CLASSICAL AND STATISTICAL MECHANICS

I - M.Sc(Physics) / I - Semester

Choice Based Credit System(CBCS)

- By
Prof. Y.C. Rathnakaran
Prof. S. Vijayabhaskar Rao
Department of Physics
Sri Venkateswara University

Tirupati-517502, Andhra Pradesh, India

Centre for Distance and Online Education

Sri Venkateswara University

Tirupathi, AP -517 502

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PAPER -I: CLASSICAL AND STATISTICAL MECHANICS

UNIT -1: LAGRANGIAN MECHANICS

Mechanics of a particle and system of particles, Conservation laws, Constraints and their classifications, Generalized coordinates, Principle of virtual work, D'Alembert's principle. Lagrange's equations: Lagrange's equations from D'Alembert's principle, Simple applications of Lagrange's equation: Linear Harmonic Oscillatory, Simple pendulum.

UNIT - II: HAMILTON'S PRINCIPLE

Hamilton's principle, Lagrange's equation from Hamilton's Principle, Extension of Hamilton's principles, Deduction of Lagrange's equation from Extended Hamilton's Principle.

UNIT - III: HAMILTONIAN MECHANICS

Legendre transformations, Generalized momentum and cyclic coordinates, Conservation theorems, Hamiltonian function, Hamiltonian equations of motion, Physical significance of Hamiltonian, Application of Hamiltonian Formulation: Linear Harmonic Oscillator, Simple pendulum.

UNIT - IV : CANONICAL TRANSFORMATIONS

Equation of Canonical Transformations, Generating functions, Examples of canonical transformations: the harmonic oscillator, 'Poisson and Lagrange brackets, Equations of motion in terms of Poisson brackets, Relationship between Angular momentum and Poisson brackets.

UNIT -V : HAMILTON-JACOBI THEORY

Hamilton-Jacobi equation, one dimensional harmonic oscillator, Physical significance of the Hamilton's characteristic function.

UNIT - VI: ENSEMBLES

Basic postulates of Statistical Mechanics, Phase space, probability, Density distribution in phase space, Liouville's theorem, Concept of Ensemble, Classification of Ensemble: Micro canonical, Canonical and Grand Canonical ensembles.

UNIT - VII: PARTITION FUNCTION

Partition functions for Micro canonical, Canonical and Grand canonical ensembles, Boltzman equipartition theorem, Partition functions for Translational, Rotational, Vibrational and Electronic energies. Maxwell - Boltzman statistics, Maxwell-Boltzman distribution of velocities.

UNIT - VIII: QUANTUM STATISTICS

Bose-Einstein statistics and its distribution: Bose-Einstein condensation, Thermodynamic properties of an ideal Bose-Einstein gas, Black body radiation, Femi-Dirac statistics: Fermi-Dirac distribution.

NOTES

ATOMIC PHYSICS, OPTICS AND ELCTROMAGNETIC THEORY

I - M.Sc(Physics) / I - Semester

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Prof. K. Vijaya Lakshmi
Prof. K.S. Reddy
Prof. Y.C. Rathnakaran
Department of Physics
Sri Venkateswara University

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PAPER -II: ATOMIC PHYSICS, OPTICS AND ELCTROMAGNETIC THEORY

UNIT-1: MANY ELECTRON ATOMS AND EXTERNAL FIELDS

Interaction energy and Spectral series of helium-Pauli's principle- LS coupling and Hand's rules, Lande's interval rule- Quantum theory of Zeeman and Paschen-Back effects- Distinguish between Normal Zeeman effect and Paschen-Back effects.

UNIT- II: ATOMIC ABSORPTION SPECTROSCOPY

Principle of Atomic Absorption Spectroscopy (AAS). Instrumentation- Atomic absorption spectrometers- Differences between atomic absorption and flame emission spectroscopy. Determination of lead in petrol.

UNIT- III: EMISSION SPECTROSCOPY

Line spectra of atoms and ions- Excitation and ionization potentials- Sample preparation: rocks and biological samples. Spectrographs : prism and grating spectrographs. Qualitative analysis: Raies-Ultimes lines. Quantitative analysis: Internal standard method.

