

R23 Regulations

B.Tech Curriculum - OPEN ELECTIVES

Offered by the department of ECE

S.No	Category	Titles
1	Open Elective -1	Entrepreneurship Development & Venture Creation 1. Electronic Devices and Circuits 2. Signals and Systems 3. Probability Theory and Random variables 4. Network Analysis
2	Open Elective-2	1. Linear and Digital IC Applications 2. Principles of communications 3. Principles of Signal Processing 4. Microprocessors & Microcontrollers
3	Open Elective-3	1. Fundamentals of VLSI Design 2. Digital Electronics 3. Electronic measurements and Instrumentations 4. Optical communications
4	Open Elective-4	1. Principles of Cellular & Mobile communications 2. Fundamentals of Satellite Communications 3. Embedded Systems 4. Transducers and Signal Conditioning 5. Quantum Science and Technology

III Year I Semester	ELECTRONIC DEVICES AND CIRCUITS	L	T	P	C
		3	0	0	3

Course Outcomes:

- Apply the basic concepts of semiconductor physics.
- Understand the formation of p-n junction and how it can be used as a p-n junction as diode in different modes of operation.
- Know the construction, working principle of rectifiers with and without filters with relevant expressions and necessary comparisons.
- Understand the construction, principle of operation of transistors, BJT and FET with their V-I characteristics in different configurations.
- Know the need of transistor biasing, various biasing techniques for BJT and FET and stabilization concepts with necessary expressions.

UNIT-I:

Review of Semi Conductor Physics: Hall effect, continuity equation, law of junction, Fermi Dirac function, Fermi level in intrinsic and extrinsic Semiconductors

Junction Diode Characteristics : Energy band diagram of PN junction Diode, Open circuited p-n junction, Biased p-n junction, p-n junction diode, current components in PN junction Diode, diode equation, V-I Characteristics, temperature dependence on V-I characteristics, Diode resistance, Diode capacitance.

UNIT-II:

Special Semiconductor Devices: Zener Diode, Breakdown mechanisms, Zener diode applications, LED, Varactor Diode, Photodiode, Tunnel Diode, UJT, PNP Diode, SCR. Construction, operation and V-I characteristics.

Rectifiers and Filters: Basic Rectifier setup, half wave rectifier, full wave rectifier, bridge rectifier, derivations of characteristics of rectifiers, rectifier circuits-operation, input and output waveforms, Filters, Inductor filter(Series inductor), Capacitor filter(Shunt inductor), π -Filter, comparison of various filter circuits in terms of ripple factors.

UNIT- III: Transistor Characteristics:

BJT: Junction transistor, transistor current components, transistor equation, transistor configurations, transistor as an amplifier, characteristics of transistor in Common Base, Common Emitter and Common Collector configurations, Ebers-Moll model of a transistor, punch through/ reach through, Photo transistor, typical transistor junction voltage values.

FET: FET types, construction, operation, characteristics μ , g_m , r_d parameters, MOSFET-types, construction, operation, characteristics, comparison between JFET and MOSFET.

UNIT- IV: Transistor Biasing and Thermal Stabilization : Need for biasing, operating point, load line analysis, BJT biasing- methods, basic stability, fixed bias, collector to base bias, self bias, Stabilization against variations in V_{BE} , I_c , and β , Stability factors, (S, S', S'') , Bias compensation, Thermal runaway, Thermal stability. FET Biasing- methods and stabilization.

UNIT- V: Small Signal Low Frequency Transistor Amplifier Models:

BJT: Two port network, Transistor hybrid model, determination of h-parameters, conversion of h-parameters, generalized analysis of transistor amplifier model using h-parameters, Analysis of CB, CE and CC amplifiers using exact and approximate analysis, Comparison of transistor amplifiers.

FET: Generalized analysis of small signal model, Analysis of CG, CS and CD amplifiers, comparison of FET amplifiers.

Text Books:

1. Electronic Devices and Circuits- J. Millman, C. Halkias, Tata Mc-Graw Hill, Second Edition, 2007
2. Electronic Devices and Circuits by David A. Bell, Oxford University Press
3. Electronics devices & circuit theory- Robert L. Boylestad and Louis Nashelsky, Pearson/Prentice hall, tenth edition, 2009

References:

1. Integrated Electronics-J. Millman, C. Halkias, Tata Mc-Graw Hill, Second Edition, 2009
2. Electronic Devices and Circuits-K. Lal Kishore, BS Publications, Fourth Edition, 2016.

III Year I Semester	SIGNALS AND SYSTEMS	L	T	P	C
		3	0	0	3

Course Outcomes:

- Differentiate the various classifications of signals and systems
- Analyze the frequency domain representation of signals using Fourier concepts
- Classify the systems based on their properties and determine the response of LTI Systems.
- Know the sampling process and various types of sampling techniques.
- Apply Laplace and z-transforms to analyze signals and Systems (continuous & discrete).

UNIT- I: INTRODUCTION: Definition of Signals and Systems, Classification of Signals, Classification of Systems, Operations on signals: time-shifting, time-scaling, amplitude-shifting, amplitude-scaling. Problems on classification and characteristics of Signals and Systems, Complex exponential and sinusoidal signals, Singularity functions and related functions: impulse function, step function signum function and ramp function.

UNIT-II: FOURIER SERIES AND FOURIER TRANSFORM:

Fourier series representation of continuous time periodic signals, Dirichlet's conditions, Trigonometric Fourier series and Exponential Fourier series, Relation between Trigonometric and Exponential Fourier series, Complex Fourier spectrum. Deriving Fourier transform from Fourier series, Fourier transform of standard signals, properties of Fourier transforms, Fourier transforms involving impulse function and Signum function. Related problems

UNIT-III:

CORRELATION: Auto-correlation and cross-correlation of functions, properties of correlation function, Energy density spectrum, Parseval's theorem, Power density spectrum, Relation between Convolution and correlation, Detection of periodic signals in the presence of noise by correlation.

SAMPLING THEOREM: Graphical and analytical proof of Band Limited Signals, impulse sampling, Natural and Flat top Sampling, Reconstruction of signal from its samples, Aliasing, Related problems.

UNIT-IV:

LAPLACE TRANSFORMS: Introduction, Concept of region of convergence (ROC) for Laplace transforms, constraints on ROC for various classes of signals, Properties of L.T's, Inverse Laplace transform, Relation between L.T's, and F.T. of a signal. Laplace transform of certain signals using waveform synthesis.

UNIT-V:

Z-TRANSFORMS: Concept of Z-Transform of a discrete sequence. Region of convergence in Z- Transform, constraints on ROC for various classes of signals, Inverse Z-transform, properties of Z-transforms, Distinction between Laplace, Fourier and Z transforms.

