact model. Distortion in amplifiers, Miller's theorem, Analysis of CE, CC, and CB Amplifiers using simolified model, CE Amplifier with emitter resistance, low frequency response of BJT Amplifiers, Effect of coupling and bypass capacitors, Design of single stage RC coupled amplifier, Different coupling schemes used in amplifiers, Analysis of Cascaded RC Coupled amplifiers, Cascode Amplifier, Darlington pair.

UNIT-II:

Transistor at High Frequency: Logarithms, Decibels. The Hybrid-pi (π)–Common Emitter transistor model, CE short circuit current gain, current gain with resistive load, Single stage CE transistor amplifier response, Gain-bandwidth product.

UNIT-III:

FET Amplifiers: Small Signal Equivalent circuit of JFET Amplifiers, Analysis of CS, CD, CG JFET Amplifiers, comparison of performance with BJT Amplifiers, Basic Concepts of MOS amplifiers, MOS Small signal model, Common source amplifier with resistive load, Diode connected and Current source loads, Source follower, Common Gate Stage amplifier.

UNIT-IV:

Positive & Negative Feedback in Amplifiers: Concepts of feedback – Classification of feedback amplifiers– General characteristics of negative feedback amplifiers, Effect of Feedback on Amplifier characteristics, Voltage series, Voltage shunt, Current series and Current shunt Feedback configurations, Simple problems.

Oscillators: Condition for Oscillations, RC and LC type Oscillators–Frequency and amplitude stability of oscillators–Generalized analysis of LC oscillators, Quartz, Hartley, and Colpitts Oscillators RC-phase shift and Wien-bridge oscillators.

UNIT-V:

Large Signal Amplifiers: Class A Power Amplifier, Maximum Value of Efficiency of Class–A power Amplifier, Transformer Coupled Class A Power Amplifier, Class B Power Amplifier, Class B Push-Pull and Complimentary Symmetry Power Amplifiers. Distortion in amplifiers, Crossover distortion and harmonic distortion. Transistor Power Dissipation, Heat Sinks.

Tuned Amplifiers: Introduction, Q-Factor, Small Signal Tuned Amplifier, Single Tuned Amplifier (Capacitive coupling & Inductive Coupling).

TEXT BOOKS:

1. David A. Bell, “Electronic Devices and Circuits”, 5th Edition, Oxford Press.
2. Robert L. Boylestead and Louis Nashelsky, “Electronic Devices and Circuit Theory”, 11th Edition, 2009, Pearson Publications.
3. Jacob Millman, Christos C Halkias, “Integrated Electronics”, McGraw Hill Education.

REFERENCE BOOKS:

1. S. Salivahanan, N. Suresh Kumar, AVallvaraj, “Electronic Devices and Circuits”, 5th Edition, McGraw Hill Education.
2. Md. H Rashid, “Electronic Circuits and Applications”, Cengage Learning, 2014.

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ELECTRONICS AND COMMUNICATION ENGINEERING
SIGNALS AND SYSTEMS

B.Tech. III Semester **L/T/P C**
3/0/0 3

COURSE OBJECTIVES: The objectives of this subject are to:
1. Classify signals and systems and their analysis in time and frequency domains.
2. Study the concepts of distortion less transmission through LTI Systems, convolution and correlation properties.
3. Understand Laplace transforms and their properties for analysis of signals and systems.
4. Identify the need for sampling of CT signals, types and merits and demerits of each type.

COURSE OUTCOMES:
Upon completion of the Course, the students will be able to:
CO1: Identify and classify different types of signals and systems.
CO2: Apply Fourier Series techniques to express and analyze periodic signals.
CO3: Analyze and interpret signals using Fourier Transform and Sampling concepts.
CO4: Use Laplace Transform to determine and Analyze the behavior of LTI systems.
CO5: Evaluate the output of linear systems using convolution and correlation.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2									
CO2	3	3			2						
CO3	3	3		2	2						
CO4	3	3		2	2						
CO5	3	3		2	3						

UNIT- I:
INTRODUCTION TO SIGNALS & SYSTEMS: Definition of Signals and Systems, Singularity functions and related functions, Standard signals. Operations on signals with respect to time and amplitude. Classification of Signals & Systems.

UNIT-II:
SIGNAL ANALYSIS: Analogy between vectors and signals, orthogonal signal space, Signal approximation using orthogonal functions, Mean square error, closed or complete set of orthogonal functions, Orthogonality in complex functions.
FOURIER SERIES: Fourier series representation of continuous time periodic signals, properties of Fourier series, Dirichlet's conditions, Trigonometric Fourier series and Exponential Fourier series, Complex Fourier spectrum.

UNIT-III:
FOURIER TRANSFORM: Deriving Fourier transform from Fourier series, Fourier transform of arbitrary signal, Fourier transform of standard signals, Fourier transform of periodic signals, properties of Fourier transforms, Fourier transforms involving impulse function and Signum function, System analysis with Fourier transform.
SAMPLING: Sampling theorem – Graphical and analytical proof for Band Limited Signals, Types of Sampling - Impulse Sampling, Natural and Flat top Sampling, Reconstruction of signal from its samples, Effect of under sampling – Aliasing.

UNIT-IV:

LAPLACE TRANSFORM: Concept of Region of Convergence (ROC) for Laplace Transforms, Constraints on ROC for various classes of signals, Properties of L.T, Relation between L.T and F.T of a signal, Laplace Transform of certain signals using waveform synthesis. Laplace transforms methods in circuit analysis, the transfer function. Inverse Laplace Transform. Analysis and characterization of LTI system using Laplace transform.

UNIT - V:

CONVOLUTION AND CORRELATION: Linear System, Impulse response, Concept of convolution, Properties and theorems of convolution, Cross Correlation and Auto Correlation of functions, Relation between Convolution and Correlation.

SIGNAL TRANSMISSION THROUGH LINEAR SYSTEMS: Response of a Linear System, Linear Time Invariant (LTI) System, Linear Time Variant (LTV) System, Transfer function of a LTI system. Filter characteristics of Ideal LPF, HPF, BPF and BSF characteristics, Distortion less transmission through a system, Signal bandwidth, System bandwidth, Causality and Paley-Wiener criterion for physical realization, Relation between Bandwidth and Rise time.

TEXT BOOKS

1. B.P. Lathi," Signals, Systems & Communications", 2013, BS Publications.
2. A.V. Oppenheim, A.S. Willsky and S.H. Nawab, "Signals and Systems", 2nd Ed., PHI.
3. Anand Kumar," Signals and Systems"- PHI.

REFERENCE BOOKS

1. Simon Haykin and Van Veen, Wiley, "Signals & Systems", 2nd Ed.
2. Iyer and K. Satya Prasad, "Signals and Systems", Cengage Lear

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ELECTRONICS AND COMMUNICATION ENGINEERING

COMPUTATIONAL MATHEMETICS LAB

B.Tech. III Semester. **L/T/P C**
0/0/2 /1

Pre-requisites: Matrices, Iterative methods and ordinary differential equations

Course Objectives: To learn

1. Solve problems of Eigen values and Eigen Vectors using Python/MATLAB.
2. Solution of Algebraic and Transcendental Equations using Python/MATLAB
3. Solve problems of Linear system of equations
4. Solve problems of **First-Order ODEs Higher order linear differential equations with**
   Constant coefficients

Course outcomes: Upon completion of the Course, the students will be able to:

1. Develop the code to find the Eigen values and Eigen Vectors using Python/MATLAB.
2. Develop the code find solution of Algebraic and Transcendental Equations and Linear system of equations using Python/MATLAB
3. Write the code to solve problems of **First-Order ODEs Higher order linear differential equations with** constant coefficients

COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	2												
CO2	3	3												
CO3	3	3	2											

Visualize all solutions graphically through programmes

UNIT - I: Eigen values and Eigenvectors:

Programs:

- Finding real and complex Eigen values.
- Finding Eigen vectors.