UNIT-IV: LASERS

Einstein coefficients. Amplification in a medium and population inversion. Spatial and temporal coherence. The ruby laser, Helium-Neon laser, four level solid state laser. CO_2 laser, Dye laser, semiconductor laser.

UNIT-V: HOLOGRAPHY

Introduction to Holography: Basic theory of Holography , Recording and reconstruction of Hologram, Fourier transform Holography, Acoustic and Holographic Microscopy, Pattern recognition and Applications of Holography.

UNIT-VI: FOURIER OPTICS

Fringe contrast variation. Fourier Transformation spectroscopy. Michelson interferometer. Advantages of Fourier transforms. Optical data processing. Diffraction.1

UNIT-VII: FIBRE OPTICS

Optical fibres. Basic optical laws. Optical fibre modes, fibre types, rays and modes. Distinction between step index fibre and graded index fibre structures. Ray optics and wave representation. Attenuation in fibres. Absorption & scattering losses, radiation losses. Material dispersion. Fibre materials. Applications of fibre optics.

UNIT-VIII: ELECTROMAGNETIC THEORY

Maxwell's equations, Poynting theorem, Vector and scalar potentials. Maxwell's equations in homogenous medium. Propagation of electromagnetic waves in conducting medium. Propagation in isotropic dielectric medium. Electromagnetic radiation -Retarded potentials, Radiation from moving point charge and oscillating dipoles.

BOOKS FOR STUDY

1. Classical Electrodynamics, J.D. Jackson, wiley, New York, 2001.
2. Fibre Optic Communication, Keiser, Mc. Graw Hill, New York, 2003.
3. Introduction to Classical and Modern Optics, J.R. Meyer, Prentice Hall, Englewood, Cliffs, New Jersy,1972.

NOTES

CONDENSED MATTER PHYSICS, ELECTRONIC DEVICES AND CIRCUITS

I - M.Sc(Physics) / I - Semester

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Imperfections in Crystals

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Superconductivity

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Semiconductor Diodes

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Transistors And Microwave Devices

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Basics of Operational Amplifier

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Applications of Operational Amplifiers

PAPER III: CONDENSED MATTER PHYSICS, ELECTRONIC DEVICES AND CIRCUITS

UNIT-I: STRUCTURE OF CRYSTALS

Crystal systems, Bravias lattices, Miller indices, Relation between inter-planar spacing and lattice spacing, Reciprocal lattice and structural factorX-ray diffraction, Laue diffraction, Bragg's law. Powder diffraction-Experimental determination of structure of cubic crystals by powder diffraction technique-Bonding in crystals-Ionic, Covalent, and metallic Binding energy of ionic crystals

UNIT-II: TRANSPORT PHENOMENA AND BAND THEORY

Classical free electron theory, Expression for thermal nd electrical conductivities for metals, Lorentz number, Different scattering mechanisms- Mathieissen's rule, formulation of Boltzmann transport equation, Relaxation time approximation, Sommerfeld model-its consequences. Electron-lattice interaction(Quantitative only), Motion of electron in periodic potential, Bloch function, Kronig-Penny model, Formation of energy bands in solids, Concept of effective mass, Brillouion zones.

UNIT-III: IMPERFECTIONS IN CRYSTALS

Classification of imperfections- Point defects-Schottky and Frenkel defects-Expressions for equilibrium defect concentrations-Diffusion-Ionic conductivity in alkali halides-Kirkendall effect-Line defects-Dislocations-Edge and Screw dislocations-Estimation of dislocation densities-Role of dislocations in crystal growth-Frank-Reed mechanism of dislocation multiplication.

UNIT-IV: SUPERCONDUCTIVITY

Concept of zero resistance, Magnetic behavior, distinction between a perfect conductor and superconductor, Meissner effect-isotope effect-specific heat behavior, Two-fluid model. Expression for entropy difference between normal and superconducting states. London's equations-Penetration depth, BCS theory, Applications of superconductor High T_c superconductors (Basics only).