TEXT BOOKS:

1. Signals, Systems & Communications-B.P.Lathi, BSPublications,2003.
2. Signals and Systems-A.V. Oppenheim, A.S. Willsky and S.H. Nawab, PHI,2ndEdn,1997
3. Signals & Systems-Simon Haykin and VanVeen, Wiley,2ndEdition,2007

REFERENCE BOOKS:

1. Principles of Linear Systems and Signals–BPLathi, Oxford University Press, 2015
2. Signals and Systems–TK Rawat, Oxford University press, 2011.

III Year I Semester	PROBABILITY THEORY AND RANDOM VARIABLES	L	T	P	C
		3	0	0	3

Course Outcomes:

- Mathematically model the random phenomena and solve simple probabilistic problems
- Identify different types of random variables and compute statistical averages of these random variables.
- Characterize the random processes in the time and frequency domains.
- Analyze the LTI systems with random inputs

UNIT I

THE RANDOM VARIABLE: Introduction, Review of Probability Theory, Definition of a Random Variable, Conditions for a Function to be a Random Variable, Discrete, Continuous and Mixed Random Variables, Distribution and Density functions, Properties, Binomial, Poisson, Uniform, Gaussian, Exponential, Rayleigh, Conditional Distribution, Conditional Density, Properties.

UNIT II

OPERATION ON ONE RANDOM VARIABLE - EXPECTATIONS: Introduction, 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 Transformations for a Continuous Random Variable, Non-monotonic Transformations of Continuous Random Variable.

UNIT III

MULTIPLE RANDOM VARIABLES: Vector Random Variables, Joint Distribution Function, Properties of Joint Distribution, Marginal Distribution Functions, Conditional Distribution and Density, Statistical Independence, Sum of Two Random Variables, Sum of Several Random Variables, Central Limit Theorem: Unequal Distribution, Equal Distributions.

OPERATIONS ON MULTIPLE RANDOM VARIABLES: Joint Moments about the Origin, Joint Central Moments, Joint Characteristic Functions, Jointly Gaussian Random Variables: Two Random Variables case, N Random Variables case, Properties, Transformations of Multiple Random Variables, Linear Transformations of Gaussian Random Variables.

UNIT IV

RANDOM PROCESSES – TEMPORAL CHARACTERISTICS: The Random 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, N^{th} -order and Strict -Sense Stationarity, Time Averages and Ergodicity, Autocorrelation Function and its Properties, Cross-Correlation Function and its Properties, Covariance Functions, Gaussian Random Processes, Poisson Random Process.

UNIT V

RANDOM PROCESSES - SPECTRAL CHARACTERISTICS: The Power Density Spectrum: Properties, Relationship between Power Density Spectrum and Autocorrelation Function, The Cross-Power Density Spectrum, Properties, Relationship between Cross-Power Density Spectrum and Cross-Correlation Function.

LINEAR SYSTEMS WITH RANDOM INPUTS: Random Signal Response of Linear Systems: System Response – Convolution, Mean and Mean-squared Value of System Response, Autocorrelation Function of Response, Cross-Correlation Functions of Input and Output, Spectral Characteristics of System Response: Power Density Spectrum of Response, Cross-Power Density Spectra of Input and Output, Band pass, Band-Limited and Narrowband Processes, Properties.

TEXT BOOKS:

1. Probability, Random Variables & Random Signal Principles, Peyton Z. Peebles, TMH, 4th Edition, 2001.
2. Probability, Random Variables and Stochastic Processes, Athanasios Papoulis and S.Unnikrishna, PHI, 4th Edition, 2002.
3. Probability Theory and Stochastic Processes – B. PrabhakaraRao, BS Publications.

REFERENCE BOOKS:

1. Probability and Random Processes with Applications to Signal Processing, Henry Stark and John W. Woods, Pearson Education, 3rd Edition.
2. Schaum's Outline of Probability, Random Variables, and Random Processes.
3. An Introduction to Random Signals and Communication Theory, B.P. Lathi, International Textbook, 1968.
4. Probability Theory and Random Processes, P. Ramesh Babu, McGrawHill, 2015.

III Year I Semester	NETWORK ANALYSIS	L	T	P	C
		3	0	0	3

Course Outcomes:

- Gain the knowledge on basic network elements.
- Will analyze the RLC circuit's behavior in detailed.
- Analyze the performance of periodic waveforms
- Gain the knowledge in characteristics of two port network parameters (Z,Y,ABCD,h& g).
- Analyze the filter design concepts in real world applications.

UNIT – I

Introduction to Electrical Circuits : Network elements classification, Electric charge and current, Electric energy and potential, Resistance parameter – series and parallel combination, Inductance parameter – series and parallel combination, Capacitance parameter – series and parallel combination. Energy sources: Ideal, Non-ideal, Independent and dependent sources, Source transformation, Kirchoff's laws, Mesh analysis and Nodal analysis problem solving with resistances only including dependent sources also.

Definitions of terms associated with periodic functions: Time period, Angular velocity and frequency, RMS value, Average value, Form factor and peak factor- problem solving, Phase angle, Phasor representation, Addition and subtraction of phasors, mathematical representation of sinusoidal quantities, explanation with relevant theory, problem solving. Principal of Duality with examples

Definitions of branch, node, tree, planar, non-planar graph, incidence matrix, basic tie set schedule, basic cut set schedule.

UNIT – II

Transients : First order differential equations, Definition of time constants, R-L circuit, R-C circuit with DC excitation, Evaluating initial conditions procedure, second order differential equations, homogeneous, non-homogenous, problem solving using R-L-C elements with DC excitation and AC excitation, Response as related to s-plane rotation of roots. Solutions using Laplace transform method.

UNIT – III

Steady State Analysis of A.C Circuits: Impedance concept, phase angle, series R-L, R-C, R-L-C circuits problem solving. Complex impedance and phasor notation for R-L, R-C, R-L-C problem solving using mesh and nodal analysis, Star-Delta conversion, problem solving.

Coupled Circuits : Coupled Circuits: Self inductance, Mutual inductance, Coefficient of coupling, analysis of coupled circuits, Natural current, Dot rule of coupled circuits, Conductively coupled equivalent circuits- problem solving.

UNIT – IV Resonance: Introduction, Definition of Q, Series resonance, Bandwidth of series resonance, Parallel resonance, Condition for maximum impedance, current in anti resonance, Bandwidth of parallel resonance, general case-resistance present in both branches, anti resonance at all frequencies.

