



M D S UNIVERSITY, AJMER

M Sc (Physics) Syllabus

SEMESTER – I

PHY-DCC -01: Classical Mechanics

UNIT-I

Constraints-holonomic and non-holonomic constraints, Forces of constraints, Generalized coordinates and notations, Principle of virtual work, D'Alembert's Principle, Lagrange's Equation from D'Alembert's Principle, Lagrange's Equation for velocity dependent potentials, simple applications of Lagrangian formulation, Generalized momentum, Cyclic or ignorable coordinates, conservation theorems for generalized momentum, conservation theorems for energy, conservation theorems for Linear Momentum, conservation theorems for angular Momentum, Hamilton's Principle, Deduction of Hamilton's Principle, Derivation of Lagrange's equation from Hamilton's principle

UNIT-II

Hamiltonian Function and conservation of energy, Noether's theorem, Hamilton's Equations, conservation theorems and symmetry properties as a consequence of homogeneity of time and space and isotropy of space, Applications of Hamiltonians Equations, Euler-Lagrange's equations, Derivation of Hamilton's equations from Modified Hamilton's Principle, Principle of least action, Deduction of principle of least action, Extension of Hamilton's Principle for non-conservative and non-holonomic systems, Liouville's theorem

UNIT-III

Legendre transformation, Generating Function and Canonical transformation, Integral invariant of Poincare, Poisson brackets, properties of Poisson bracket, Hamilton's Canonical equation in terms of Poisson bracket, Lagrange's brackets, properties of Lagrange's bracket, Lagrange's and Poisson brackets as canonical invariants, Infinitesimal contact transformation and generators of symmetry, Hamilton-Jacobi equation and its application, theory of small oscillation in Lagrangian formulation, normal coordinates and its applications The Lagrangian and Hamiltonian of a particle in Relativistic Mechanics, Relativistic Lagrangian and Hamiltonian of a charged Particle in an Electromagnetic Field

Reference Books:

1. Classical Mechanics – Herbert Goldstein, Charles P. Poole Jr., and John L. Safko. Pearson Education, 2002.
2. Classical Mechanics – N. C. Rana and P. S. Joag. Tata McGraw-Hill Education, New Delhi.
3. Classical Mechanics – J. C. Upadhyaya. Himalaya Publishing House, Mumbai.
4. Classical Mechanics – S. P. Gupta, V. Kumar, and H. P. Sharma. Pragati Prakashan, Meerut

PHY-DCC-02: Electrodynamics

UNIT-I

Electrostatics: Electric field, Gauss Law, Differential form of Gaussian law. Another equation of electrostatics and the scalar potential, surface distribution of charges and dipoles and discontinuities in the electric field and potential, Poisson and Laplace equations, Green's Theorem, Uniqueness of the solution

with the Dirichlet or Neumann boundary Conditions, Formal Solutions of electro static Boundary value problem with Green's function, Electrostatic potential energy and energy density, capacitance. Boundary Value Problems in Electrostatics: Methods of Images, point charge near a grounded conducting plane, point charge in the presence of a grounded conducting sphere, point charge in the presence of a charged insulated conducting sphere, point charge near a conducting sphere at a fixed potential, conducting sphere in a uniform electric field by method of images

UNIT-II

Multipoles, electrostatics of Macroscopic Media Dielectric: Multipole expansion, multipole expansion of the energy of a charge distribution in an external field, Elementary treatment of electrostatics with permeable media. Boundary value problems with dielectrics, Molar polarizability and electric susceptibility, Models for molecular polarizability, electrostatic energy in dielectric media

Magnetostatics: Introduction and definition, Biot and Savart Law, the differential equations of magnetostatics and Ampere's law, Vector potential and magnetic induction for a current loop, Magnetic fields of a localized current distribution: Magnetic moment, Force, torque and potential energy of a localized current distribution in an external

magnetic induction, Macroscopic equations, Boundary conditions on B and H. Methods of solving Boundary value Problems in magnetostatics, uniformly magnetized sphere, magnetized sphere in an external field, permanent magnets, magnetic shielding, spherical shell of permeable material in a uniform field

UNIT-III

Time varying fields: Faraday's Law of induction, Maxwell's displacement current, Maxwell's equations; vector and scalar potentials, Gauge

transformations, Lorentz gauge, Coulomb gauge, Electromagnetic waves in vacuum: The wave equation for E and B, Energy and momentum in Electromagnetic waves, Green function for the wave equation, Poynting's Theorem and conservation of energy and momentum for a system of charged particles and EM fields

Reference Books:

1. Classical Electrodynamics – John David Jackson. John Wiley & Sons.
2. Classical Electricity and Magnetism – Wolfgang K. H. Panofsky and Melba Phillips. Addison-Wesley.
3. Introduction to Electrodynamics – David J. Griffiths. Pearson Education.
4. The Classical Theory of Fields – Lev D. Landau and Evgeny M. Lifshitz. Butterworth-Heinemann (Course of Theoretical Physics, Vol. 2).
5. Electrodynamics of Continuous Media – Lev D. Landau and Evgeny M. Lifshitz. Butterworth-Heinemann (Course of Theoretical Physics, Vol. 8).

PHY-DCC-03: Quantum Mechanics

UNIT-I

Origins of Quantum Physics: inadequacy of classical mechanics, Particles versus Waves, Complementarity, Principle of Linear Superposition, Indeterministic Nature of the Microphysical World

Mathematical Tools of Quantum Mechanics :The Hilbert Space and Wave Functions, Dimension and Basis of a Vector Space , Dirac Notation ,Operators ,Hermitian Adjoint ,Projection Operators , Commutator Algebra, Uncertainty Relation between Two Operators ,Functions of Operators ,Inverse and Unitary Operators ,Eigen values and Eigenvectors of an Operator ,Infinitesimal and Finite Unitary Transformations ,Representation in Discrete Bases ,Matrix Representation of Kets, Bras, and Operators ,Change

of Bases and Unitary Transformations ,Matrix Representation of the Eigen value Problem ,Representation in Continuous Bases, Position Representation, Momentum Representation, Connecting the Position and Momentum Representations, Parity Operator, Matrix and Wave Mechanics

UNIT-II

Postulates of Quantum Mechanics: The State of a System, Probability Density, The Superposition Principle, Observables and Operators, Measurement in Quantum Mechanics, Expectation Values, Complete Sets of Commuting Operators, Measurement and the Uncertainty Relations, Time Evolution Operator, Stationary States: Time-Independent Potentials, Time Evolution of Expectation Values.