UNIT-V: SEMICONDUCTOR DIODES

p-n Junction diode-Equivalent Circuit, Diffusion capacitance, Reverse recovery time-Diode Applications: Half-wave rectifier, Full-wave rectifier, Bridge rectifier.

Special diodes: Zener diode, Varicap diode, Photodiode, Schottky diode, Tunnel diode, LED and Laser Diode

UNIT-VI: TRANSISTORS AND MICROWAVE DEVICES

Bipolar Junction Transistor (BJT), Field Effect Transistor, (n-channel, p-channel), Depletion and Enhancement MOSFETs, CMOS device, pnpn Devices: SCR, UJT. Microwave Devices: PIN, APD-Important applications.

UNIT-VII: BASICS OF OPERATIONAL AMPLIFIER

Block diagram of Op Amp 741, Characteristics of Op Amp: dc offset voltage, offset current, CMRR and slew rate. Experimental techniques to measure OpAmp characteristics, open and closed loop configurations. OpAmp configurations: Inverting and non-inverting amplifiers, Voltage and Current followers, Differential amplifier.

UNIT-VIII: APPLICATIONS OF OPERATIONAL AMPLIFIERS

Mathematical operations: Addition, Subtraction and Multiplication, Log and Antilog amplifiers, Sample and hold circuit, Integrator, Differentiator and Comparator circuit, Solving second-order differential equations using OpAmp. Waveform generators: Wein-bridge, Colpitts Oscillators, Astable Multivibrator

BOOKS FOR STUDY

1. Solid State Physics, C.Kittel, Wiley Publishers, 8th Edition, 2004.
2. Solid state Physics, A.J.Dekker, Macmillan India Ltd., 2000.
3. Elementary Solid State Physics, M.Ali Omar, Pearson Education, 2002.
4. High T_c Superconductivity, C.N.R.Rao and S.V.Subramanyam, World Scientific Publishing Co. Pvt. Ltd, 1991.
5. X-ray Diffraction, B.E.Warren, Addison Wesley, 1962.
6. Electronic Devices and Circuit theory, Boylstead and Nashelsky, PHI, 2002.
7. Electronic Devices and Circuits: An Introduction, Alien Mottershead, PHI, 2011
8. Operational Amplifiers and Linear Integrated circuits, R.F.Coughlin and F.F.Driscoll, PHI, 2008.
9. An Introduction to Operational Amplifiers and their Applications, S.V. Subramanyam and Y.Narasimha Murthy, Mac Millan Publishers, 2010.

Notes

MATHEMATICAL PHYSCIS

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PAPER -IV: MATHEMATICAL PHYSCIS

UNIT -1: TENSORS

Introduction: Notations and Conventions - The rank of a tensor - Contra-variant and Co-variant tensors - Tensor Algebra: addition, subtraction, contraction, inner product and outer product - Symmetric and anti-symmetric tensors - Applications of tensor: Stress, Strain, Piezo-electricity and elasticity tensors.

UNIT-II: GROUP THEORY

Isomorphism and Homomorphism - The group of symmetry of an equilateral triangle - Group of symmetry of a square - Representation of groups: Reducible and Irreducible representations — Character representation — Construction of character tables (C_{2v}, C_{3v}).

UNIT - III: PARTIAL DIFFERENTIAL EQUATIONS

Method of separation of variables - Equation of vibrating string - Solution of wave equation by D'Alembert's method - One dimensional heat flow - Two dimensional heat flow - Laplace equation in polar co-ordinates - Transmission line equation.

UNIT-IV : COMPLEX VARIABLES

Functions - Complex differentiation - Analytic function - Cauchy-Riemann equations - Derivatives of elementary function - Complex integration - Cauchy's theorem - Cauchy integral formula.

UNIT-V : SPECIAL FUNCTIONS

Definitions of beta and gamma functions and their properties - Different forms of beta and gamma functions - Relationship between beta and gamma functions.

UNIT-VI: DIFFERENTIAL EQUATIONS

Bessel's differential equations: Bessel's function of first and second kind (recurrence formula, generating function and orthogonality relations only) - Legendre's equations - Laguerre and Hermite polynomials (recurrence formulae, generating function and Rodrigue's formulae only).