UNIT-II: Solution of Algebraic and Transcendental Equations

Bisection method, Newton Raphson Method

Programs:

- Root of a given equation using Bisection method.
- Root of a given equation Newton Raphson Method.

UNIT-III: Linear system of equations:

Jacobi's iteration method and Gauss-Seidal iteration method

Programs:

- Solution of given system of linear equations using Jacobi's method
- Solution of given system of linear equations using Gauss-Seidal method

UNIT-IV: First-Order ODEs

Exact and non-exact equations, Applications: exponential growth/decay, Newton's law of cooling.

Programs:

- Solving exact and non-exact equations
- Solving exponential growth/decay and Newton's law of cooling problems

UNIT-V: Higher order linear differential equations with constant coefficients

6P Programs:

- Solving homogeneous ODEs
- Solving non-homogeneous ODEs

TEXT BOOKS:

1. MATLAB and its Applications in Engineering, Rajkumar Basal, Ashok Kumar Geo, Manoj Kumar Sharma, Pearson publication.
2. Kenneth A. Lambert, The fundamentals of Python: First Programs, 2011, Cengage Learnings.
3. Think Python First Edition, by Allen B. Downey, Orielly publishing.
4. Introduction to Python Programming, William Mitchell, Povel Solin, Martin Novak et al., NCLab Public Computing, 2012.
5. Introduction to Python Programming, ©Jacob Fredslund, 2007.

REFERENCE BOOKS:

1. An Introduction to Python, John C. Lusth, The University of Alabama, 2011.
2. Introduction to Python, ©Dave Kuhlman, 2008.

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ELECTRONICS AND COMMUNICATION ENGINEERING
DIGITAL LOGIC DESIGN LAB

B.Tech. III Semester. **L/T/P C**
0/0/2 /1

Course Objectives:

1. To learn basic techniques for the design of Digital Circuits and fundamental concepts used in the design of Digital Systems.
2. To understand common forms of number representation in Digital Electronic Circuits and to be able to convert between different representations.
3. To implement simple Logical operations using Combinational Logic Circuits.
4. To impart students the concepts of Sequential Circuits.

COURSE OUTCOMES:

Upon completion of the Course, the students will be able to:
CO1: Analyze and simplify Boolean expressions and implement them using logic gates and ICs.
CO2: Design and realize combinational and sequential logic circuits using logic gate hardware.
CO3: Model digital systems in Verilog HDL using dataflow, behavioral, and structural styles.
CO4: Simulate and verify digital designs using industry-standard EDA tools and test benches.
CO5: Build modular and hierarchical designs such as counters, FSMs, and shift registers.

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO11	PSO12
CO1	3	3	2		2							2
C02	3	3	3	2	3							3
CO3	3	2	3	1	3							3
CO4	2	3	3	3	3							3
CO5	3	3	3	2	3							3

(**Note: Min 5- Experiments to be conducted from each part)**

List of Experiments

A. Realization in Hardware Laboratory (Using Logic ICs)

These are fundamental hands-on experiments conducted using logic ICs such as AND, OR, NOT, NAND, NOR, XOR gates, flip-flops, multiplexers, and decoders.

1. Construct and analyze basic logic gates (AND, OR, NOT, XOR, XNOR,NAND and NOR gates).
2. Design and implement code converters such as Binary to Gray, Gray to Binary .
3. Design and implement simple combinational circuits: 2-to-1 multiplexer, 8-to-1 multiplexer.
4. Design a 8 bit Comparator using 4 bit comparator.
5. Study of Flip Flops.
6. Design an 8 bit serial in and serial out shift register using two 4 bit shift registers.
7. Design a Ring counter and twisted ring counter using a 4-bit shift register.

B. Verilog HDL-Based Digital Design Experiments (Simulation-Based)

These experiments are implemented using Verilog HDL with different modeling styles (dataflow, behavioral, structural) and simulated using tools like Vivado, ModelSim, or Xilinx ISE.

1. Design and simulate a Full adder using dataflow modeling; extend it to using two half adders in structural modeling.
2. Implement a 2:1 multiplexer using dataflow modeling and design an 8:1 multiplexer using structural modeling.
3. Design a 2-to-4 decoder using dataflow modeling and realize a 3-to-8 decoder using structural modeling.
4. Implement a given Boolean function using a decoder-based approach in behavioral modeling.
4. Implement a given Boolean function using a decoder-based approach in behavioural modeling.
5. Design and simulate a universal n-bit shift register (left, right, hold, parallel load) using behavioural modeling.
6. Design a synchronous MOD-n counter using behavioural modeling with D or JK flip-flops.
7. Design and simulate an asynchronous (ripple) counter for a custom sequence using structural modeling.
8. Implement a sequence detector for a given binary pattern using FSM (Moore/Mealy) in behavioural modeling.

Required Hardware (for Hardware Lab Experiments)

Component Description	Component Description
Digital Trainer Kit	Breadboard with power supply and clock generator
Logic ICs	7400 (NAND), 7402 (NOR), 7408 (AND), 7432 (OR), 7486 , (XOR), 7404 (NOT), etc.
Flip-Flop ICs 7	7474 (D Flip-Flop), 7476 (JK Flip-Flop)
MUX/Decoder ICs	74153, 74138, 74139
LEDs, switches, connecting wires	For I/O interface and testing

Required Software Tools (for Verilog HDL Experiments) (Any one of the tool below)

Software	Purpose
Xilinx Vivado	HDL simulation and synthesis (preferred tool)
ModelSim	Verilog simulation and waveform analysis
Xilinx ISE	Legacy support for simulation and FPGA design

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ELECTRONICS AND COMMUNICATION ENGINEERING
ELECTRONIC CIRCUIT ANALYSIS LAB

B.Tech. III Semester **L/T/P/C**
0/0/2/1

COURSE OBJECTIVE:
To develop the students ability in conducting and analysing experiments with the applications of Bipolar Junction Transistor (BJT) and Field Effect Transistor FET.

COURSE OUTCOMES:
Upon completion of the Lab, the students will be able to
CO-1: Analyze and simulate single and multi-stage amplifier for required gain. L4
CO-2: Analyze and simulate FET Amplifier. L4
CO-3: Analyze and simulate Feedback amplifier circuits. L4
CO-4: Analyze and simulate various oscillator circuits for different frequencies. L4
CO-5: Analyze and simulate the power and tuned amplifier for required efficiency and resonant frequency respectively. L4

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO-1	3	3	3	2	2	1						2	3
CO-2	3	3	3	2	2	1						2	3
CO-3	3	3	3	2	1							2	3
CO-4	2	2	3	3	3							2	3
CO-5	3	3	2	3	2	1					1	2	3

NOTE: Minimum Five Experiments are to be done in hardware and Software

LIST OF EXPERIMENTS using Hardware:
1. Plot the frequency response of Common Emitter Amplifier and estimate Bandwidth.
2. Plot the frequency response of Current Shunt Feedback Amplifier and estimate Bandwidth
3. Plot the frequency response of Voltage Series Feedback Amplifier and estimate Bandwidth
4. Analyze Hartley Oscillator.
5. Analyze Colpitt's Oscillator.
6. Analyze Class A Power Amplifier (Transformer less) and draw its output waveforms
7. Plot the frequency Response of Single Tuned Voltage Amplifier and identify Resonant Frequency.