Angular Momentum: Orbital Angular Momentum, General Formalism of Angular Momentum, Matrix Representation of Angular Momentum, Geometrical Representation of Angular Momentum, Spin Angular Momentum, Experimental Evidence of the Spin, General Theory of Spin, Spin $1/2$ and the Pauli Matrices, Eigen functions of Orbital Angular Momentum

Addition of Angular Momenta: Addition of Two Angular Momenta-General Formalism, Calculation of the Clebsch–Gordan Coefficients.

UNIT-III

Three-Dimensional Problems: 3D Problems in Cartesian Coordinates, The Harmonic Oscillator, 3D Problems in Spherical Coordinates, Central Potential: General Treatment, The Spherical Square Well Potential, The Isotropic Harmonic Oscillator,

Identical Particles: Many-Particle Systems, Interchange Symmetry, Systems of Distinguishable Non interacting Particles, Systems of Identical Particles, Exchange Degeneracy, Symmetrization Postulate, Constructing Symmetric and Anti-symmetric Functions, System of Identical Non-interacting Particles, The Pauli Exclusion Principle.

Reference Books:

1. Quantum Mechanics: Concepts and Applications – Nouredine Zettili. John Wiley & Sons.
2. Mechanics: A Modern Approach – Ashok Das and A. C. Melissinos. Gordon and Breach Science Publishers.
3. Quantum Mechanics (2nd Edition) – Eugen Merzbacher. John Wiley & Sons.
4. Modern Quantum Mechanics – J. J. Sakurai and Jim Napolitano. Cambridge University Press.

PHY-DCC-04: Mathematical Methods in Physics**UNIT-I**

Orthogonal curvilinear coordinates, scale factors, expressions for gradient, divergence and curl and their applications to Cartesian, cylindrical and spherical polar coordinate system,

Coordinate transformation, transformation of covariant, contra variant and mixed tensors, Addition, multiplication and contraction of tensors, quotient Law, pseudo tensors, Metric tensors and its use in transformation of Tensors

UNIT-II

Vector spaces and Matrices: Linear independence, Bases; Dimensionality, Inner product, Linear transformation, Matrices, Inverse orthogonal and unitary matrices, independent elements of a matrix, Eigen values and Eigen matrix; Diagonalization: complete orthonormal sets of functions

Differential equations and special functions: Second order linear differential equation with variable coefficients, solution by series expansion, Legendre, Bessel, Hermite and Laguerre equations, physical application, generating function, recurrence relations

UNIT-III

Integral transforms: Laplace transform, First and second shifting theorems, inverse L T by partial fractions; LT derivative and integral of a function; Fourier series: FS of arbitrary period; half wave expansion; Partial sums; Fourier integral and transforms, FT of a delta function.

Reference books:

1. Mathematical Methods for Physicists – George B. Arfken and Hans J. Weber. Academic Press.
2. Elements of Group Theory for Physicists – A. W. Joshi. New Age International Publishers.
3. Mathematical Physics – Satya Prakash. Sultan Chand & Sons.
4. Mathematical Physics – B. S. Rajput. Pragati Prakashan, Meerut.

PHY-DCC-05: OPTICS AND GENERAL PHYSICS LAB

1. To use a Michelson Interferometer to determine:
 - (I) the wave length of sodium yellow light
 - (II) The difference between the wave lengths of the two sodium D-lines.
 - (III) The thickness of a mica sheet.
2. To test the validity of Hartmann's prism dispersion formula using the visible region of the mercury spectrum.
3. To find the refractive index of air by means of a Fabry-Perot Etalon, the thickness between the plates being given.
4. Determination of wave length of Neon light taking Hg source as a standard source applying Hartmann formula.
5. Determine Stefan's constant.

6. Determination of Ionization potential of Lithium.
7. Determination of e/m of electron by Normal Zeeman Effect.
8. Determination of dissociation energy of Iodine (I) molecules by photography, the absorption band of I in the visible region.
9. Using He-Ne laser light.
 - (I) Measure of wavelength with the help of a ruler.
 - (II) Measure the thickness of the wire.
10. Testing goodness of fit of Poisson distribution to cosmic ray bursts by Chi-square test.

Any other Experiments of the equivalent standard can be set

SEMESTER - II

PHY-DCC-06: STATISTICAL MECHANICS

UNIT- I

Introduction to statistical mechanics, connection between statistical and thermodynamics quantities, Phase space, trajectories and density of states, Liouville's Theorem, Microstates and macrostates, statistical ensemble: Microcanonical, canonical, and grand Canonical ensemble; equation of states, specific heat and Entropy of a gas using microcanonical ensemble; thermodynamics function for canonical ensemble, calculation of mean values, energy fluctuations in a gas using grand canonical ensemble, thermodynamic functions for the grand canonical ensemble, and density and energy fluctuations

UNIT-II

Classical Ideal gas, Entropy of mixing and Gibb's paradox, Partition functions and Statistics: Partition functions and properties, partition function for an ideal Gas and calculation of thermodynamic quantities, validity of classical approximation, Determination of translational, rotational and vibration contributions to the partition function of an Ideal diatomic gas. Specific heat of a diatomic gas, Ortho and Para hydrogen

UNIT-III

Quantum statistics: Identical particles and symmetry requirements, difficulties with Maxwell-Boltzmann statistics, quantum distribution functions, Boson: occupation number, Bose-Einstein statistics, Blackbody radiations, Planck's radiation formula, Bose-Einstein condensation, liquid He⁴ as a bosonic system, Fermions: occupation number, Fermi-Dirac statistics, degenerate Fermi gas, Phase Transition: First order and second order phase Transition, One dimensional Ising Model

Reference Books:

1. Statistical Mechanics – R. K. Pathria and Paul D. Beale. Academic Press.
2. Statistical Mechanics – Kerson Huang. John Wiley & Sons.
3. Fundamentals of Statistical and Thermal Physics – Frederick Reif. McGraw-Hill.
4. Statistical Mechanics and Thermal Physics – Stephen A. Rice. W. H. Freeman & Company.
5. Elementary Statistical Physics – Charles Kittel. John Wiley & Sons.