Network Theorems: Thevinin's, Norton's, Milliman's, Reciprocity, Compensation, Substitution, Superposition, Max Power Transfer, Tellegens- problem solving using dependent sources also

UNIT – V Two-port Networks: Relationship of two port networks, Z-parameters, Y-parameters, Transmission line parameters, h-parameters, Inverse h-parameters, Inverse Transmission line parameters, Relationship between parameter sets, Parallel connection of two port networks, Cascading of two port networks, series connection of two port networks, problem solving including dependent sources also.

TEXT BOOKS:

1. Network Analysis – ME Van Valkenburg, Prentice Hall of India, 3rd Edition, 2000.
2. Network Analysis by K.Satya Prasad and S Sivanagaraju, Cengage Learning
3. Electric Circuit Analysis by Hayt and Kimmarle, TMH

REFERENCES:

1. Network lines and Fields by John. D. Ryder 2nd edition, Asia publishing house.
2. Basic Circuit Analysis by DR Cunningham, Jaico Publishers.
3. Network Analysis and Filter Design by Chadha, Umesh Publications.

III Year II Semester	LINEAR AND DIGITAL IC APPLICATIONS	L	T	P	C
		3	0	0	3

Course Outcomes:

- Analyze and design various configurations of operational amplifiers, and applications such as instrumentation amplifiers, voltage regulators, comparators, and waveform generators.
- Design and implement active filters and waveform generators using op-amps, IC-555, and IC-565, and evaluate their performance for signal processing applications
- Compare different data conversion techniques (DAC and ADC) and implement digital-to-analog and analog-to-digital conversion circuits in real-time applications.
- Apply combinational logic ICs such as multiplexers, de-multiplexers, encoders, decoders, and arithmetic circuits to solve complex digital design problems.
- Develop sequential circuits using flip-flops, counters, and shift registers, and analyze their use in digital memory systems, including ROM, RAM, and their variants

UNIT-I

Operational Amplifier: Ideal and Practical Op-Amp, Op-Amp Characteristics, DC and AC Characteristics, features of 741 Op-Amp, Modes of Operation-Inverting, Non-Inverting, Differential, Instrumentation Amplifier, AC Amplifier, Differentiators and Integrators, Comparators, Schmitt Trigger, Introduction to Voltage Regulators, Features of 723 Regulator, Three Terminal Voltage Regulators.

UNIT-II

Op-Amp, IC-555 & IC565 Applications: Introduction to Active Filters, Characteristics of Bandpass, Band reject and All Pass Filters, Analysis of 1st order LPF & HPF Butterworth Filters, Waveform Generators – Triangular, Sawtooth, Square Wave, IC555 Timer-Functional Diagram, Monostable and Astable Operations, Applications, IC565 PLL-Block Schematic, principle and Applications.

UNIT-III

Data Converters: 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

Combinational Logic ICs: Specifications and Applications of TTL-74XX & CMOS 40XX Series ICs - Code Converters, Decoders, LED & LCD Decoders with Drivers, Encoders, Priority Encoders, Multiplexers, De-multiplexers, Priority Generators/Checkers, Parallel Binary Adder/Subtractor, Magnitude Comparators.

UNIT-V

Sequential Logic IC's and Memories: Familiarity with commonly available 74XX & CMOS40XX Series ICs - All Types of Flip-flops, Synchronous Counters, Decade Counters, Shift Registers.

Memories - ROM Architecture, Types of ROMS & Applications, RAM Architecture, Static & Dynamic RAMs.

TEXTBOOKS:

1. Ramakanth A.Gayakwad-Op-Amps & LinearICs, PHI,2003.
2. FloydandJain-DigitalFundamentals,8thEd.,Pearson Education,2005.

REFERENCEBOOKS:

1. D.Roy Chowdhury–Linear Integrated Circuits, NewAge International(p)Ltd ,2ndEd.,2003.
2. John.F.Wakerly–DigitalDesignPrinciplesandPractices,3rdEd.,Pearson,,2009.
3. Salivahana-Linear Integrated Circuits and Applications,TMH,2008.
4. William D.Stanley-Operational Amplifiers with Linear Integrated Circuits, 4thEd.,Pearson Education India, 2009

III Year II Semester	PRINCIPLES OF COMMUNICATIONS	L	T	P	C
		3	0	0	3

Course Outcomes:

- Analyze the performance of analog modulation schemes in time and frequency domains.
- Analyze the performance of angle modulated signals.
- Characterize analog signals in time domain as random processes and noise
- Characterize the influence of channel on analog modulated signals
- Determine the performance of analog communication systems in terms of SNR
- Analyze pulse amplitude modulation, pulse position modulation, pulse code modulation and TDM systems.

UNIT1 : Basic tools for communication, Fourier Series/Transform, Properties, Autocorrelation, Energy Spectral Density, Parsevals Relation, Amplitude Modulation (AM), Spectrum of AM, Envelope Detection, Power Efficiency, Modulation Index.

UNIT2 : Double Sideband Suppressed Carrier (DSB-SC) Modulation, Demodulation, Costas Receiver, Single Sideband Modulation (SSB), Hilbert Transform, Complex Pre-envelope/Envelope, Demodulation of SSB, Vestigial Sideband Modulation (VSB)

UNIT 3 : Angle Modulation, Frequency Modulation (FM), Phase Modulation (PM), Modulation Index, Instantaneous Frequency, Spectrum of FM Signals, Carsons Rule for FM Bandwidth, Narrowband FM Generation, Wideband FM Generation via Indirect Method, FM Demodulation

UNIT 4 : Introduction to Sampling, Spectrum of Sampled Signal, Aliasing, Nyquist Criterion, Signal Reconstruction from Sampled Signal, Pulse Amplitude Modulation, Quantization, Uniform Quantizers – Midrise and Midtread, Quantization noise, , Non uniform Quantizers, Delta Modulation, Differential Pulse Code Modulation (DPCM)

UNIT 5: : Basics of Probability, Conditional Probability, MAP Principle, Random Variables, Probability Density Functions, Applications in Wireless Channels, Basics of Random Processes ,Gaussian Random Process, Noise.

TEXTBOOKS:

1. Simon Haykin, Communications Systems, 4th Edition. John Wiley and Sons, Inc
2. Fundamentals of Wireless Communication by David Tse

III Semester	Year II	PRINCIPLES OF SIGNAL PROCESSING	L	T	P	C
			3	0	0	3

Course Outcomes:

- Acquire the knowledge in signals and systems.
- Get familiarized with various transforms to analyze continuous time signals.
- Understand sampling theorem and z-transform.
- Get familiarized with the transforms of discrete time signals.
- Design the digital filter design

Unit- I: Introduction:

Definition of Signals and Systems, Classification of Signals, Classification of Systems, Operations on signals: time-shifting, time-scaling, amplitude-shifting, Amplitude - scaling. Problems on classification and characteristics of Signals and Systems. Complex exponential and sinusoidal signals, impulse Function, step function, signum function and ramp function. Introduction, Linear system, impulse response, Linear time invariant (LTI) system, Linear time invariant(LTV) system, Concept of convolution in time domain and frequency domain, Graphical representation of convolution, Transfer function of a LTI system, Related problems.