LIST OF EXPERIMENTS using software:
1. Simulate Two stage RC Coupled amplifier circuit and compare their frequency responses with and without feedback.
2. Simulate a Common Source amplifier and calculate bandwidth.
3. Simulate Voltage series feedback amplifier circuit and compare their frequency responses with and without feedback.
4. Simulate weinbridge oscillator circuit using BJT and calculate the frequency of sustained oscillations.
5. Simulate RC Phase Shift oscillator circuit using BJT and calculate the frequency of sustained oscillations.
6. Simulate a complementary symmetry Class-B Power Amplifier.

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ELECTRONICS AND COMMUNICATION ENGINEERING
PULSE AND DIGITAL CIRCUITS LAB

B.Tech. III Semester **L/T/P C**
0/0/2/1

Course Objectives:
1. Ability to design an Integrator & Differentiator using R, L&C circuits.
2. Ability to design Clipping, Clamping, and Pulse circuits such as Multivibrators, Time Base Generators.
3. Ability to understand the switching characteristics of devices
4. Realization of Logic Gates using Diodes and Transistors.
5. To gain the knowledge on existing and future Analog circuits.

Course Outcomes:
Upon completion of the Lab, students will be able to:
CO1: Design RC circuits.
CO2: Design Multivibrators for various Applications.
CO3: Design Time Base Generators and Relaxation Oscillators.
CO4: Design different types of Digital Circuits by using Logic Gates and Flip-Flops.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3									3	2
CO2	3	3	3									3	2
CO3	3	3	2									3	2
CO4	3	2	3									3	2

Note: Minimum Twelve experiments to be conducted:
1. Linear wave Shaping
   a. RC Low Pass Circuit for different time constants
   b. RC High Pass Circuit for different time constants
2. Non-linear wave shaping
   a. Transfer characteristics and response of Clippers
      i. Positive and Negative Clippers
      ii.Clipping at two independent levels
   b. The steady state output waveform of clampers for a square wave input
      i. Positive and Negative Clampers
      ii. Clamping at different reference voltage
3. Different types of Comparators.
4. Switching characteristics of a transistor
5. Design a Bistable Multivibrator and draw its waveforms
6. Design an Astable Multivibrator and draw its waveforms
7. Design a Monostable Multivibrator and draw its waveforms.
8. Response of Schmitt Trigger circuit for loop gain less than and greater than one
9. The output- voltage waveform of Boot strap sweep circuit
10. The output- voltage waveform of Miller sweep circuit
11. Response of a transistor Current sweep circuit
12. Response of Unidirectional gate
13. Response of Bidirectional gate using transistors
14. Study of Logic Gates

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ELECTRONICS AND COMMUNICATION ENGINEERING
BASIC SIMULATION LAB

B.Tech. III Semester **L/T/P C**
0/0/2 /1

Course Objectives:
1. To provide background and fundamentals of MATLAB or equivalent tool for the analysis and processing of signals and to generate various continuous and discrete time signals.
2. To determine the Fourier transform of signals and convert a continuous time signal to discrete time signal using Sampling.
3. To apply convolution and correlation for continuous time signal.
4. To use Laplace transform for analyzing continuous time signals and systems.

Course Outcomes: Upon completion of this Course, the students will be able to
CO1: Understand MATLAB tool-L2
CO2: Analyze various signals and sequences in MATLAB including operations-L4
CO3: Analyze the behavior of continuous-time and discrete-time systems-L4
CO4: Verify Wiener-Khintchine Relation and Sampling Theorem-L3

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2				3				1		2		2
CO2	3	3			3			2	1		2	2	3
CO3	3	3			3			2	1		3	2	3
CO4	3	3			3			2	1		3	2	3

Note: All the experiments are to be simulated using MATLAB or equivalent software Minimum of 12 programs are to be completed

List of Experiments:
1. Basic Operations on Matrices.
2. Generation of Various Signals and Sequences (Periodic and Aperiodic), such as Unit Impulse, Unit Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc.
3. Operations on Signals and Sequences such as Addition, Multiplication, Scaling, Shifting, Folding, Computation of Energy and Average Power.
4. Finding the Even and Odd parts of Signal/Sequence and Real and Imaginary parts of Signal.
5. Convolution for Signals and sequences.
6. Auto Correlation and Cross Correlation for Signals and Sequences.
7. Verification of Linearity and Time Invariance of a given Continuous/Discrete System.
8. Finding the Fourier transform of a given signal.
9. Gibbs Phenomenon Simulation.
10. Finding the Laplace transform of a given signal.
11. For the given poles and zeros, find the transfer function and plot the Pole-Zero maps in S-plane, also find the stability of the system.
12. Sampling Theorem Verification.
13. Removal of noise by Autocorrelation / Cross correlation.
14. Verification of Weiner-Khintchine Relations.

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ELECTRONICS AND COMMUNICATION ENGINEERING

LINUX AND SHELL PROGRAMMING

B.Tech. III Semester. **L/T/P/C**
0/0/2//1

Course Objectives:
1. To introduce students to Linux operating system fundamentals, including installation, file systems, utilities, and shell environments.
2. To develop skills in shell scripting and command-line operations for automation, system management, and efficient task execution.
3. To provide hands- system on experience in Linux administration and server configuration, including web, file, Samba, and network-based file systems.

Course Outcomes: Upon completing this course, the student will be able to
CO1: Install, configure, and operate Linux systems, including software installation, networking, and file system management.
CO2: Use Linux commands, utilities, editors, and shell environments (Bash, TC Shell) to perform system tasks efficiently.
CO3: Write and execute shell scripts to automate processes, manage files, users, and system services.
CO4: Configure and manage Linux-based servers such as web servers, file servers, Samba servers, and network file systems (NFS).

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	2	1	3	1	1			1		2		
CO2	3	2	1	1	3	1	1			1		3		
CO3	3	2	3	2	3	1	1			1		3		
CO4	3	2	3	2	3	1	1			1		3		

Note: Minimum of 12 experiments to completed out of 14 experiments.
List of Experiments:
1. Getting Started with Linux
2. Installation Guide
3. Connecting to Internet
4. Installing Software
5. Utilities
6. File Systems
7. The Shell and popular Editors
8. The Bourne Again Shell and TC Shell
9. Programming the Bourne Again Shell
10. Linux System Administration
11. Web Server Configuration
12. File Server Configurati
13. Samba Servers
14. Network File Systems

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ELECTRONICS AND COMMUNICATION ENGINEERING
PROBABILITY THEORY AND STOCHASTIC PROCESS

B.Tech. IV Semester **L/T/P C**
3/0/0/3

Pre-requisite: Mathematics Course

Course Objectives:

1. To introduce the fundamental concepts of probability and random variables used in modeling random Experiments.
2. To understand various probability distributions and their properties for discrete and continuous random variables.
3. To understand the concept of single, multiple random variables, their joint behavior, and operations involving them.
4. To know the Temporal and Spectral Characteristics of Random Process.