UNIT-VII: FOURIER TRANSFORMS

Fourier Transforms: Fourier transforms and its inverse transform - Linearity and shifting properties - Fourier sine and cosine transforms - Convolution theorem and Deconvolution theorem.

QUANTUM MECHANICS

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Prof. S. Vijayabhaskar Rao
Department of Physics
Sri Venkateswara University
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PAPER - V: QUANTUM MECHANICS

UNIT-1: PRINCIPLES OF QUANTUM MECHANICS

Postulates of quantum mechanics-Operator formalism-Eigen values and Eigen vectors-Schrodinger equations: Development of the Schrodinger time independent and time dependent wave equations-Solution of the time dependent Schrodinger equation-Concept of stationary states.

UNIT- II: ONE DIMENSIONAL PROBLEMS AND SOLUTIONS

Potential step - Reflection and Transmission at the interface. - Potential well: Square well potential with rigid walls - Square well potential with finite walls - Potential barrier: Penetration of a potential barrier (tunneling effect) - Radioactive emission of alpha particle. Periodic potential - Harmonic oscillator.

UNIT- III: MATRIX FORMULATION

Matrix representation of wave functions - Linear operators - The concept of row and column matrices - Matrix algebra - Hermitian operators-Definition - Dirac's bra and ket notation - Expectation values - Heisenberg (operator) representation of harmonic oscillator - Ladder operators and their significance.

UNIT- IV : ANGULAR MOMENTUM

Angular momentum (AM) operators: Definition - Eigen functions and Eigen values of AM operators - Matrix representation of AM operators - System with spin half(l/2) - Spin angular momentum - Pauli's spin matrices - Clebsch-Gordon coefficients - Rigid Rotator.

UNIT-V : IDENTICAL PARTICLES AND MOLECULES

Identical Particles - Symmetric and anti-symmetric wave functions - Indistinguishability of identical particles - Pauli's exclusion principle - Hydrogen molecule ion - Hydrogen molecule - Concept of Ortho and Para Hydrogen.

UNIT-VI: APPROXIMATION METHODS

Time-independent perturbation method - Effect of anharmonicity on the solution of harmonic oscillator problem - Time-dependent perturbation theory - Fermi-Golden rule.

UNIT-VII: THEORY OF SCATTERING

The scattering experiment - The method of partial waves - Scattering by a central potential - Zero energy scattering - The Scattering length - Scattering by square-well potential - Effective range - Resonance scattering.

UNIT-VIII: RELATIVISTIC QUANTUM MECHANICS

Klein-Gordon equation - Probability and current densities - Dirac matrices - Dirac relativistic equation for free particles - Concept of negative energy states - Theory of holes.

NUCLEAR PHYSICS AND MOLECULAR SPECTROSCOPY

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Infrared and Raman Spectroscopy

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Basics of NMR & ESR Spectroscopy

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Basics of NQR & Mossbauer Spectroscopy

UNIT-I: INTRODUCTION TO NUCLEAR PHYSICS

Introduction to Nuclear properties-Radius, Mass, Packing fraction and binding energy, nuclear angular momentum, parity and symmetry, Magnetic dipole moment and electric quadrapole moment. Nuclear Two-Body problem: The Deuteron-Introduction, Simple theory of Deuteron, Spin dependence of Nuclear forces, Tensor forces. Meson theory of Nuclear forces.

UNIT-II: NUCLEAR MODELS AND NUCLEAR REACTIONS

Introduction, the nuclear shell or independent particle model, The liquid drop model and semi-empirical binding energy formula, the collective nuclear model. Reaction Dynamics: Q-equation, Cross sections for nuclear reactions, the compound nucleus, compound nucleus formation and break-up, Stripping and Photo-nuclear reactions

UNIT-III: ELEMENTARY PARTICLES

Stable particles against decay through nuclear forces-parameters: Mass, particles and anti-particles, strangeness, decay times. Conservation laws: Conservation of Baryons, Conservation of Strangeness, Conservation of parity and isotopic spin, Stable particles: Mass-less Bosons, Leptons, Mesons, Baryons.