PHY-DCC-07: Atomic and Molecular Physics

UNIT-I

Pauli exclusion principle and atomic structure, Identical particles, exchange Symmetry of wave functions, Magnetic dipole moments, Space quantization, Electron spin and vector atom Model, Spin-Orbit interaction: Hydrogen fine structure, General features of the spectra of one and two electron system – singlet, doublet and triplet characters of emission spectra, general features of alkali spectra, Spectroscopic terms : Terminology, L-S Coupling, Lande's Interval rule, Normal and inverted Multiplets, Determination of spectroscopic terms for L-S couplings, Order of Terms and fine Structure Levels, selection rules for Multi electron atoms in L-S coupling

Determination of spectroscopic terms for J-J coupling, selection rules in J-J coupling

UNIT-II

Zeeman, Paschen-Back and Stark effects, examples of Zeeman effect in some Transitions, hyperfine structure of spectral lines, Isotope effect, The Breadth of spectral lines

Molecular Structure and Bonding: Born-Oppenheimer Approximation, Molecular Orbital Theory, Electronic States of Diatomic Molecules, Pure Rotational spectra, Vibrational Rotational Spectra

UNIT-III

Raman Spectra: Raman effect, classical theory of Raman effect, quantum theory of Raman effect, Stokes and Anti-Stokes lines, Raman shift, rotational and vibrational Raman spectra, Raman selection rules, Raman-active and infrared-active vibrations, factors affecting Raman intensity, applications of Raman spectroscopy in molecular structure determination, Electronic spectra, Born-Oppenheimer approximation, Vibrational coarse structure,

Franck-Condon principle, Rotational fine structure of electronic-vibration transitions, Electron spin and nuclear magnetic resonance spectroscopy

Reference Books:

1. Atomic and Molecular Spectroscopy – G. Banwell and E. M. McCash. McGraw-Hill.
2. Atomic and Molecular Physics – Ashok Das and A. C. Melissinos. Gordon and Breach Science Publishers.
3. Atomic and Molecular Physics – Raj Kumar. Krishna Prakashan Media.
4. Atomic and Molecular Physics – R. Murugesan and K. Sivaprasath. S. Chand & Company Ltd.
5. Atomic and Molecular Physics – S. N. Ghoshal. S. Chand & Company Ltd.

PHY-DCC - 08: ANALOG ELECTRONICS

UNIT-I

Differential amplifier: circuit configurations, dual-input balanced output differential amplifier, DC and AC analysis, inverting and non-inverting inputs, CMRR, constant current source/current mirror biasing, level translator, frequency response. Operational amplifier: block diagram, internal architecture, open-loop and closed-loop characteristics, inverting and non-inverting amplifiers, voltage follower, summing amplifier, difference amplifier, integrator, and differentiator, Practical OP-Amp: input offset voltage, input bias current, input offset current, output offset voltage, slew rate, gain-bandwidth product, CMRR, PSRR, Feedback amplifiers: voltage-series feedback, effect of feedback on gain, bandwidth, input/output resistance and stability. Instrumentation amplifier, impedance matching, signal conditioning, noise reduction, shielding and grounding

UNIT-II

Wave Shaping Circuits and Semiconductor Devices Wave shaping circuits: clippers, clampers, precision rectifiers, comparators, Schmitt trigger, window comparator and zero-crossing detector, Multivibrators : Astable, Monostable and Bistable multivibrators, square-wave and triangle-wave generators, IC 555 timer and applications, Advanced semiconductor devices: Zener, Schottky, Tunnel, PIN, Varactor and Avalanche diodes, metal-semiconductor junctions, Ohmic and rectifying contacts, heterojunction devices and high-frequency semiconductor devices, Field-effect devices: JFET, MOSFET, CMOS fundamentals and applications

UNIT-III

Optoelectronics, Data Acquisition and Experimental Electronics Optoelectronic devices: LED, laser diode, photodiode, phototransistor, solar cell and optical detectors, Analog-to-digital and digital-to-analog conversion: sampling theorem, sample-and-hold circuit, ADC and DAC principles, flash and successive approximation ADCs, resolution, accuracy and quantization error, Experimental data analysis: precision and accuracy, error analysis, propagation of errors, least-square fitting, linear and nonlinear curve fitting and chi-square test. Sensors and transducers: temperature, pressure, magnetic, optical, vibration and particle detectors. Measurement techniques: signal conditioning, Fourier transform, lock-in amplifier, box-car integrator, high-frequency generators and detectors

Reference Books:

1. Electronic Devices and Circuit Theory – Robert L. Boylestad and Louis Nashelsky. Pearson Education.
2. Microelectronic Circuits – Adel S. Sedra and Kenneth C. Smith. Oxford University Press.

3. Semiconductor Physics and Devices – Donald A. Neamen. McGraw-Hill.
4. Integrated Electronics: Analog and Digital Circuits and Systems – Jacob Millman and Christos C. Halkias. McGraw-Hill.
5. Op-Amps and Linear Integrated Circuits – Ramakant A. Gayakwad. Pearson Education.