Course Outcomes:

Upon completing this course, the student will be able to
CO1: apply the fundamental principles of probability theory and Bayes' theorem to analyze and predict outcomes in random experiments.
CO2: Analyze distributions and operations of discrete and continuous random variables.
CO3: Analyze multiple random variables by calculating different statistical parameters.
CO4: Analyze the Temporal Characteristics of random processes.
CO5: Analyze the Spectral Characteristics of random processes.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2								
CO2	3	3	2								
CO3	3	3	2								
CO4	3	3	3								
CO5	3	3	3								

UNIT – I

Probability: Probability introduced through Sets and Relative Frequency: Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability Definitions and Axioms, Joint Probability, Conditional Probability, Total Probability, Bay's Theorem, Independent Events.
Random Variables- Definition, Conditions for a Function to be a Random Variable, Discrete, Continuous and Mixed Random Variables.

UNIT – II

Distribution and Density functions: Properties, Binomial, Poisson, Uniform, Gaussian, Exponential, Rayleigh, Methods of defining Conditioning Event, Conditional Distribution, Conditional Density and their Properties
Operations on single Random Variable: Expected Value of a Random Variable, Function of a Random Variable, Moments about the Origin, Central Moments, Variance and Skew, Chebychev's Inequality, Characteristic Function, Moment Generating Function, Transformations of a Random Variable- Monotonic and Non-monotonic Transformations of Continuous and Discrete Random Variable.

UNIT – III

Multiple random variables and Operations on Multiple random variables: Vector Random Variables, Joint Distribution Function and its Properties, Marginal Distribution Functions, Conditional Distribution and Density– Point and Interval conditioning, Statistical Independence, Sum of Two and more Random Variables, Central Limit Theorem, Equal and Unequal Distribution (Proof not expected).
Expected Value of a Function of Random Variables- Joint Moments about the Origin, Joint Central Moments, Joint Characteristic Functions, and Jointly Gaussian Random Variables: Two Random Variables case, N Random Variable case, Properties, Transformations of Multiple Random Variables, and Linear Transformations of Gaussian Random

Variables.

UNIT-IV:

Stochastic Processes – Temporal Characteristics: The Stochastic Process Concept, Classification of Processes, Deterministic and Nondeterministic Processes, Distribution and Density Functions, Concept of Stationarity and Statistical Independence, First-Order Stationary Processes, Second Order and Wide- Sense Stationarity, Nth Order and Strict-Sense Stationarity, Time Averages and Ergodicity, Mean-Ergodic Processes, Correlation-Ergodic Processes, Autocorrelation Function and its Properties, Cross-Correlation Function and its Properties, Covariance and its Properties, Linear System Response of Mean and Mean- squared Value, Autocorrelation Function, Cross-Correlation Functions, Gaussian Random Processes, Poisson Random Process.

UNIT-V:

Random processes – Spectral characteristics: The Power Spectrum: Properties, Relationship between Power Spectrum and Autocorrelation Function, The Cross-Power Density Spectrum, Properties, Relationship between Cross-Power Spectrum and Cross-Correlation Function. Spectral Characteristics of System Response: Power Density Spectrum of Response, Cross-Power Density Spectrums of Input and Output.

Noise Definitions- Resistive / Thermal Noise, White and colored Noise and their statistical characteristics.

TEXT BOOKS:

1. Peyton Z. Peebles, “Probability, Random Variables & Random Signal Principles”, TMH, 4th Edition, 2001.
2. Y Mallikarjuna Reddy - Probability Theory and Stochastic Processes, 4th Edition, University Press.

REFERENCE BOOKS:

1. P Ramesh Babu - Probability Theory and Random Processes – McGraw Hill Education
2. Athanasios Papoulis and S. Unnikrishna Pillai - Probability, Random Variables and Stochastic Processes – McGraw Hill Education, 4th Edition
3. K. N. Hari Bhat, K. Anitha Sheela and Jayant Ganguly - Probability Theory and Stochastic Processes for Engineers - Pearson, 1st Edition, 2011
4. Taub and Schilling - Principles of Communication systems by (TMH), 2008

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ELECTRONICS AND COMMUNICATION ENGINEERING
ANALOG AND DIGITAL COMMUNICATIONS

B.Tech. IV Semester **L/T/P/C**
3/0/0 /3

Pre-requisite : Signal & Systems

Course Objectives:

1. To understand modulation and demodulation techniques used in communication systems, and develop the modulation techniques used in both time and frequency domains.
2. To gain the knowledge on pre-emphasis and de-emphasis circuits used in Analog communication.
3. To analyze various digital modulation techniques like ASK, FSK, PSK, DPSK and QPSK.
4. To analyze the fundamentals in PLL and VCO.

Course Outcomes: Upon completion of this course, the student will be able to:
CO1: Analyze different AM modulation schemes and their time/frequency domain behavior.
CO2: Apply and evaluate FM/PM techniques with bandwidth estimation and PLL-based demodulation.
CO3: Compare pulse and digital modulation methods and analyze their noise performance and multiplexing.
CO4: Calculate entropy, information rate, channel capacity and implement basic coding techniques.
CO5: Describe and compare the architecture and operation of AM and FM transmitters and receivers.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1		1						
CO2	3	3	2	2	1						
CO3	3	3	2	1	1						
CO4	3	3	2	2							
CO5	3	2	1	1	1						

UNIT - I
Amplitude Modulation: Need for modulation, Amplitude Modulation: Time and frequency domain description, Generation – Switching modulator, Detection - Envelope detector, DSB-SC Modulation: Generation – Balanced Modulator, Detection- Synchronous detector, COSTAS Loop, SSB Modulation: Time and frequency domain description, Generation – Phase discrimination Method and Demodulation - coherent detection, Vestigial side band modulation and demodulation.

UNIT - II
Angle Modulation: Basic concepts of Phase Modulation, Frequency Modulation: Single tone frequency modulation, Spectrum Analysis, Carson's Rule, Generation of FM Waves- Armstrong Method, Detection of FM Waves - Phase locked loop, Comparison of FM and AM.

UNIT - III
Pulse Modulation: Types of Pulse modulation-PAM, PWM and PPM, Comparison of FDM and TDM, PCM : Generation and Reconstruction, Quantization, Non-Uniform Quantization and companding, DPCM DM and Adaptive DM, Noise in PCM & DM.
Digital Modulation Techniques: Digital Modulation formats, Coherent binary modulation techniques (ASK,BPSK, BFSK), Coherent quadrature modulation techniques (QPSK, QAM,DPSK)

UNIT – IV
Information theory: Entropy, Information rate, Mutual information, Channel capacity of discrete channel, Shannon-Hartley law; Trade-off between bandwidth and SNR. Source coding - Huffman coding, Shannon Fano coding, Channel coding - Linear block codes and cyclic codes.

UNIT – V

Transmitters & Receivers: Classification of Transmitters, AM Transmitters, FM Transmitters, AM Receivers - Super heterodyne receiver, FM Receiver, Comparison of AM and FM Receiver.

TEXT BOOKS:

1. Electronics Communication Systems-Fundamentals through Advanced-Wayne Tomasi, 5th Edition, PHI, 2009.
2. Digital and Analog Communication System – K. Sam Shanmugam, Wiley, 2019.
3. Principles of Communication Systems - Herbert Taub, Donald L Schiling, Goutam Saha, 3rd Edition, McGraw-Hill, 2008.

REFERENCES:

1. Electronic Communications – Dennis Roddy and John Coolean, 4th Edition, PEA, 2004
2. Electronics & Communication System – George Kennedy and Bernard Davis, TMH, 2004
3. Communication System - Simon Haykin and Michael Moher, Wiley, 5th edition, 2022

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DEPARTMENT OF ELECTRICAL AND ELECTRONICSENGINEERING

INNOVATION AND ENTREPRENEURSHIP

SEMESTER IV **L/T/P/C**
2/0/0/2

Course Objectives:

1. To familiarize on the basic concepts of innovation, entrepreneurship and its importance.
2. To identify and analyze the process of problem-opportunity identification, market segmentation, and idea generation techniques.
3. To initiate prototype development and understand minimum viable product.
4. To develop initial business and financial planning and Go-to-Market strategies.
5. To impart knowledge on establishing startups, venture pitching and IPR.