Unit-II: Analysis of continuous time signals

Fourier Series and Fourier Transform:

Fourier series representation of continuous time periodic signals, Dirichlet's conditions, Trigonometric Fourier series and Exponential Fourier series,. Deriving Fourier transform from Fourier series, Fourier transform of standard signals, properties of Fourier transforms, Related problems.

Laplace Transforms:

Introduction, Concept of region of convergence (ROC) for Laplace transforms, Properties of L.T's, Inverse Laplace transform, Relation between Laplace Transform and Fourier Transform of a signal.

Unit III: Sampling Theorem: Graphical and analytical proof or Band Limited Signals, impulse sampling, Reconstruction of signal from its samples, Aliasing

Z-Transforms: Concept of Z-Transform of a discrete sequence. Region of convergence in Z-Transform, Inverse Z-transform, properties of Z-transforms

Unit IV: Fourier Transforms of discrete signal: Fourier Transform of Discrete Signal, Properties, and Inverse Fourier Transforms, related problems

Discrete Fourier Transforms: Definition, Properties, Inverse DFT, related problems.

Fast Fourier Transform: Decimation in Time domain and Decimation in Frequency Algorithms.

Unit V: Digital Filters: Structures of IIR filters and FIR filters: Director form-1 and Direct form 2; cascade form; parallel form **Analog filter design** LPF, BPF, HPF and BEF filter design using Butterworth **Frequency Transformations:** Analog to Analog; Digital and Digital **IIR Filter Design:** IIR filter from analog filter – IIR filter design by Impulse Invariance, Bilinear transformation. **FIR Filter Design:** Filter design using windowing techniques. Rectangular Window, Hamming Window, Hanning Window

Text Books:

1. Signals, Systems & Communications - B. P. Lathi, BS Publications, 2003.
2. Digital Signal Processing - P. Ramesh Babu, 5th Edition, SCITECH Publishers.

Reference Books:

1. Signals & Systems – Simon Haykin and VanVeen, Wiley, 2nd Edition, 2007.
2. Signals and Systems-A.V. Oppenheim, A.S. Willsky and S.H. Nawab, PHI, 2ndEdn, 1997.
3. Discrete Time Signal Processing – A.V.Oppenheim and R.W. Schaffer, 3rd Edition, Pearson, 2014.

III Year II Semester	MICROPROCESSORS & MICROCONTROLLERS	L	T	P	C
		3	0	0	3

Course Outcomes:

- Understand the architecture of 8086 and its operation.
- Develop the students to compose the assembly language program for 8086.
- Applying 8086 processor to interface with necessary peripherals.
- Understand the architecture of 8051 and interfacing with necessary peripherals.
- Understand the introductory concepts of advanced processors, viz., ARM processors.

UNIT-1:

Introduction: Microprocessor based system, Origin of microprocessors, Harvard and Von Neumann architectures with examples, Microprocessor Unit versus Microcontroller Unit.

8086 Architecture: internal architecture of 8086 microprocessor, register organization, physical memory organization, general bus operation.

UNIT-2:

8086 Programming: instruction set, addressing modes, assembler directives, programming with assembler, writing simple programs with an assembler, stack and stack structure, interrupts and interrupt service routines, interrupt cycle of 8086.

UNIT-3:

8086 Interfacing: Semiconductor memories interfacing (RAM, ROM), Intel 8255 programmable peripheral interface, Interfacing switches and LEDs, Interfacing seven segment displays, Intel 8251 USART architecture and interfacing, stepper motor, A/D and D/A converters

UNIT-4:

Intel 8051 MICROCONTROLLER and Interfacing

Introduction to microcontrollers, internal architecture of 8051 microcontroller, I/O ports and memory organization, MCS51 addressing modes and instruction set, assembly language programming, simple programs, counters/timers, serial data input/output, interrupts. Interfacing to 8051: A/D and D/A Convertors, keyboard, LCD Interfacing.

UNIT-5:

ARM Architectures and Processors: introduction to CISC and RISC architectures, ARM Architecture, ARM Processors Families, Introduction to 16/32 bit processors, ARM7 architecture and organization, Thumb instructions, ARM Cortex-M3 Processor Functional Description.

TEXTBOOKS:

1. Advanced microprocessors and peripherals by K. M. Bhurchandi, A. K. Ray 3e
2. The 8051 Microcontrollers and Embedded systems Using Assembly and C, Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D.McKinlay; Pearson 2-Edition,2011.
3. Microprocessors and Microcontrollers by N. Senthil Kumar, M. Saravanan and S. Jeevanathan Oxford higher education

REFERENCE BOOKS:

1. Embedded Systems Fundamentals with Arm Cortex-M based Microcontrollers: A Practical Approach in English, by Dr. Alexander G. Dean, Published by Arm

EducationMedia,2017.

2. Cortex-M3TechnicalReference Manual.
3. TheDefinitiveGuidetoARMCortex-M3andCortex-M4ProcessorsbyJosephYiu.,Newnes Third edition

IV Year I Semester	FUNDAMENTALS OF VLSI DESIGN (OE-III)	L	T	P	C
		3	0	0	3

CO1: Understand the physical structure, operation, and electrical characteristics of MOS transistors, including threshold voltage, transconductance, and body effects.

CO2: Describe the MOS fabrication technology process steps, including wafer fabrication, oxidation, photolithography, diffusion, and CMOS/NMOS fabrication techniques, and analyze common fabrication issues like latch-up and short-channel effects.

CO3: Apply layout design rules to CMOS circuits, including scalable CMOS design rules, micron design rules, and circuit elements, ensuring compliance with fabrication constraints.

CO4: Design and analyze MOS combinational logic circuits, including pass-transistor logic, CMOS gate logic, dynamic logic circuits, and advanced logic families such as domino and NORA logic.

CO5: Understand and design sequential MOS logic circuits, including bistable elements, SR latches, clocked latches, and CMOS flip-flops, to implement memory and timing functions.