PHY-DSE/GEC-01A: Numerical methods and Computer Programming

UNIT-I

Errors-Sources of errors, absolute, relative and percentage errors, Significant figures, Truncation and round-off errors, Error propagation, Solutions of algebraic and transcendental equations-Bisection method, Regula falsi method, fixed point iteration, Secant method

UNIT-II

Interpolation-Finite differences, Newton's forward Interpolation formula, Newton's backward Interpolation formula, Lagrange's Interpolation, Inverse Interpolation

Numerical differentiation-Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Runge Kutta Method

UNIT-III

Introduction to Python, Variables and data types, Input and output, Comments and documentation

Operators and Expressions-Arithmetic operators, Comparison operators, Logical operators, Assignment operators

Control statements-If, elif, else Nested conditions, for loop, while loop, Break, continue, pass, Data Structures-Strings, Lists, Sets, Functions-Parameters and arguments, return statement, recursion, Lambda functions and scope of variables, File handling-Reading files, writing files, Appending files

Reference Books:

1. A First Course in Numerical Analysis – A. Ralston and P. Rabinowitz. McGraw-Hill, 1985.
2. Computer Oriented Numerical Methods – V. Rajaraman. Prentice-Hall of India.
3. Introductory Methods of Numerical Analysis – S. S. Sastry. Prentice-Hall of India, 1979.
4. Python Programming: Using Problem Solving Approach – Reema Thareja. Oxford University Press.
5. Python Programming – R. Nageswara Rao. Dreamtech Press.

PHY-DSE/GEC-01B: ENERGY STUDIES**UNIT-I**

Solar Energy: Fundamentals of photovoltaic energy Conversion, p-n junction, photovoltaic cell, solar cell equivalent circuit, fill factor, efficiency, power curve, maximum power point, effect of irradiation and temperature on solar cell outputs, factors responsible for optical, recombination and ohmic losses, techniques and measures for minimization of losses, solar module, series and parallel combination, Brief descriptions of single crystal silicon solar cells and amorphous silicon solar cells, elementary ideas of advanced solar cells e.g., Tandem Solar Cells, solid-Liquid Junction Solar Cells

Photovoltaic applications: Battery chargers, domestic lighting, street lighting and water pumping

UNIT-II

Hydrogen Energy: Relevance in depletion of fossil fuels and environmental considerations

Hydrogen Production: Solar Hydrogen through Photo electrolysis and Photo catalytic process, Physics and material characteristics for production of Solar Hydrogen

UNIT-III

Safety and Utilization of Hydrogen: Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Elementary concepts of other Hydrogen Based devices such as Air Conditioners and Hydride Batteries. Other Renewable Clean Energies: Elements of Solar Thermal Energy, Wind Energy and Ocean Thermal Energy Conversion

Reference Books:

1. Solar Photovoltaics: Fundamentals, Technologies and Applications – C. S. Solanki. PHI Learning Pvt. Ltd.
2. Fundamentals of Renewable Energy Sources – G. N. Tiwari and M. K. Ghosal. Alpha Science International.
3. Renewable Energy: Engineering and Technology – S. P. Sukhatme and J. K. Nayak. Oxford University Press.
4. Non-Conventional Energy Resources – B. H. Khan. McGraw-Hill

PHY-DCC-09: CONDENSED MATTER AND COMPUTATIONAL PHYSICS LAB

1. To determine the Curie temperature for the given sample (BaTiO_3) of ferroelectric material
2. To determine the e/k ratio using a power transistor

3. Find out the first excitation potential of an argon atom and demonstrate the physical contribution of the atom
4. Study the electro optic effect and calculate the value of the half wave voltage
5. Study of Hall Effect in semiconductor to determine hall voltage, hall coefficient, the number of charge carriers per unit volume, hall angle and mobility of semiconductor
6. To determine e/m the specific charge of an electron by magnetization
7. To study Faraday Effect with He –Ne laser and determine verdet constant
8. To study dispersion relation for the mono atomic and diatomic lattice
9. To determine unknown source energy using gamma ray spectroscopy
10. To study the electron spin resonance (ESR) in DPPH
11. To determine velocity of ultrasonic waves in distilled water
12. To determine e/m for an electron by Zeeman effect
13. Find out the energy of a given γ -ray source with the help of a scintillation spectrometer
14. Plot the Gaussian distribution curve for a radioactive source
15. To determine the magnetic susceptibility of two given samples by Gouy's method
16. Determination of Lande's 'g' factor for IRRH crystal using electron spin resonance spectrometer
17. Programming Exercises in PYTHON
18. Simple Programming Exercises based on assembly language for microprocessor 8085

Any other Experiments of the equivalent standard can be set

SEMESTER III

PHY-DCC -10: NUCLEAR PHYSICS

UNIT-I

Two Nucleon system and nuclear forces: General nature of the force between nucleons, saturation of nuclear forces, charge independence and spin dependence, General forms of two nucleon interaction, Central, non-central and velocity dependent potential, Analysis of the ground state ($^3S_1$) of deuteron using a square well potential, range-depth relationship, Discussion of the ground state of deuteron under non-central force, D-state admixture. Nucleon-Nucleon Scattering and Potentials: partial wave analysis of the neutron-proton scattering at low energy assuming central potential with square well shape, concept of the scattering length, coherent scattering of neutrons by protons in (Ortho and para) hydrogen molecule; the effective range theory (in neutron-proton scattering) and the shape independence of nuclear potential

UNIT-II

A qualitative discussion of proton-proton scattering at low energy; General features of two-body scattering at high energy, effect of exchange forces Interaction of radiation and charged particle with matter (Not derivation) : Law of absorption and attenuation coefficient photoelectric effect, Compton, scattering, pair production, Energy loss of charged particles due to ionization, Bremsstrahlung, energy target and projectile dependence of all three processes, Range-energy curves; Straggling

UNIT-III

Experimental Techniques: Gas filled counters; Scintillation counter; Cerenkov counters; Solid state detectors; Surface barrier detectors, multi-wire proportion chambers; Nuclear emulsions, techniques of measurement and analysis of tracks; Proton synchrotron; Linear accelerators

Reference Books:

1. Nuclear Physics – R. R. Roy and B. P. Nigam. New Age International Publishers.
2. Nuclear Physics – D. C. Tayal. Himalaya Publishing House.
3. Nuclear Physics – S. N. Ghoshal. S. Chand & Company Ltd.
4. Radiation Detection and Measurement – Glenn F. Knoll. John Wiley & Sons.
5. Techniques for Nuclear and Particle Physics Experiments – William R. Leo. Springer.