UNIT-IV : PARTICLE DETECTORS AND ACCELERATORS

Particle detectors: Gas filled detectors, Solid state detectors, Scintillation counter, Nuclear Emulsions. High energy particle detectors, Cerenkov detectors. Bubble chamber and Cloud chamber. Particle accelerators: Ion sources, Direct current accelerators, The cyclotron. The linear accelerators, Betatron.

UNIT -V : DIATOMIC MOLECULAR SPECTRA

Born-oppenheimer approximation, Rotational spectra, Vibrational spectra, Electronic spectra, Vibrational isotope effect, Potential curves, Dissociation energies, Franck-Condon principle.

UNIT- VI: INFRARED AND RAMAN SPECTROSCOPY

Theory of IR, IR double beam spectrometer, Vibrations of polyatomic molecules, Analysis of IR spectra of thymidine and Hydrocarbons.

Raman Spectroscopy: Classical and quantum theories of Raman Effect, Laser Raman spectrometer, Raman spectra of CO_2, N_2O, SO_2. Differences between IR and Raman, Advantages of Raman spectroscopy over IR.

UNIT - VII: BASICS OF NMR & ESR SPECTROSCOPY

Theory of ESR spectroscopy, Instrumentation, Hyperfine splitting, Application to ESR spectra of Mn^{2+} and Cu^{2+} ions.

Theory of NMR spectroscopy, Instrumentation, Chemical shift and its origin, Spin-lattice and spin-spin relaxation, Applications to CH_3CHO and C_2H_5OH .

UNIT -VIII: BASICS OF NQR & MOSSBAUER SPECTROSCOPY

Theory of NQR spectroscopy, Instrumentation, Applications (brief details only): Structural information about group III halides, Charge transfer compounds. Recoil-less emission and absorption of γ rays, Mossbauer effect, Instrumentation, Applications to Mossbauer spectroscopy.

NUMERICAL TECHNIQUES & COMPUTER PROGRAMMING

I - M.Sc(Physics) / II- Semester
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PAPER VII: NUMERICAL TECHNIQUES & COMPUTER PROGRAMMING

UNIT -1: ROOTS OF EQUATION

Solution of algebraic and transcendental equations: Bisection method, Method of false position and Newton-Raphson method. Principle of least squares - fitting of polynomials.

UNIT-II: INTERPOLATION

Definition of Interpolation- Finite difference operation (forward, backward and central difference), Newton forward difference interpolation formula, Newton backward difference interpolation formula, Gauss's Central difference Interpolation formula, Lagrange's Interpolation formula and Inverse Interpolation.

UNIT - III: NUMERICAL DIFFERENTIATION & INTEGRATION

Numerical Differentiation: Cubic Spline Method, Maximum and minimum values of a tabulated function. Numerical Integration: Trapezoidal Rule, Simpson's 1/3 Rule and 3/8 Rule.

UNIT - IV : MATRICES AND LINER SYSTEM OF EQUATIONS

Introductions - Basic definitions- Matrix operations- Transpose of a matrix. Inverse of a Matrix - Rank of amatrix. Solutions of linear systems- Direct methods: Matrix Inversion method, Gaussian Elimination method, Modification of Gaussian Elimination method(Gauss-Jordan Method). Iterative methods: Jacobi method, Gauss Seidel method.

UNIT-V : NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS

Introduction, Solution by Taylor's series, Picard's method of successive approximations, Euler's method. Modified Euler's method.

Runge-Kutta method: Second order Runge-Kutta formula, and Runge-Kutta fourth order formula.

UNIT - VI: INTRODUCTION TO 'C' LANGUAGE

Character Set, C tokens, Key words and Identifiers, Constants and Variables, Data types, Declaration of variables. Operators and expressions: Arithmetic, Relational, Logical, Assignment, Increment and Decrement operators, Conditional, Bitwise and Special operators. Precedence in evaluating arithmetic operators. Reading and Writing a character. IF, IF-ELSE, Nesting IF-ELSE, ELSE IF ladder and GOTO statements, WHILE, DO, FOR loop statements. Simple programs.

UNIT - VII: PROGRAMMING IN 'C' LANGUAGE

Arrays: One and Two dimensional arrays, Declaring and initializing string variables.