Course Outcomes:

After learning the contents, the student must be able to

CO1: Understand the entrepreneurship and the entrepreneurial process and its significance in economic development.

CO2: Assess the problem from an industry perspective and generate solutions using the design thinking principles.

CO3: Assess market competition, estimate market size, and develop a prototype.

CO4: Analyze business and financial planning models and Go-to-Market strategies.

CO5: Build a startup, register IP and identify funding opportunities.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2								2		2	1
CO2	2	3	3	2								3	2
CO3	2	2	3	3	2							3	2
CO4	2	3	2	3	2					2		2	3
CO5	3	2	2	2	3					2			

UNIT – I Fundamentals of Innovation and Entrepreneurship

Innovation: Introduction, need for innovation, Features, Types of innovations, innovations in manufacturing and service sectors, fostering a culture of innovation, planning for innovation. **Entrepreneurship:** Introduction, types of entrepreneurship attributes, mindset of entrepreneurial and intrapreneurial leadership, Role of entrepreneurs in economic development. Woman En-trepreneurship, Importance of on-campus startups. Understanding to build entrepreneurial mindset, attributes and networks individuals while on campus.

Core Teaching Tool: Simulation, Game, Industry Case Studies (Personalized for students – 16 industries to choose from), Venture Activity.

UNIT – II Problem and Customer Identification
Identification of gap, problem, analyzing the problem from a industry perspective, real-world problems, market and customer segmentation, validation of customer problem fit, Iterating problem-customer fit, Competition and Industry trends mapping and assessing initial oppor-tunity, Porter's Five Force Model.

Idea generation, Ideation techniques: Brainstorming, Brain writing, Round robin, and SCAM-PER, Design thinking principles, Mapping of solution to problem.

Core Teaching Tool: Several types of activities including: Class, game, Gen AI, 'Get out of the Building' and Venture Activity.

UNIT – III Opportunity assessment and Prototype development
Identify and map global competitors, review industry trends, and understand market sizing: TAM, SAM, and SOM. Assessing scope and potential scale for the opportunity.

Understanding prototyping and Minimum Viable Product (MVP). Developing a prototype: Testing, and validation.

Core Teaching Tool: Venture Activity, no-code Innovation tools, Class activity.

UNIT – IV Business & Financial Models
Introduction to Business Model and types, Lean Canvas Approach: 9-block lean canvas model, building lean canvas for your startup.

Business planning: components of Business plan - Sales plan, People plan and financial plan. Financial Planning: Types of costs, preparing a financial plan for profitability using a finan-cial template, understanding the basics of Unit economics, Economies of Scale and analyzing financial performance.

Go-To-Market (GTM) approach – Selecting the Right Channel, creating digital presence, and building customer acquisition strategy.

Core Teaching Tool: Founder Case Studies – Sama and Securely Share; Class activity and discussions; Venture Activities.

UNIT – V Startups and IPR
Startup requirements, building founding team members and mentors, pitch preparation, start-up registration process, funding opportunities and schemes, institutional support to entrepreneurs, startup lifecycle, documentation, legal aspects in startup, venture pitching readiness, National Innovation Startup Policy (NISP) and its features. Patents, Designs, Patentability, Procedure for grants of patents. Indian Scenario of Patenting, International Scenario: International cooperation on Intellectual Property. Patent Rights: Scope of Patent Rights. Copyright, trademark, and GI. Licensing and transfer of technology.

Core Teaching Tool: Expert talks; Cases; Class activity and discussions; Venture Activities.

SUGGESTED READINGS:

1. John R Bessant, Joe Tidd, "Innovation and Entrepreneurship", 4E, Wiley, Latest Edition.
2. Ajay Batra, "The Startup Launch Book - A Practical Guide for Launching Customer Centric Ventures", Wiley, 2020.
3. Poornima M Charantimath, "Entrepreneurship Development and Small Business Enter-prises", 3E, Pearson, 2018.
4. D.F. Kuratko and T.V. Rao, "Entrepreneurship: A South-Asian Perspective", Cengage Learning, 2013.
5. Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, Sabyasachi Sinha, "Entrepreneur-ship", McGraw Hill, 11th Edition, 2020.
6. NISP - Bochure inside pages - startup policy 2019.pd

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ELECTRONICS AND COMMUNICATION ENGINEERING
LINEAR AND DIGITAL IC APPLICATIONS

B.Tech. IV Semester **L/T/P C**
3/0/0/3

COURSE OBJECTIVES:
The main objective of the course is:
1. To introduce the basic building blocks of linear integrated circuits.
2. To teach the linear and non-linear applications of operational amplifiers.
3. To introduce the theory and applications of analog multipliers and PLL.
4. To teach the theory of ADC and DAC.
5. To implement the concept and working of basic digital circuits.

COURSE OUTCOMES:
Upon completion of the subject, students will be able to:
CO1: Understand Operational Amplifiers with Linear Integrate Circuits.
CO1: Design circuits using Operational Amplifiers for various Applications.
CO3: Design different ADC's and DAC's.
CO4: Understand different families of Digital Integrated Circuits and their Characteristics.
CO5 :Design Combinational and Sequential circuits using IC's.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	1							
CO2	3	3	3	1							
CO3	3	3	3	1							
CO4	3	3	2	1							
CO5	3	3	2	1							

UNIT - I
Operational Amplifier: IC packages, Study of differential op-amp, Ideal and Practical Op-Amp, Op-Amp Characteristics-DC and AC Characteristics, Features of 741 Op-Amp, Modes of Operation - Inverting, Non-Inverting, Adder, Differential Amplifier (Subtractor), Differentiators and Integrators, Instrumentation Amplifier, Comparators, Schmitt Trigger, Introduction to Voltage Regulators-Three Terminal Voltage Regulators.

UNIT - II
Op-Amp & IC-555 Applications: Introduction to Active Filters, Characteristics and Analysis of 1st order Low Pass, High Pass, Band Pass, Band Reject and All Pass filters, waveform Generators - Triangular, Sawtooth, Square wave, IC555 Timer - Functional Diagram, Monostable and Astable Operations, Applications

UNIT - III:
PLL & Data Converters: IC565 PLL - Block Schematic, Description of Individual Blocks, Applications. ADC&DAC: Introduction, Basic DAC techniques, Different types of DACs-Weighted resistor DAC, R-2R ladder DAC, Inverted R-2R DAC, Different Types of ADCs - Parallel Comparator Type ADC, Counter Type ADC, Successive Approximation ADC and Dual Slope ADC, DAC and ADC Specifications.

UNIT - IV:
Digital Integrated Circuits: Classification of Integrated Circuits, Comparison of Various Logic Families, CMOS Transmission Gate, IC interfacing. TTL Driving CMOS & CMOS Driving TTL, Combinational Logic ICs - Specifications and Applications of TTL-74XX & CMOS 40XX Series ICs – Binary to Gray, Gray to Binary & BCD to Binary Code Converters, Decoders, Encoders, Priority Encoders, Multiplexers, Demultiplexers, Magnitude Comparators.