PHY-DCC -11: SOLID STATE PHYSICS

UNIT-I

Crystal Structure and Diffraction: Crystal systems and Bravais lattices; unit cell and symmetry elements; Miller indices; crystal planes and directions; simple, body-centered and face-centered cubic structures; reciprocal lattice; concept of reciprocal space; X-ray diffraction and Bragg's law; Laue and powder diffraction methods; atomic and crystal structure factors; determination of crystal structures; defects in crystals: point, line and planar defects; dislocations and their effects on physical properties

UNIT-II

Lattice Dynamics and Thermal Properties: Lattice vibrations in monoatomic and diatomic lattices; harmonic approximation; normal modes of vibration; acoustic and optical phonon branches; quantization of lattice vibrations and phonons; Einstein and Debye theories of specific heat; density of phonon states; thermal expansion; thermal conductivity; phonon scattering and

Umklapp processes; anharmonic effects; electron-phonon interaction; basic concepts of thermal properties of crystalline solids

UNIT-III

Electronic Properties of Solids: Classical free electron theory and Sommerfeld quantum theory; electrical and thermal conductivity; Hall effect and magnetoresistance; energy bands in solids; Bloch theorem; nearly free electron model; Kronig-Penney model; tight-binding approximation; effective mass of electrons; density of states; Fermi energy and Fermi surface; classification of metals, insulators and semiconductors; intrinsic and extrinsic semiconductors; carrier concentration and mobility; p-n junction and basic semiconductor devices.

Reference Books:

1. Solid State Physics – S. O. Pillai. New Age International Publishers.
2. Solid State Physics – R. L. Singhal. Kedar Nath Ram Nath Publishers.
3. Solid State Physics – M. A. Wahab. Narosa Publishing House.
4. Introduction to Solid State Physics – Charles Kittel. John Wiley & Sons.
5. Introduction to Solid State Physics – J. P. Srivastava. Prentice-Hall of India.

PHY-DSE-02A: ADVANCED-ELECTRODYNAMICS

UNIT-I

Plane Electromagnetic Waves and Wave Equation: Plane wave in a non-conducting medium. Frequency dispersion characteristics of dielectrics, conductors and plasma, waves in a conducting or dissipative medium, superposition of waves in one dimension, group velocity, casualty connection between D and E. Kramers- Kroning relation

UNIT-II

Covariant Form of Electro-dynamic Equations: Mathematical properties of the space-time special relativity, Invariance of electric charge covariance of electrodynamics Transformation of electromagnetic field. Radiation by moving charges: Lienard- Wiechert, Potential for a point charge, Total power radiated by an accelerated charge: Larmour's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary extremely relativistic motion. Distribution in frequency and angle of energy radiated by accelerated charges, Thomson scattering and radiation, Scattering by quasi-free charges, coherent and incoherent scattering, Cerenkov radiation

UNIT-III

Radiation damping, self-fields of a particle, scattering and absorption of radiation by a bound system; Introductory considerations, Radiative reaction force from conservation of energy, Abraham Lorentz evaluation of the self-force, difficulties with Abraham Lorentz model, Integro-differential equation of motion including radiation damping, Line Breadth and level shift of an oscillator, Scattering and absorption of radiation by an oscillator, Energy transfer to a harmonically bound charge

Reference Books:

1. Classical Electrodynamics – J. D. Jackson. John Wiley & Sons.
2. Classical Electricity and Magnetism – W. K. H. Panofsky and M. Phillips. Addison-Wesley.
3. Introduction to Electrodynamics – David J. Griffiths. Pearson Education.
4. The Classical Theory of Fields – L. D. Landau and E. M. Lifshitz. Butterworth-Heinemann.

PHY-DSE-02B: DIGITAL-ELECTRONICS

UNIT-I

Combinational Logic Design

Boolean algebra, canonical forms, standard representation of logic functions, Karnaugh map, don't-care-conditions and Quine-McCluskey method, Combinational circuits: half and full adders, half and full subtractors, comparators, multiplexers, demultiplexers, encoders, priority encoders, decoders, code converters, parity generators/checkers and arithmetic logic unit (ALU)

UNIT-II

Sequential Logic Design

Flip-flops: RS, JK, Master-Slave JK, D and T flip-flops. Registers: shift registers and universal shift registers, Counters: Ripple synchronous, asynchronous, ring, Johnson and Mod-N counters. Sequential circuit design: state tables, state diagrams, Moore and Mealy machines. Memory devices: RAM, ROM, PROM, EPROM, EEPROM and Flash memory

UNIT-III

Microprocessors, Microcontrollers and Digital Interfacing

Microprocessor fundamentals: architecture, instruction cycle, memory organization, addressing modes and interrupts. 8085 microprocessors: architecture, programming concepts and interfacing

Microcontroller fundamentals: 8051 architecture, timers, interrupts and serial communication. Digital interfacing: ADC/DAC interfacing, UART, SPI and I²C. Embedded systems: basic architecture, sensor interfacing and data acquisition systems

Reference Books:

1. Digital Design – M. Morris Mano and Michael D. Ciletti. Pearson Education.
2. Digital Principles and Applications – A. P. Malvino and Donald P. Leach. McGraw-Hill.
3. Digital Fundamentals – Thomas L. Floyd. Pearson Education.
4. Microprocessors and Interfacing: Programming and Hardware – Douglas V. Hall. McGraw-Hill.
5. Modern Digital Electronics – R. P. Jain. McGraw-Hill Education.