UNIT 1: MOS Transistors

Introduction, The Structure of MOS Transistors, The Fluid Model, The MOS Capacitor, The MOS Transistor, Modes of Operation of MOS Transistors, Electrical Characteristics of MOS Transistors, Threshold Voltage, Transistor Transconductance g_m , Figure of Merit, Body Effect, Channel-Length Modulation, MOS Transistors as a Switch, Transmission Gate

UNIT 2: MOS Fabrication Technology

Introduction, Basic Fabrication Processes, Wafer Fabrication, Oxidation, Mask Generation, Photolithography, Diffusion, Deposition. N-MOS Fabrication Steps, CMOS Fabrication Steps, n-Well Process, p-Well Process, Twin-Tub Process, Latch-Up Problem and Its Prevention, Use of Guard Rings, Use of Trenches, Short-Channel Effects-Channel Length Modulation Effect. Drain-Induced Barrier Lowering, Channel Punch Through, Hot carrier effect, Velocity Saturation Effect

UNIT 3: Layout Design Rules

Design Rule Background, Scribe Line and Other Structures MOSIS Scalable CMOS Design Rules, Micron Design Rules, CMOS Process Enhancements, Transistors, Interconnect, Circuit Elements, Beyond Conventional CMOS

UNIT4: MOS Combinational Circuits

Pass-Transistor Logic, Realizing Pass-Transistor Logic, Advantages and Disadvantages, Pass-Transistor Logic Families, Gate Logic, Fan-In and Fan-Out, n-MOS NAND and NOR Gates, CMOS Realization, Switching Characteristics, CMOS NOR Gate, CMOS Complex Logic Gates,

MOS Dynamic Circuits, Single-Phase Dynamic Circuits, Two-Phase Dynamic Circuits, CMOS Dynamic Circuits, Advantages and Disadvantages Domino CMOS Circuits, NORA Logic

UNIT 5: Sequential MOS Logic Circuits

Behaviour of bistable elements, SR Latch, Clocked latch and flip flop circuits, CMOS D latch and edge triggered flip-flop.

TEXT BOOKS

1. 1.Principals of CMOS VLSI Design-N.H.EWeste, K. Eshraghian, 2nd Edition, Addison Wesley.
2. 2.CMOS Digital Integrated Circuits Analysis and Design – Sung-Mo Kang, Yusuf Leblebici, TMH, 3rd Ed., 2011.
3. 3.Low-Power VLSI Circuits and Systems,Ajit Pal, SPRINGER PUBLISHERS

REFERENCE BOOKS:

1. Digital Integrated Circuit Design – Ken Martin, Oxford University Press, 2011.
2. Digital Integrated Circuits – A Design Perspective, Jan M. Rabaey, Anantha Chandrakasan, BorivojeNikolic, 2nd Ed., PHI.

IV Year I Semester	DIGITAL ELECTRONICS (OE-III)	L	T	P	C
		3	0	0	3

Course Outcomes:

- Classify different number systems and apply to generate various codes.
- Use the concept of Boolean algebra in minimization of switching functions
- Design different types of combinational logic circuits.
- Apply knowledge of flip-flops in designing of Registers and counters
- The operation and design methodology for synchronous sequential circuits and algorithmic state machines.
- Produce innovative designs by modifying the traditional design techniques.

UNIT – I

REVIEW OF NUMBER SYSTEMS & CODES:

Representation of numbers of different radix, conversion from one radix to another radix, $r-1$'s complements and r 's complements of signed members. Gray code, 4 bit codes; BCD, Excess-3, 2421, 84-2-1 code etc., Error detection & correction codes: parity checking, even parity, odd parity, Hamming code

Boolean theorems and logic operations

Boolean theorems, principle of complementation & duality, De-morgan theorems. Logic operations ; Basic logic operations -NOT, OR, AND, Universal Logic operations, EX-OR, EX-NOR operations. Standard SOP and POS Forms, NAND-NAND and NOR-NOR realizations.

UNIT – II

MINIMIZATION TECHNIQUES:

Minimization and realization of switching functions using Boolean theorems, K-Map (up to 6 variables) and tabular method

COMBINATIONAL LOGIC CIRCUITS DESIGN

Design of Half adder, full adder, half subtractor, full subtractor, applications of full adders; 4-bit adder-subtractor circuit, BCD adder circuit, Excess 3 adder circuit and carry look-a-head adder circuit

UNIT – III

COMBINATIONAL LOGIC CIRCUITS DESIGN USING MSI &LSI :

Design of encoder ,decoder, multiplexer and demultiplexers, Implementation of higher order circuits using lower order circuits . Realization of Boolean functions using decoders and multiplexers. Design of Priority encoder, 4-bit digital comparator and seven segment decoder

UNIT – IV

INTRODUCTION OF PLD's :

PLDs: PROM, PAL, PLA -Basics structures, realization of Boolean functions. Architectures of CPLD,FPGA, flash memories(NAND,NOR)

UNIT – IV

SEQUENTIAL CIRCUITS I:

Classification of sequential circuits (synchronous and asynchronous) , operation of NAND & NOR Latches and flip-flops; truth tables and excitation tables of RS flip-flop, JK flip-flop, T

flip-flop, D flip-flop with reset and clear terminals. Conversion from one flip-flop to another flip-flop, Design of ripple counters, design of synchronous counters, Johnson counter, ring counter. Design of registers - Buffer register, control buffer register, shift register, bi-directional shift register, universal shift register

TEXT BOOKS:

1. Switching and finite automata theory Zvi.KOHAVI 3RD EDITION
2. Fundamentals of Logic Design by Charles H. Roth Jr, Jaico Publishers
3. Digital Design by Mano PHI.

REFERENCES:

1. Switching Theory and Logic Design by A. Anand Kumar
2. Switching Theory and Logic Design by Hill and Peterson Mc-Graw Hill TMH edition

IV Semester	Year I	ELECTRONIC MEASUREMENTS AND INSTRUMENTATIONS (OE-III)	L	T	P	C
			3	0	0	3

Course outcomes:

- understand the various Analog and Digital measuring Instruments
- aware of the principles and operations of various oscilloscopes
- learn measurements using various bridges
- familiarize different Signal Generators and function generators
- learn various transducers

UNIT I

Measuring Instruments: Introduction, Errors in Measurement, Accuracy, Precision, Resolution and Significant figures, Basic PMMC Meter- construction and working, DC and AC Voltmeters- Multirange, Range extension, DC Ammeter, Multimeter for Voltage, Current and resistance measurements.

Digital Instruments: Digital Voltmeters – Introduction, DVM's based on V-T, V-F and Successive approximation principles, Resolution and sensitivity, General specifications, Digital Multimeters, Digital frequency meters, Digital measurement of time.