UNIT - V:

Sequential Logic IC's and Memories: Familiarity with commonly available 74XX & CMOS 40XX Series ICs - All Types of Flip-flops, Shift Registers, Synchronous Counters, Decade Counters. Memories - ROM Architecture, Types of ROMS & Applications, RAM Architecture, Static & Dynamic RAMs.

TEXT BOOKS:

1. OP-Amp and Linear ICs – Ramakanth A Gayakwad, PHI, 2003.
2. Linear Integrated Circuits – D. Roy Chowdhury, New Age International (p) Ltd, 2nd Edition,2003.
3. Digital Design Principles& Practices-John F.Wakerly, PHI/Preason Education Asia, 3rd ED., 2005.

REFERENCES

1. Linear Integrated Circuits Application by K. Lal Kishore, Pearson Edition 2005.
2. Modern digital electronics-RP Jain 4/e-MC GRAW HILL EDUCATION, 2010.
3. Design with operational amplifiers& Analog Integrated circuits –Sergio Franco,Mc Graw Hill. 3rdEdition, 2002.

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ELECTRONICS AND COMMUNICATION ENGINEERING

CONTROLSYSTEMS

B.Tech. IV Semester **L/T/P/C**
3/0/0/2

Pre-Requisites: Linear Algebra and Calculus, Ordinary Differential Equations and Multivariable Calculus Laplace Transforms, Numerical Methods and Complex variables

Course Objectives:

1. To understand the different ways of system representations such as Transfer Function representation to assess the system dynamic response.
2. To assess the system performance using Time domain analysis and Methods for improving it.
3. To assess the system performance using Frequency domain analysis and techniques for improving the performance.
4. To design various Controllers and Compensators to improve system performance.
5. To understand the different ways of System behavior using State space representation for continuous systems

Course Outcomes: Upon completion of this Course, the students will be able to:

CO1: Classify the different open-loop and closed-loop control systems and develop mathematical models for linear time-invariant systems.
CO2: Determine time domain specifications of a second order system and analyze its response.
CO3: Apply frequency domain techniques to assess and analyze system performance.
CO4:Analyze the stability of linear systems using Nyquist stability criteria and design compensators to improve system performance.
CO5: Analyze MIMO system using state variable approach

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	-	-						
CO2	3	3	2	1	1						
CO3	3	3	2	1	1						
CO4	3	3	3	2	1						
CO5	3	3	2	1	1						

UNIT - I

Control System fundamentals: Classification of control systems, Open and Closed loop systems. Mathematical modelling of mechanical systems and their conversion into electrical systems. Block diagram reduction and Signal flow graphs.

UNIT - II

Time response Analysis: Transfer function and Impulse response, types of input. Transient response of second order system for step input. Time domain specifications. Types of systems, static error coefficients.

UNIT – III

Stability Analysis: The concept of stability- Effects of Location of poles on stability- Routh-Hurwitz criterion-Limitations of Routh's stability.

Root locus techniques: Analysis of typical systems using root locus techniques. Effect of location of roots on system response.

Frequency Response Analysis: Frequency domain specifications-Bode plots- Stability Analysis from Bode Plots.

UNIT – IV

Stability Analysis in Frequency Domain: Polar plot, Nyquist plot, and Nyquist criterion for stability.

Compensators and controllers: Introduction to compensators, Lag compensator, Lead compensator, Lag- Lead compensator, Design of compensators using bode plot. Introduction to controllers, P, I, D, PI, PD, PID controllers.

UNIT - V

State space representation: Concept of state and state variables. State models of linear time invariant systems, State transition matrix, Solution of state equations. Controllability and observability.

TEXT BOOKS:

1. I.J. Nagrath and M. Gopal, Control System Engineering, 5ed., New Age Publishers, 2009.
2. Benjamin C. Kuo, Automatic Control Systems, 7ed., PHI, 2010.

REFERENCE BOOKS:

1. K. Ogata, Modern Control Engineering, 2ed., Prentice Hall, 2010.
2. M. Gopal, Control Systems: Principles and Design, Tata McGraw-Hill, 1997.
3. Norman S. Nise, Control Systems Engineering, 5ed., John Wiley & Sons, 2007.
4. A.K. Jairath, Solutions and Problems of Control Systems, CBS Publishers, 2013.
5. A. Nagoor Kani, Control Systems, 2ed., RBA Publications, 2007.

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ELECTRONICS AND COMMUNICATION ENGINEERING
ELECTROMAGNETIC THEORY AND TRANSMISSION LINES

B.Tech. IV Semester **L/T/P/C**
3/0/0/3

COURSE OBJECTIVES: This is a structured foundation course, dealing with concepts, formulations and applications of Electromagnetic Theory and Transmission Lines, and is the basic primer for all electronic communication engineering subjects. The main objectives of the course are:

1. To explain the basics of electrostatic and magneto static concepts and show the time varying electromagnetic fields as applied to high frequency circuit design.
2. To interpret the electromagnetic wave characteristics at interface of different boundaries.
3. To illustrate the importance of transmission line theory and applications of it to circuit design with the help of Smith chart.
4. To understand the basic concepts of guided waves

COURSE OUTCOMES:
Upon completion of this Course, the students will be able to:
CO1: Analyze the electric fields due to different charge distributions and analyze the electric fields in different mediums .
CO2: Distinguish between the static and time-varying fields, illustrate the corresponding sets of Maxwell's Equations and Boundary Conditions, and use them for solving engineering problems
CO3: Analyze the EM wave propagation and attenuation in various media and analyze the importance of poynting theorem.
CO4: Determine transmission line parameters, for different lines characterizethe distortions andestimate the characteristics for different lines.
CO5: Construct smith chart to design transmission lines to find the reflection coefficient for given impedance and vice versa.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO2
CO1	3	3										2
CO2	3	2										2
CO3	3	2										2
CO4	3	3										2
CO5	3	2	2									2

UNIT – I:
Electrostatics: Introduction to coordinate systems and Vector analysis. Coulomb's Law, Electric Field Intensity - Fields due to Different Charge Distributions, Electric Flux Density, Gauss Law and Applications, Electric Potential, Relations Between E and V, Maxwell's Two Equations for Electrostatic Fields, Energy Density. Convection and Conduction Currents, Dielectric Constant, Isotropic and Homogeneous Dielectrics, Continuity Equation, Relaxation Time, Poisson's and Laplace's Equations; Capacitance - Parallel Plate, Coaxial, Spherical Capacitors, Illustrative Problems.

UNIT – II:
Magneto statics: Biot-Savart's Law, Ampere's Circuital Law and Applications, Magnetic Flux Density, Maxwell's Two Equations for Magneto static Fields, Magnetic Scalar and Vector Potentials, Forces due to Magnetic Fields, Ampere's Force Law. Maxwell's Equations (Time Varying Fields): Faraday's Law and Transformer EMF, Inconsistency of Ampere's Law and Displacement Current Density, Maxwell's Equations in Different Final Forms and Word Statements, Conditions at a Boundary Surface : Dielectric- Dielectric and Dielectric- Conductor Interfaces, Illustrative Problems.

UNIT – III:

EM Wave Characteristics - I: Wave Equations for Conducting and Perfect Dielectric Media, Uniform Plane Waves - Definition, All Relations Between E & H, Sinusoidal Variations, Wave Propagation in Lossless and Conducting Media, Conductors & Dielectrics- Characterization, Wave Propagation in Good Conductors and Good Dielectrics, Depth of penetration, Polarization of uniform Plane wave. EM Wave Characteristics - II: Reflection and Refraction of Plane Waves - Normal and Oblique Incidences for both Perfect Conductor and Perfect Dielectrics, Brewster Angle, Critical Angle and Total Internal Reflection, Surface Impedance, Poynting Vector and Poynting Theorem - Application.