PHY-DSE-03A: MICROWAVE ELECTRONICS

UNIT-I

Introduction to microwaves and its frequency spectrum, Application of microwaves, Wave Guides: Rectangular wave guides: Wave Equation and its solutions, TE and TM modes, Dominant mode and choice of wave guide dimensions

Circular wave guide: Wave equation and its solutions, TE, TM and TEM modes

Attenuation: Cause of attenuation in wave guides, wall current, derivation of attenuation constant, Q of the wave guide

UNIT-II

Microwave Devices (Overview and Basic Principle of the Following): Klystrons, Magnetrons and Travelling Wave Tubes, velocity Modulation, Basic principles of Two-Cavity Klystrons and Reflex Klystrons

Transferred Electron Devices, Gunn Effect, Read Diode, IMPATT Diode, TRAPATT Diode

UNIT-III

Microwave Communications: Advantages and disadvantages of microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on propagation

Satellite Communications: Orbital satellites, Geostationary satellites, Orbital patterns, Look angles, Orbital spacing, Satellite systems

Reference Books:

1. Introduction to Microwave Theory – Atwater. McGraw-Hill.
2. Microwaves – M. L. Sisodia and Vijay Laxmi Gupta. New Age International Publishers.
3. Microwave Principles – H. J. Reich. D. Van Nostrand Company.
4. Microwave and Radar Engineering – Vinita Chauhan. Khanna Publishers.

PHY-DSE- 03B: SOLID STATE ELECTRONICS

UNIT- I

Semiconductor Junction and Field-Effect Devices:PNPN structures: PNPN and NPNP devices Silicon Controlled Rectifier (SCR): construction, working, V–I characteristics, triggering, turn-on and turn-off mechanisms, applications DIAC and TRIAC: construction, operation, characteristics and applications Gate Turn-Off Thyristor (GTO): principle of operation, characteristics and applications Light Activated Silicon Controlled Rectifier (LASCR): construction, operation and applications, Schottky junction: formation, barrier height, thermionic emission and I–V characteristics

UNIT- II

Microwave and High-Frequency Semiconductor Devices:High-frequency limitations of conventional semiconductor devices Transit-time devices: basic concepts and principles IMPATT diode: structure, avalanche transit-time mechanism, negative resistance, characteristics and microwave applications TRAPATT diode: principle of operation, avalanche plasma formation, characteristics and applications Gunn diode: transferred electron effect, negative differential resistance, domain formation, V–I characteristics and microwave applications Tunnel diode: quantum tunneling, negative differential resistance, characteristics and applications, Avalanche diode: avalanche multiplication, breakdown mechanism and high-frequency applications

UNIT- III

Superconducting, Mesoscopic and Quantum Devices:SQUID: DC and RF SQUID, operating principle and magnetic-field detection, Applications of SQUIDs in precision measurements and quantum technologies, Quantum confinement and low-dimensional semiconductor structures, Quantum dots: density of states, fabrication, electronic properties and applications, Quantum wires: confinement, energy levels and transport properties, Single Electron Transistor (SET): Coulomb blockade, charging energy, operation, characteristics and applications, Comparison of conventional and quantum electronic devices , Basic principles of quantum cascade lasers, Construction and working of QCL, Population inversion and optical transitions, Characteristics, advantages and applications of Quantum Cascade Lasers

Reference Books:

1. Semiconductor Physics – K. Seeger. Springer-Verlag.
2. Solid State and Semiconductor Physics – John P. McKelvey. Harper & Row.
3. Semiconductor Devices and Integrated Electronics – A. G. Milnes. Van Nostrand.

4. Physics of Semiconductor Devices – S. M. Sze. John Wiley & Sons.
5. VLSI Technology – S. M. Sze. McGraw-Hill.

PHY-DCC -12: ANALOG AND DIGITAL ELECTRONICS LAB

1. To draw characteristics of a UJT and study the waveform of a relaxation oscillator using UJT
2. To study amplitude modulation and demodulation and calculate percentage modulation index
3. To study the operation of the following flip-flop using discrete gates (i) RS flip-flop using NAND gates (ii) Clocked RS flip-flop using NAND gates
4. To study the operation of the following flip-flops using IC7476 (+ve edged triggered JK flip-flops) (i) JK flip-flop (ii) D flip-flop (iii) T flip-flop
5. To study an astable multivibrator with reference to output voltage terminals (collector base with respect to emitter) and measure frequency of output waveform
6. To study BCD to 7-segment binary to gray code, decimal to BCD, BCD to decimal encoder-decoder circuits
7. To study clipping and clamping circuits using diodes, R and C and also study various levels of clipping and clamping
8. To study a 4-bit ripple up counter, down counter and Modulo-counter
9. To study and design various combinatorial circuits namely Half Adder and Half subtractor, Multiplexer and demultiplexer
10. Design of a Regulated Power supply
11. Design of a Common Emitter Transistor Amplifier
12. Characteristics and applications of Silicon Controlled Rectifier
13. Experiment on FET and MOSFET characterization and application as an amplifier

14. Experiment on Uni-junction Transistor and its application
15. To study Basic Logic Gates, TTL, NAND and NOR
16. To study Combinational logic

Any other Experiments of the equivalent standard can be set

SEMESTER – IV

PHY-DCC-13: ADVANCED QUANTUM MECHANICS

UNIT- I

Approximation Methods for Stationary States: Time-Independent Perturbation Theory, Non-degenerate Perturbation Theory, Degenerate Perturbation Theory, The Variational Method, The Wentzel-Kramers-Brillouin Method, General Formalism, Bound States for Potential Wells with No Rigid Walls, Bound States for Potential Wells with One Rigid Wall, Bound States for Potential Wells with Two Rigid Walls, Tunnelling through a Potential Barrier, Time-Dependent Perturbation Theory: The Schrödinger, Heisenberg and Interaction Picture, Time-Dependent Perturbation Theory, Transition Probability for a Constant and Harmonic Perturbation, Adiabatic and Sudden Approximations

UNIT-II

Interaction of Atoms with Radiation, Classical Treatment of the Incident Radiation, Quantization of the Electromagnetic Field, Transition Rates for Absorption and Emission of Radiation, Transition Rates within the Dipole

Approximation, The Electric Dipole Selection Rules, Spontaneous Emission, Scattering Theory, Scattering and Cross Section, Connecting the Angles and Cross Sections in the Lab and CM frames, Scattering Amplitude of Spinless Particles, Scattering Amplitude and Differential Cross Section, The Born Approximation, Partial Wave Analysis, Partial Wave Analysis for Elastic and Inelastic Scattering, Scattering of Identical Particles