UNIT II

Oscilloscopes: Introduction, Block diagram of CRO, Basic principle of CRT, CRT Construction and features, vertical amplifiers, horizontal deflection system- sweep, trigger pulse, delay line, sync selector circuits. Dual beam and dual trace CROs, Sampling and Digital storage oscilloscopes.

UNIT III

Bridges: DC Bridges for Measurement of resistance - Wheat stone bridge, Kelvin's Bridge, AC Bridges for Measurement of inductance- Maxwell's bridge, Hay's Bridge, Anderson bridge, Measurement of capacitance - Schearing Bridge, Wien Bridge, Errors and precautions in using bridges.

UNIT IV

Signal Generators: Introduction, Fixed and variable AF oscillator, Standard signal generator, Laboratory type signal generator, AF sine and Square wave generator, Function generator, Square and Pulse generator, Sweep frequency generator.

UNIT V

Transducers: Introduction, Types of Transducers, Electrical transducers, Selecting a transducer, Resistive transducer, Strain gauges, Piezoelectric transducer, Photoelectric transducer, Photovoltaic transducer, Temperature transducers-RTD, LVDT.

TEXT BOOKS

1. H. S. Kalsi, “Electronic Instrumentation”, Third edition, Tata McGraw Hill, 2010.
2. A. D. Helfrick and W.D. Cooper, “Modern Electronic Instrumentation and Measurement Techniques”, PHI, 6th Edition, 2010.

REFERENCE BOOKS

1. A.K. Sawhney, Dhanpat Rai & Co., “A course in Electrical and Electronic Measurements and Instrumentation”, 9th Edition, 2010.
2. David A. Bell, “Electronic Instrumentation & Measurements”, PHI, 2nd Edition, 2006.

IV Year I Semester	OPTICAL COMMUNICATIONS (OE-III)	L	T	P	C
		3	0	0	3

Course Outcomes:

- Choose necessary components required in modern optical communications systems.
- Design and build optical fiber experiments in the laboratory, and learn how to calculate electromagnetic modes in waveguides, the amount of light lost going through an optical system, dispersion of optical fibers.
- Use different types of photo detectors and optical test equipment to analyze optical fiber and light wave systems.
- Choose the optical cables for better communication with minimum losses
- Design, build, and demonstrate optical fiber experiments in the laboratory.

UNIT I

Overview of optical fiber communication - Historical development, The general system, advantages of optical fiber communications. Optical fiber waveguides-Introduction, Ray theory transmission, Total Internal Reflection, Acceptance angle, Numerical Aperture, Skew rays, Cylindrical fibers- Modes, V-number, Mode coupling, Step Index fibers, Graded Index fibers, Single mode fibers-Cutoff wave length, Mode Field Diameter, Effective Refractive Index, Related problems.

UNIT II

Fiber materials:- Glass, Halide, Active glass, Chalcogenide glass, Plastic optical fibers. Signal distortion in optical fibers-Attenuation, Absorption, Scattering and Bending losses, Core and Cladding losses, Information capacity determination, Group delay, Types of Dispersion:- Material dispersion, Wave-guide dispersion, Polarization-Mode dispersion, Intermodal dispersion, Pulse broadening in Graded index fiber, Related problems.

UNIT III

Optical fiber Connectors-Connector types, Single mode fiber connectors, Connector return loss, Fiber Splicing-Splicing techniques, Splicing single mode fibers, Fiber alignment and joint loss- Multimode fiber joints, single mode fiber joints.

UNIT IV

Optical sources-LEDs, Structures, Materials, Quantum efficiency, Power, Modulation, Power bandwidth product. Injection Laser Diodes- Modes, Threshold conditions, External quantum efficiency, Laser diode rate equations, Resonant frequencies, Reliability of LED&ILD, Optical detectors- Physical principles of PIN and APD, Detector response time, Comparison of Photo detectors, Related problems.

UNIT V

Source to fiber power launching - Output patterns, Power coupling, Power launching, Equilibrium Numerical Aperture, Laser diode to fiber coupling, Optical receiver operation- Fundamental receiver operation, Digital signal transmission, error sources, Receiver configuration, Digital receiver performance, Probability of Error, Quantum limit, Analog receivers. Optical system design - Point-to- point links- Component choice and

considerations, Link power budget, Rise time budget with examples, Line coding in Optical links, WDM, Necessity, Principles, Measurement of Attenuation and Dispersion, Eye pattern.

TEXT BOOKS:

1. Optical Fiber Communications–Gerd Keiser, McGraw Hill International edition, 3rd Edition, 2000.
2. Fiber Optic Communications– Joseph C. Palais, 4th Edition, Pearson Education, 2004.

REFERENCES:

1. Fiber Optic Communications–D.K. Mynbaev, S.C. Gupta and Lowell L. Scheiner, Pearson Education, 2005.
2. Text Book on Optical Fiber Communication and its Applications–S.C. Gupta, PHI, 2005.
3. Fiber Optic Communication Systems–Govind P. Agarwal, John Wiley, 3rd Edition, 2004.

IV Year I Semester	PRINCIPLES OF CELLULAR & MOBILE COMMUNICATIONS (OE-IV)	L	T	P	C
		3	0	0	3

OUTCOMES:

- The student will be able to understand impairments due to multipath fading channel
- The student will be able to understand the fundamental techniques to overcome the different fading effects
- The student will be able to understand co-channel and non co-channel interferences.
- The student will be able to understand the frequency management, channel assignment and types of handoff
- The student will be able to understand the Multiple access schemes in mobile communications

UNIT I CELLULAR SYSTEMS: Limitations of Conventional System, Basic Cellular Mobile System, First, second, third and fourth and Generation cellular wireless systems. Operation of Cellular System. Uniqueness of Mobile Radio Environment –Fading, coherence bandwidth, Doppler Spread. Fundamentals of cellular Radio System Design: concept of frequency reuse channels, Co-channel Interference, Co-channel Interference Reduction Factor, desired C/I from a normal case in a Omni directional Antenna system. Trunking and grade of service

UNIT II CO-CHANNEL & NON-CO-CHANNEL INTERFERENCE: Measurement of Real Time Co-Channel Interference, design of Antenna system, Antenna parameters and their effects, diversity techniques: Space Diversity, Polarization diversity, frequency diversity and time diversity. Non-co channel interference-adjacent channel interference.

UNIT III Frequency Management And Channel Assignment : Numbering and grouping, setup access and paging channels ,channel assignments to cell sites and mobile units, channel sharing and borrowing, sectorization, overlaid cells, non fixed channel assignment

UNIT IV HANDOFFS: Handoff Initiation, types of handoff, delaying handoff, advantages of Handoff, power difference handoff, forced handoff, mobile assisted and soft and Hard handoffs. Intersystem and Intrasystem handoffs, Concept of Call drop rates.