UNIT – IV:

Transmission Lines - I: Types, Parameters, Transmission Line Equations, Primary & Secondary Constants, Infinite Line Concepts, Expressions for Characteristic Impedance, Propagation Constant, Phase and Group Velocities, Lossless, Distortion less and High Frequency Transmission Lines, Condition for Minimum Attenuation, Line Distortion, Loading - Types of Loading

UNIT – V:

Transmission Lines - II: Input Impedance Relations, SC and OC Lines, Reflection Coefficient, VSWR. UHF Lines as Circuit Elements; $\lambda/4$, $\lambda/2$, $\lambda/8$ Lines - Impedance Transformations, Significance of Zmin and Zmax , Single and Double Stub Matching, Smith Chart - Configuration and Applications, Illustrative Problems

TEXT BOOKS

1. Matthew N.O. Sadiku and S.V. Kulkarni,"Principles of Electromagnetics", 6 thEd. Oxford University Press, Asian Edition, 2015.
2. E.C. Jordan and K.G. Balmain, "Electromagnetic Waves and Radiating Systems", 2ndEd. 2000, PHI.
3. Umesh Sinha, SatyaPrakashan, "Transmission Lines and Networks ", 2001, (Tech. India Publications), New Delhi.

REFERENCE BOOKS

1. William H. Hayt Jr. and John A. Buck, "Engineering Electromagnetics" 8thEd. 2014, McGraw Hill Education.
2. John D. Ryder, "Networks, Lines and Fields", 2 ndEd. 1999, PH

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ELECTRONICS AND COMMUNICATION ENGINEERING
ANALOG AND DIGITAL COMMUNICATIONS LAB

B.Tech. IV Semester **L/T/P/C**
0/0/2/1

Course Objectives:
1. To understand modulation, demodulation techniques used in communication system, and develop the Modulation techniques used in both time and frequency domains.
2. To gain the knowledge on pre-emphasis and de-emphasis circuits used in Analog communication.
3. To analyze various digital modulation techniques like ASK, FSK, PSK, DPSK and QPSK
4. To analyze the fundamentals in PLL, VCO.

Course Outcomes:
Upon completion of the lab, students will be able to:
CO1: Design and implement various Analog modulation and demodulation Techniques and observe the time and frequency domain characteristics.
CO2: Design and implement various Pulse modulation and demodulation Techniques and observe the time and frequency domain characteristics.
CO3: Apply different types of Sampling with various Sampling rates and duty Cycles.
CO4: Design and implement various Digital modulation and demodulation Techniques and observe the waveforms of these modulated Signals practically.

course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	3	2	2					1	
CO2	3	2	3	2	2					1	
CO3	3	2	2	2	2					1	
CO4	3	2	3	3	3					1	

Note: Minimum 12 experiments should be conducted
Experiments are to be simulated first either using MATLAB or any other simulation software tools or then testing to be done in hardware.

LIST OF EXPERIMENTS:

Cycle-I
1. Amplitude modulation and demodulation
2. Frequency modulation and demodulation
3. DSB-SC Modulator & Detector
4. SSB-SC Modulator & Detector (Phase Shift Method)
5. Frequency Division Multiplexing & De multiplexing
6. Pulse Amplitude Modulation & Demodulation
7. Pulse Width Modulation & Demodulation
8. Pulse Position Modulation & Demodulation
9. Study of spectrum analyzer and Measurement of frequency spectrum of AM and FM Signals

Cycle-II
1. PCM Generation and Detection
2. Delta Modulation
3. Frequency Shift Keying: Generation and Detection
4. Binary Phase Shift Keying: Generation and Detection
5. Generation and Detection (i) DPSK (ii) QPSK
6. Generate FSK modulated signal using PLL

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ELECTRONICS AND COMMUNICATION ENGINEERING
LINEAR AND DIGITAL IC APPLICATIONS LAB

B.Tech. IV Semester **L/T/P/C**
0/0/2/1

Course Outcomes:
CO1: Design and implementation of various analog circuits using 741 ICs.
CO2: Design and implementation of various Multivibrators using 555 timer
CO3: Design and implement various circuits using digital ICs
CO4: Design and implement ADC, DAC and voltage regulators.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	1	0	3	3	3				3	3	
CO2	1	0	3	3	3				3	3	
CO3	1	0	3	3	3				3	3	
CO4	1	0	3	3	3				3	3	

Note:
Minimum 12experiments should be conducted.
Verify the functionality of the IC in the given application.

List of Experiments:
1. Design an Inverting and Non-inverting Amplifier using Op Amp and calculate gain.
2. Design Adder and Subtractor using Op Amp and verify addition and subtraction process.
3. Design a Comparator using Op-Amp and draw the comparison results of A=B, A<B, A>B.
4. Design a Integrator and Differentiator Circuits using IC741 and derive the required condition practically.
5. Design a Active LPF, HPF cutoff frequency of 2 KHz and find the roll off of it.
6. Design a Circuit using IC741 to generate sine / square / triangular wave with period of 1 KHz and draw the output waveform.
7. Construct Mono-stable Multivibrator using IC555 and draw its output waveform.
8. Construct Astable Multivibrator using IC 555 and draw its output waveform and also find its duty cycle.
9. Design a Schmitt Trigger Circuit and find its LTP and UTP.
10. Design Voltage Regulator using IC723, IC 7805 / 7809 / 7912 and find its load regulation factor.
11. Design R-2R ladder DAC and find its resolution and write a truth table with respective voltages.
12. Design a Gray code converter and verify its truth table.
13. Design an even priority encoder using IC74xx and verify its truth table.
14. Design a 8x1multiplexer using digital ICs.
15. Design a 4-bit Adder / Subtractor using digital ICs and Add / Sub the following bits.
    (i) 1010 (ii) 0101 (iii) 1011
    0100 0010 1001.
16. Design a Decade counter and verify its truth table and draw respective waveforms.
17. Design a Up/down counter using IC 74163 and draw read/write waveforms.
18. Design a Universal shift register using IC74194 / 195and verify its shifting operation.
19. Design a 16x4 RAM using 74189 and draw its read /write operation.
20. Design a 8x3 encoder / 3x8 decoder and verify its truth table.

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ELECTRONICS AND COMMUNICATION ENGINEERING
PCB DESIGN AND FABRICATION LAB

B. Tech. IV Semester. **L/T/P/C 0/0/2/1**

Prerequisite: Knowledge of analog and digital circuits.

Course Objectives:

Understand the need for PCB Design and steps involved in PCB Design and Fabrication process.
Familiarize Schematic and layout design flow using Electronic Design Automation (EDA) Tools.

Course Outcomes: Upon completing this course, the student will be able to

CO1: Appreciate the necessity and evolution of PCB, types and classes of PCB.
CO2: Understand the steps involved in schematic, layout, fabrication and assembly process of PCB design.
CO3: Understand basic concepts of Electronic Design Automation (EDA) Tools.
CO4:Design (schematic and layout) PCB for analog circuits, digital circuits and mixed circuits.