UNIT-III

Relativistic Formulation and Dirac Equation: Attempt for relativistic formulation of quantum theory, The Klein-Gordon equation, Probability density and probability current density, solution free particle K.G. equation in momentum representation, interpretation of negative probability density and negative energy solutions, Dirac equation for a free particle, properties of Dirac matrices and algebra of gamma matrices, non-relativistic correspondence of the Pauli equation (inclusive of electromagnetic interaction), Solution of the free particle Dirac equation, Orthogonality and completeness relations for Dirac spinors, interpretation of negative energy solution and hole theory

Reference Books:

1. Quantum Mechanics: Concepts and Applications – Nouredine Zettili. John Wiley & Sons.
2. Quantum Mechanics: A Modern Approach – Ashok Das and A. C. Melissinos. Gordon and Breach Science Publishers.
3. Quantum Mechanics (2nd Edition) – Eugen Merzbacher. John Wiley & Sons.
4. Relativistic Quantum Mechanics – James D. Bjorken and Sidney D. Drell. McGraw-Hill.

PHY-DCC -14: RESEARCH METHODOLOGY, SCIENTIFIC WRITING AND AI TOOLS IN PHYSICS

UNIT- I

Research Methodology in Physics: Introduction to scientific research, types and objectives of research, identification and formulation of research problems, literature survey, research design and methodology, primary and secondary sources, scientific journals and databases, experimental and theoretical methods, data collection, measurement errors and uncertainty, statistical analysis, data interpretation, graphical representation and curve fitting, research ethics, plagiarism, copyright, intellectual property rights and reference management

UNIT-II

Scientific Writing and Research Communication: Basics of scientific and technical writing, structure of research papers, abstract, introduction, methodology, results, discussion and conclusion, preparation of research proposals, project reports, dissertations and research papers, scientific presentations and posters, use of tables, graphs and figures, citation and referencing, bibliography, LaTeX and scientific document preparation, journal selection, peer review and publication ethics

UNIT-III

AI Tools in Physics: Introduction to Artificial Intelligence, Machine Learning and Large Language Models, applications of AI in Physics research, AI-assisted literature search and scientific writing, data analysis, image and signal processing, numerical modelling and simulation, AI-assisted coding and visualization, use of AI for research presentations and academic tasks, prompt engineering, verification of AI-generated information, limitations and ethical

issues of AI, plagiarism, authorship and responsible use of AI in scientific research

Reference Books:

1. Research Methodology: Methods and Techniques – C. R. Kothari and Gaurav Garg. New Age International Publishers.
2. Research Methodology: A Step-by-Step Guide for Beginners – Ranjit Kumar. SAGE Publications.
3. Research Methodology and Statistical Techniques – Santosh Gupta. Deep & Deep Publications.
4. Research Methodology: Concepts and Cases – Deepak Chawla and Neena Sondhi. Vikas Publishing House.

PHY-DSE -04A: ADVANCED NUCLEAR PHYSICS

UNIT-I

Nuclear Shell Model: Single particle and collective motions in nuclei. Empirical evidences of magic numbers, Assumptions and justification of the shell model, Average shell potential, spin orbit coupling; single particle wave functions and level sequence; magic numbers, shell model predictions for ground state parity, angular momentum, magnetic dipole and electric quadrupole moments and their comparison with experimental data; configuration mixing; Nuclear isomerism. Collective nuclear deformation-rotational and vibrational modes, Generalized nuclear deformation and Nielsson model

UNIT-II

Nuclear Gamma and Beta decay: Electric and magnetic multipole moments and gamma decay probabilities in nuclear system (no derivations) Reduced transition probability, Selection rules, Internal conversion and zero-zero

transition. General characteristics of weak interaction; nuclear beta decay, and lepton capture; electron energy spectrum and Fermi-Kurie plot; Fermi theory of beta decay (parity conserved selection rules Fermi and Gamow-Teller) for allowed transitions; ft-values; Forbidden transitions; Experimental verification of parity violation; The V-A interaction and experimental verification

UNIT-III

Nuclear Reactions: Theories of Nuclear Reactions; Partial wave analysis of reaction Cross section; Compound nucleus formation and breakup; Resonance scattering and reaction-Breit-Wigner dispersion formula for s-waves ($l = 0$), continuum cross section; Statistical theory of nuclear reactions; The optical model, Stripping and pick-up reactions

Reference Books:

1. Structure of the Nucleus – M. A. Preston and R. K. Bhaduri. Addison-Wesley, 1975.
2. Nuclear Physics – R. R. Roy and B. P. Nigam. Wiley Eastern, 1979.
3. Introductory Nuclear Theory – L. R. B. Elton. EleBS Publishers, London, 1959.
4. Nuclear Physics – B. K. Agrawal. Lokbharti Publications, Allahabad, 1989.

PHY-DSE-04B: ADVANCED SOLID STATE PHYSICS

UNIT-I

Advanced Electronic and Semiconductor Physics: Advanced concepts of band theory; Fermi surfaces and their experimental determination; electron dynamics in periodic potentials; cyclotron resonance; quantum Hall effect;

semiconductor heterostructures; quantum wells, quantum wires and quantum dots; low-dimensional electron systems; excitons and optical properties of semiconductors; dielectric response and polarization; plasmon excitations; optical absorption and dispersion in solids; semiconductor superlattices and applications

UNIT-II

Magnetism and Superconductivity: Diamagnetism and Langevin theory of para-magnetism; Pauli para-magnetism; ferromagnetism and exchange interaction; Heisenberg model; mean-field theory; Curie and Curie-Weiss laws; anti-ferromagnetism and ferrimagnetism; magnetic domains and hysteresis; spin waves and magnons; magnetic materials and their applications. Superconductivity and Meissner effect; critical temperature, critical field and critical current; Type-I and Type-II superconductors; London equations; flux quantization; BCS theory and Cooper pairs; energy gap; Josephson effects; high-temperature superconductors and technological applications

UNIT-III

Modern Solid State Materials and Advanced Topics: Nanomaterials and nanostructured materials; size-dependent physical properties; quantum confinement; graphene and two-dimensional materials; carbon nanotubes; fullerenes; topological insulators and topological materials; spintronics and spin-dependent transport; multiferroic materials; smart and functional materials; semiconductor and photovoltaic materials; organic and molecular solids; defects and their role in advanced materials; introduction to computational methods in solid-state physics; applications of advanced solid-state materials in electronics, photonics, energy storage, sensors and modern technology

Reference Books:

1. Advanced Solid State Physics – R. L. Singhal. Kedar Nath Ram Nath Publishers.
2. Nanoscience and Nanotechnology – P. K. Sharma. Viva Books.
3. Semiconductor Physics and Devices – S. M. Sze. John Wiley & Sons.
4. Magnetism and Magnetic Materials – J. M. D. Coey. Cambridge University Press.
5. Superconductivity – Charles P. Poole Jr., Horacio A. Farach and Richard J. Creswick. Academic Press.