Reading strings from terminal and writing strings to screen. User defined functions: Definition of functions, Return values and their types. Function calls and function declaration. Pointers: Declaring and initializing pointers, Accessing a variable through its

pointer. C- Programming: Linear regression, Sorting of numbers, Calculation of standard deviation and Matrix multiplication.

UNIT - VIII: PROGRAMMING IN C -NUMERICAL METHODS

Bisection method, Method of false position and Newton-Raphson method.

Numerical Integration: Trapezoidal Rule and Simpson's 1/3 Rule. Numerical solution of Differential equation: Runge-Kuuta method of order four.

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PAPER -VIII: DIGITAL ELECTRONICS, MICROPROCESSORS AND COMMUNICATION ELECTRONICS

UNIT -1: FUNDAMENTALS OF DIGITAL ELECTRONICS

Number systems and codes. Logic gates: AND, OR, NOT, NAND, NOR operation, Boolean algebra, De Morgan's laws, Karnaugh map, Multiplexer, Demultiplexer, 3-of-8 decoder and BCD-to-Seven Segment Decoder, Encoders, Binary addition, Subtraction, Half and Full adders, 4-bit Parallel adder, 2's Complement subtracter.

UNIT - II: FLIP-FLOPS, COUNTERS AND REGISTERS

Flip-Flops: NAND -Latch, RS, D and JK flip-flops.

Counters: Asynchronous(ripple)counters: 4-bit ripple counter,MOD-5 and decade Counters, Syncronous(parallel)counters: 4-bit parallel counter.

Registers: Shift register-Serial in / Serial out and Serial in/Parallel out, Ring Counter.

UNIT-III:DIGITAL-TO-ANALOG AND ANALOG-TO-DIGITAL CONVERTERS

Digital-to-Analog conversion: Variable Resistor network and R-2R ladder network, Accuracy and Resolution.Analog-to-Digital Conversion: Counter Method, Successive Approximation and Dual-slope techniques, Accuracy and Resolution.

UNIT - IV : INTEL 8085 MICROPROCESSOR

Introduction, Pin out configuration and signals, Functional Block diagram and explanation of blocks, Register architecture, De-multiplexing and generating Control signals. Instruction timing and execution - Basic timing, memory Read and memory write cycles. Memory, I/O and Interrupt Structures. Addressing Modes: Direct, Register, Register Indirect and immediate Addressing modes. Instruction format, Brief summary of Instruction Set. Simple Programs (Addition, Subtraction and Multiplication).

UNIT - V : BASICS OF PERIPHERAL DEVICES AND INTERFACING

Programmable Serial Interface 8251, Programmable Peripheral interface 8255, Programmable Interval Timer 8254, Keyboard/Display Controller 8279 and DMA Controller 8237.

UNIT - VI: REAL WORLD INTERFACING WITH 8085 MICROPROCESSOR

Interfacing 8085 based microcomputer with: Seven Segment Display, Stepper Motor, Digital - to - Analog Converter 1C DAC 0800, Analog - to- Digital Converter 1C ADC 0804.

UNIT - VII: ANALOG COMMUNICATIONS

Amplitude Modulation: Introduction, Amplitude modulation, Frequency Spectrum, coefficient of modulation, AM Voltage and Power Dissipation, AM Modulator Circuit, AM transmitter, AM Super-heterodyne receiver, AM Detector-Peak Detector. Single side band(SSB) Modulation: Principle, SSB Generation - Balanced Ring Modulator, comparison of SSB to Convertional AM. Angle Modulation: Frequency Modulation, Percentage Modulation, Frequency Spectrum, Power, FM Modulataor -

Varactor diode Modulator, FM Transmitter, FM receiver, FM demodulator - Balanced Slope Detector.

UNIT - VIII: DIGITAL COMMUNICATIONS

Shannon limit for information capacity, Digital Amplitude Modulation, Frequency Shift Keying, Phase Shift Keying, M-ary encoding, Quadrature Amplitude Modulation, Band Width efficiency, Carrier recovery, Differential Phase Shift Keying, Pulse Code Modulation.