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	3							2			2	3
CO2	3	3	3	2						2			2	3
CO3	3	3	3	2	2					2			2	3
CO4	3	3	3	2	2					2			2	3

List of Experiments:

PART A: Tutorials and Practice Exercises

1. Introduction to PCB Installation Guide: Definition and Need/Relevance of PCB, Background and History of PCB, Types of PCB, Classes of PCB Design, Terminology in PCB Design, Different Electronic design automation (EDA) tools and comparison
2. PCB Design Process: PCB Design Flow, Placement and routing, Steps involved in layout design, Artwork generation Methods - manual and CAD, General design factor for digital and analog circuits, Layout and Artwork making for Single-side, double-side and Multilayer Boards, Design for manufacturability, Design-specification standards
3. Introduction to PCB Fabrication & Assembly: Steps involved in fabrication of PCB, PCB Fabrication techniques-single, double sided and multilayer, Etching: chemical principles and mechanisms, Post operations-stripping, black oxide coating and solder masking, PCB component assembly processes
4. Using any Electronic design automation (EDA) software, Practice PCB Design steps:

   Example circuit: Basic RC Circuit

   i) Schematic Design: Familiarization of the Schematic Editor, Schematic creation, Annotation, Netlist generation

   ii) Layout Design: Familiarization of Footprint Editor, Mapping of components, Creation of PCB layout Schematic

   iii) Create new schematic components

   iv) Create new component footprints

PART B: Design any **Four** PCB (schematic and Layout) for following exercises.

1. Regulator circuit using 7805.
2. Inverting Amplifier and Non-Inverting Amplifier
3. Full-wave Rectifier
4. Astable or Monostable multivibrator using IC555
5. RC Phase-shift or Wein-bridge Oscillator using transistor.
6. Water level Indicator Alaram.

PART C: Fabricate single-side PCB for simple network

1. Fabricate single-sided PCB, mount the components and assemble in a cabinet for any FOUR of the circuits mentioned in Part-B.

References

1. Printed Circuit Board by RS Khandpur, Tata McGraw Hill Education Pvt Ltd., New Delhi.
2. Electronic Product Design Volume-I by S D Mehta, S Chand Publications.
3. Open source EDA Tool KiCad Tutorial: http://kicad-pcb.org/help/tutorials
4. Fabrication user guide page: http://www.wikihow.com/Create-Printed-Circuit-Boards , http://www.siongboon.com/projects/2005-09-07_home_pcb_fabrication/ http://reprap.org/wiki/MakePCBInstructions#Making_PCBs_yourself
5. PCB Fabrication at home(video): https://www.youtube.com/watch?v=mv7Y0A9YeUc, https://www.youtube.com/watch?v=imQTCW1yWkg

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ELECTRONICS AND COMMUNICATION ENGINEERING

ENVIRONMENTAL SCIENCE

B.Tech. IV Semester. **L/T/P/C**
0/0/2/1

Course Objectives:

This Course provides elaborate analysis effect on environment and the ecosystem due to human interferences. The topics covered in this course are Biodiversity; Environmental Pollution; Natural Resources; Social Issues; Human Population and the Environment. At the end of the course, the student would be able to assess the various issues in the environment and engineer the solutions with regard to human activities.

Course Outcomes:

CO1:Explain the structure, function, and importance of ecosystems, and analyze energy flow, ecological interactions, and bio-geochemical cycles influencing environmental balance.

CO2: Identify and evaluate the sustainable utilization of natural resources including water, minerals, forests, and energy sources, emphasizing environmental impacts and conservation needs.

CO3: Assess biodiversity at genetic, species, and ecosystem levels, recognize threats to biodiversity, and apply conservation methods in alignment with the National Biodiversity Act.

CO4: Analyze different types of pollution and adopt appropriate environmental control technolo-gies and management practices to mitigate global challenges such as climate change and ozone depletion.

CO5: Interpret environmental legislation, policies, and the Environmental Impact Assessment (EIA) process for effective environmental planning, risk assessment, and sustainable devel-opment.

UNIT - I

Ecosystems: Definition, Scope, and Importance of Ecosystem. Classification, Structure, and Function of an Ecosystem, Food Chains, Food Webs, and Ecological Pyramids. Flow of Energy, Bio-geochemical Cycles, Bio-accumulation, Bio-Magnification, Ecosystem Value, Services and Carrying Capacity.

UNIT - II

Natural Resources: Classification of Resources: Living and Non-Living Resources, Water Resources: Use and Over Utilization of Surface and Ground Water, Floods and Droughts, Dams: Benefits and Problems. Mineral Resources: Use and Exploitation, Environmental Ef-fects of Extracting and Using Mineral Resources, Land Resources: Forest Resources, Energy Resources: Growing Energy Needs, Renewable and Non-Renewable Energy Sources, Use of Alternate Energy Source, Case Studies.

UNIT - III

Biodiversity and Biotic Resources: Introduction, Definition, Genetic, Species and Ecosystem Diversity. Value of Biodiversity; Consumptive Use, Productive Use, Social, Ethical, Aesthetic and Optional Values. India as a Mega Diversity Nation, Hot Spots of Biodiversity. Threats to Biodiversity: Habitat Loss, Poaching of Wildlife, Man – Wildlife Conflicts; Conser-vation of Biodiversity: In-Situ and Ex-Situ Conservation. National Bio-Diversity Act.

UNIT - IV

Environmental Pollution and Control Technologies: Environmental Pollution: Classification of Pollution, Air Pollution: Primary and Secondary Pollutants, Automobile and Industrial Pollution, Ambient Air Quality Standards. Water Pollution: Sources and Types of Pollution, Drinking Water Quality Standards.

Soil Pollution: Sources and Types, Impacts of Modern Agriculture, Degradation of Soil.
Noise Pollution: Sources and Health Hazards, Standards.

Solid Waste: Municipal Solid waste Management, Composition and Characteristics of E-waste and Its Management.

Pollution Control Technologies: wastewater Treatment Methods: Primary, Secondary and Tertiary. Overview of Air Pollution Control Technologies, Concepts of Bio-remediation. Global Environmental Issues and Global Efforts: Climate Change and Impacts on Human Environ-ment. Ozone Depletion and Ozone Depleting Substances (ODS). Deforestation and Desertifi-cation.

UNIT - V

Environmental Policy, Legislation & EIA: Environmental Protection Act, Legal Aspects Air Act–1981, Water Act, Forest Act, Wild Life Act, Municipal Solid waste Management and Handling Rules, Biomedical waste Management and Handling Rules, Hazardous waste Management and Handling Rules.

EIA: EIA Structure, Methods of Baseline Data Acquisition. Overview on impacts of Air, Water, Biological and Socio-Economic Aspects. Strategies for Risk Assessment, Concepts of Environmental Management Plan (EMP).

TEXT BOOKS:

1. Gilbert M. Masters, "Introduction to Environmental Engineering and Science", 2nd Edition, Pearson Education.
2. Benny Joseph, "Environmental Science and Engineering", Tata McGraw Hill Publishing Co. Pvt. Ltd., New Delhi.
3. Textbook of Environmental Studies for Under Graduate Courses by Erach Bharucha for University Grants Commission.
4. R. Rajagopalan, "Environmental Studies", Oxford University Press, New Delhi.

REFERENCE BOOKS:

1. Richard T. Wright, "Environmental Science: Towards a Sustainable Future", PHI Learning Private Ltd., New Delhi, 2008.
2. Gilbert M. Masters and Wendell P. Ela, "Environmental Engineering and Science", PHI Learning Pvt. Ltd.
3. Daniel B. Botkin and Edward A. Keller, "Environmental Science", Wiley India Edition.
4. Anubha Kaushik, "Environmental Studies", 4th Edition, New Age.
5. Dr. M. Anji Reddy, "Text Book of Environmental Science and Technology", BS Publicatios.