UNIT V Multiple access schemes in mobile communications: TDMA, FDMA, CDMA. Introduction to MIMO systems Principles of CDMA cellular systems, Principles of OFDM based broadband wireless systems , 4G LTE basics – OFDM, and OFDMA ,Generalised framework for Filtered OFDM and FBMC .Introduction of 5G

TEXT BOOKS:

1. Mobile Cellular Telecommunications – W.C.Y. Lee, Tata McGraw Hill, 2nd Edn., 2006.
2. Wireless Communications - Theodore. S. Rappoport, Pearson education, 2nd Edn., 2002.
2. T. S. Rappoport, “Wireless Communications – Principles and Practice” (2nd edition) Pearson, 2010, ISBN 9788131731864

REFERENCES:

1. Principles of Mobile Communications – Gordon L. Stuber, Springer International 2nd Edition, 2001.
2. Modern Wireless Communication –Simon Haykin Michael Moher, Persons Education,2005.
3. Wireless Communication theory and Techniques, Asrar U.H .Sheikh ,Springer,2004.
4. A. Goldsmith, “Wireless Communications,” Cambridge Univ Press, 2005
5. D. Tse and P. Viswanath, “Fundamentals of Wireless Communications,” Cambridge Univ Press, 2005

IV Year I Semester	FUNDAMENTALS OF SATELLITE COMMUNICATIONS (OE-IV)	L	T	P	C
		3	0	0	3

UNIT I

INTRODUCTION: Origin of Satellite Communications, Historical Back-ground, Basic Concepts of Satellite Communications, Frequency allocations for Satellite Services, Applications, Future Trends of Satellite Communications. Orbital Mechanics, launches and launch vehicles, Orbital effects in communication systems performance

UNIT II

SATELLITE SUBSYSTEMS: Attitude and orbit control system, telemetry, tracking, Command and monitoring system, power systems, communication subsystems, Satellite antennas, Equipment reliability and Space qualification

UNIT III

SATELLITE LINK DESIGN: Basic transmission theory, link equation, C/N ratio, system noise temperature and G/T ratio, Design of down links, up link design, Design of satellite links for specified C/N, System design example.

UNIT IV

MULTIPLE ACCESS: Frequency division multiple access (FDMA): Intermodulation, Calculation of C/N. Time division Multiple Access (TDMA); Frame structure, Examples. Code Division Multiple access (CDMA): Spread spectrum transmission and reception.

UNIT V

GLOBAL NAVIGATION SATELLITE SYSTEM(GNSS):

Introduction, various GNSS: GPS, GLONASS, GALILEO, BeiDou, QZSS, IRNSS. GPS-location principle, GPS navigation message, GPS receiver operation, differential GPS;IRNSS-introduction, IRNSS satellites, IRNSS constellation, IRNSS configuration, IRNSS services, navigation data, applications of IRNSS; multi GNSS.

TEXT BOOKS:

1. Satellite Communications – Timothy Pratt, Charles Bostian and Jeremy Allnutt, WSE, Wiley Publications, 3RD Edition, 2020.
2. Satellite Communications Engineering – Wilbur L. Pritchard, Robert A Nelson and Henri G.Suyderhoud, 2nd Edition, Pearson Publications, 2003.

REFERENCES:

1. Satellite Communications: Design Principles – M. Richharia, BS Publications, 2nd Edition, 2003.
2. Satellite Communication - D.C Agarwal, Khanna Publications, 5th Ed.
3. Satellite Communications – Dennis Roddy, McGraw Hill, 2nd Edition

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IV Year I Semester	EMBEDDED SYSTEMS (OE-IV)	L	T	P	C
		3	0	0	3

COURSE OUTCOMES:

- Understand the basic concepts of an embedded system and able to know an embedded system design approach to perform a specific function.
- The hardware components required for an embedded system and the design approach of an embedded hardware.
- The various embedded firmware design approaches on embedded environment.
- Understand how to integrate hardware and firmware of an embedded system using real time operating system.

UNIT-I

INTRODUCTION: Embedded system-Definition, history of embedded systems, classification of embedded systems, major application areas of embedded systems, purpose of embedded systems, the typical embedded system-core of the embedded system, Memory, Sensors and Actuators, Communication Interface, Embedded firmware, Characteristics of an embedded system, Quality attributes of embedded systems, Application-specific and Domain-Specific examples of an embedded system.

UNIT-II

EMBEDDED HARDWARE DESIGN: Analog and digital electronic components, I/O types and examples, Serial communication devices, Parallel device ports, Wireless devices, Timer and counting devices, Watchdog timer, Real time clock.

UNIT-III

EMBEDDED FIRMWARE DESIGN: Embedded Firmware design approaches, Embedded Firmware development languages, ISR concept, Interrupt sources, Interrupt servicing mechanism, Multiple interrupts, DMA, Device driver programming, Concepts of C versus Embedded C and Compiler versus Cross-compiler.

UNIT-IV

REAL TIME OPERATING SYSTEM: Operating system basics, Types of operating systems, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling, Task communication, Task synchronization.

HARDWARE SOFTWARE CO-DESIGN: Fundamental Issues in Hardware Software Co-Design, Computational models in embedded design, Hardware software Trade-offs, Integration of Hardware and Firmware.

UNIT-V:

EMBEDDED SYSTEM DEVELOPMENT, IMPLEMENTATION AND TESTING: The integrated development environment, Types of files generated on cross-compilation, Deassembler/ De-compiler, Simulators, Emulators and Debugging, Target hardware debugging,

Embedded Software development process and tools, Interpreters, Compilers and Linkers, debugging tools, Quality assurance and testing of the design, Testing on host machine, Simulators, Laboratory Tools.

Text Books:

1. Embedded Systems Architecture- By Tammy Noergaard, Elsevier Publications, 2013.
2. Embedded Systems-By Shibu. K.V-Tata McGraw Hill Education Private Limited, 2013.

References:

1. Embedded System Design, Frank Vahid, Tony Givargis, John Wiley Publications, 2013.
2. Embedded Systems-Lyla B.Das-Pearson Publications,2013.

IV Year I Semester	TRANSDUCERS AND SIGNAL CONDITIONING (OE-IV)	L	T	P	C
		3	0	0	3

Course Outcomes: At the end of the course, student will be able to

- Choose Suitable sensor/transducer for a given physical variable and understand its principle, characteristics and determine order of the sensor.
- Measure displacement, pressure, flow, temperature variables.
- Design suitable signal conditioning circuit for sensor/transducers.
- Analyze the bridge circuits for calculating L, C, R.
- Understand noise reduction using grounding and shielding techniques and design high input impedance instrumentation amplifiers

UNIT – I

Generalized Performance characteristics of Instruments:

Functional elements of an instrument, generalized performance characteristics of instruments- static characteristics, dynamic characteristics, Experimental determination of measurement system parameters, loading effects under dynamic conditions.