PHY-DSE- 05A- QUANTUM INFORMATION AND QUANTUM COMPUTING

UNIT-I

Foundations of Quantum Information: Review of Quantum Mechanics: Hilbert space, state vectors, bra-ket notation, operators and measurements, Classical Information vs Quantum Information, Qubits, Pure and Mixed States, Density Matrix Formalism, Bloch Sphere Representation, Quantum Superposition and Quantum Measurement, Composite Quantum Systems, Tensor Product, Quantum Entanglement and Bell States, Bell's Inequalities and Non-locality

UNIT-II

Quantum Computing: Quantum Logic Gates: Pauli Gates, Hadamard, Phase, T-Gate, CNOT, Toffoli and Fredkin Gates, Quantum Circuits and Circuit Model of Computation, Universal Quantum Gates, Quantum Parallelism, Quantum Fourier Transform (QFT)

UNIT-III

Quantum Communication and Applications: Quantum Teleportation, Superdense Coding, Quantum Cryptography (BB84 and E91 Protocols),

Quantum Error Correction and Fault-Tolerant Quantum Computing, Physical Realizations of Quantum Computers: Superconducting Qubits, Trapped Ions, Photonic Quantum Computing, Quantum Dots and NV Centers, Applications of Quantum Computing in Physics, Chemistry, Machine Learning, Optimization, Finance and Artificial Intelligence

Reference Books:

1. Quantum Computation and Quantum Information – Michael A. Nielsen and Isaac L. Chuang. Cambridge University Press.
2. Quantum Computing Explained – David McMahon. Wiley-Interscience.
3. Quantum Computing: A Gentle Introduction – Eleanor Rieffel and Wolfgang Polak. MIT Press.
4. An Introduction to Quantum Computing – Phillip Kaye, Raymond Laflamme and Michele Mosca. Oxford University Press.
5. Quantum Computer Science: An Introduction – N. David Mermin. Cambridge University Press.

PHY-DSE -05B: LASER PHYSICS

UNIT I

Introduction to Lasers: Classical absorption of light; Quantum absorption of light; Interaction of Light with matter: Absorption and Emission processes; Light Source; Properties of Laser, Einstein Coefficients and Light Amplification; Population Inversion; Pumping; Gain

UNIT- II

Laser Fundamentals: Laser rate equations; Three and four level Lasers; Laser beam propagation; Properties of Gaussian beam; Resonator; Various types of resonators; Resonator for high gain and high energy Lasers; Gaussian beam focusing; General lasers and their types: CW and pulsed Lasers; Laser pulse

generation: Q-switching and mode locking; ultra-short (nanosecond, pico-second and femto-second) laser pulse generation

UNIT -III

Introduction to Laser Spectroscopic techniques, Laser systems for spectroscopy; Instrumentation for detection of optical signals and time-resolved measurements; Pump and probe techniques; Absorption and fluorescence spectroscopy; Raman spectroscopy: basics and instrumentation

Reference Books:

1. Lasers and Non-Linear Optics – B. B. Laud. New Age International Publishers.
2. Laser Physics and Applications – Anuradha De. PHI Learning.
3. Lasers: Principles and Applications – J. Wilson and J. F. B. Hawkes. Prentice Hall
4. Lasers – A. K. Maini. Wiley India.

PHY-DCC -15: MICROWAVE ELECTRONICS AND ADVANCED PHYSICS LAB

1. To study the characteristics curve of Klystron.
2. To study the mode characteristics of reflex Klystron and hence to determine mode number. Transmit time, Electronics, tuning range, electronic tuning sensitivity
3. To study the E-Plane radiation pattern of pyramidal horn antenna and compute the beam width
4. To study the H plane radiation pattern of pyramidal horn antenna and compute the Directional gain of the Antenna
5. To determine the dielectric constant of a given sample at Microwave frequency.

6. To determine the dielectric constant of Benzene using plunger technique at room temperature
7. To determine the unknown impedance using the slotted line section Smith chart in the K-band
8. To study the microwave absorption in dielectric sheets.
9. To study the characteristics of LEDs and determine the wavelength of emitted light
10. To study the characteristics of the following optoelectronic devices. • Opto-coupler • LDR • Photo-transistor
11. To determine the effective carrier life-time of minority carriers in p-n junction diode and study the variation of lifetime with temperature and also determine the energy of trap level
12. To study the transient behavior of a p-n junction and calculate the minority carrier life-time from the method of reverse recovery
13. To study the I-V characteristics of a Solar-Cell under dark and constant illumination and to determine. • Maximum power • Fill-factor • Ideality factor
14. To study the PI characteristics of a laser diode
15. To determine the beam parameter of a laser treating it as a Gaussian beam. • Beam Waist • Beam divergence • Modes
16. To study dark and illumination characteristic of p-n-junction solar cell and to determine (i) Its internal series resistance (ii) Diode ideality factor
17. To study the characteristics of MESFET and MESFET amplifiers
18. To study capacitance variation of p-n-junction with bias voltage in reverse bias and determination of built in potential and other related parameters.
19. To study temperature characteristics of a thermistor and determination of activation energy.

Any other Experiments of the equivalent standard can be set Based on the syllabus