UNIT – II

Signal Conditioning Circuits:

Signal Generator- fixed and variable, AF oscillators, Standard and AF sine and square wave signal generators, Function Generators, Square pulse, sweep, Arbitrary waveform. Wave Analyzers, Harmonic Distortion Analyzers, Spectrum Analyzers, Digital Fourier Analyzers. Signal Conditioning Circuits:

INTRODUCTION: Need for pre-processing, identification of signal conditioning blocks and their characteristics. BRIDGE CIRCUITS: Analysis of DC and AC bridges with applications

UNIT – III

Transducers: Motion and Dimensional Measurements: Relative displacement, translation and rotational resistive potentiometers, resistance strain gauges, LVDT, capacitance pickups. Piezo-electric transducers.

Force Measurement: Bonded strain gauge transducers, variable reluctance pickup, torque measurement dynamometers.

Pressure Measurement: Manometers, elastic transducers, very high-pressure transducers, thermal conductivity gauges.

Temperature Measurement: Thermal expansion methods, thermometers (liquid in glass), Thermocouples materials, Thermistors, Junction semiconductors and Sensors. Smart sensors, MEMS and Nano Sensors.

UNIT – IV

Intelligent Sensors: definition of intelligent instrumentation, types of instruments, Static Characteristics: Accuracy and Precision, Error, Correction, and Uncertainty, Repeatability, Reproducibility, and Hysteresis, Sensitivity, Offset, and Dead Band, Resolution and Linearity, Statistical Characteristics, Error Modeling, Dynamic Characteristics, Dynamic Error and Dynamic Sensitivity, Input-Output Impedances., Historical Perspective, Current status, software based instruments.

Classification, Smart sensors , Cogent Sensors, Soft or Virtual sensors, Self-Adaptive Sensors, Self-Validating Sensors, Temperature Compensating Intelligent Sensors, Pressure Sensor, Indirect Sensing

UNIT – V

Instrumentation Amplifiers & Isolation Amplifiers: Specifications and use of instrumentation amplifiers for signal conditioning circuits using commercial ICs. Necessity for isolation amplifiers, industrial and medical applications of isolation amplifiers, Grounding and Shielding.

Text Books:

1. Measurement Systems -Application and Design, DOEBELIN, E.O., McGraw Hill, 4th Ed.1990
2. Electronic Instrumentation & Measurements - David A. Bell, PHI, 2nd Edition, 2003.
3. Manabendra Bhuyan, —Intelligent Instrumentation: Principles and Applications|| CRC Press,2011.

Reference Books:

1. Instrumentation Systems and Devices, Rangan, Mani, Sarma., Tata McGraw Hill. 2nd ed
2. Transducers and Instrumentation, Murthy, D.V.S.,PHI, New Delhi.

IV Year I Semester	QUANTUM SCIENCE AND TECHNOLOGY	L	T	P	C
		3	0	0	3

Prerequisites: Basic Physics, Linear Algebra, and Introduction to Modern Physics

Course Objectives:

1. To introduce fundamental concepts of quantum mechanics and its mathematical formalism.
2. To explore quantum computing and communication principles and technologies.
3. To understand the physical implementation and limitations of quantum systems.
4. To enable students to relate quantum theory to practical applications in computing, cryptography, and sensing.
5. To familiarize students with the emerging trends in quantum technologies.

Course Outcomes:

After completing this course, students will be able to:

CO1. Explain core principles of quantum mechanics and their technological implications.

CO2. Analyze quantum phenomena like superposition and entanglement.

CO3. Apply mathematical tools to model and solve quantum systems.

CO4. Demonstrate understanding of quantum algorithms and quantum circuits.

CO5. Evaluate potential applications and challenges in quantum communication and sensing.

Unit 1: Fundamentals of Quantum Mechanics: Historical background: Blackbody radiation, photoelectric effect, and Compton scattering; Dual nature of light and matter; De Broglie hypothesis; Schrödinger equation; Free particle, infinite potential well, step potential; Operators and observables: position, momentum, Hamiltonian; Commutation relations and uncertainty principle; Quantum postulates and measurement theory; Eigenvalues, eigenfunctions.

Unit 2: Quantum Information Theory: Classical vs. quantum information; Qubit representation using Bloch sphere; Quantum superposition and quantum entanglement; Dirac notation (bra-ket), tensor products, and composite systems; Bell states and EPR paradox; Quantum gates: Pauli-X, Y, Z; Hadamard; Phase; T; CNOT; Quantum circuit models and notation; Measurement in computational basis; Quantum teleportation and no-cloning theorem; Quantum state tomography (introductory)

Unit 3: Quantum Computing: Classical computing review and limitations; Quantum parallelism and interference; Deutsch and Deutsch-Jozsa algorithms; Grover's search algorithm, Oracle and amplitude amplification; Shor's factoring algorithm (overview and significance); Quantum Fourier Transform (QFT); Quantum error correction: Bit-flip, phase-flip, and Shor's 9-qubit code; Introduction to quantum programming: Qiskit, Cirq, IBM Quantum Experience (overview)

Unit 4: Quantum Communication: Introduction to quantum cryptography; Quantum key distribution (QKD): BB84 protocol; Entanglement-based QKD: Ekert protocol (E91); Eavesdropping and security of QKD; Quantum teleportation (circuit and protocol); Quantum

dense coding; Quantum networks and entanglement swapping; Role of quantum repeaters; Single-photon sources and detectors; Implementation challenges (loss, decoherence, noise)

Unit 5: Quantum Technologies and Applications: Quantum sensors: magnetometry, gravimetry; Quantum metrology: standard time, atomic clocks; Quantum imaging and lithography; Quantum materials: topological insulators, graphene, quantum dots; NV centers in diamonds for sensing; Hardware platforms: Superconducting qubits, Trapped ions, Photonic quantum processors; Quantum supremacy and NISQ era; Global initiatives: IBM, Google, D-Wave, IonQ, India's NQM; Ethical concerns and future prospects

Text Books:

1. **"Quantum Computation and Quantum Information"** by Michael A. Nielsen and Isaac L. Chuang
2. **"Quantum Mechanics: Concepts and Applications"** by Nouredine Zettili

Online Learning Resources:

1. <https://nptel.ac.in/courses/104104082>
2. <https://nptel.ac.in/courses/115104096>
3. <https://nptel.ac.in/courses/122106034>