Multanimal Modi College, Modinagar

DEPARTMENT OF PHYSICS

Program Outcomes: B.Sc. program aims at preparing the students for higher studies in the field of natural sciences and M.Sc. program is to prepare them for research in physics and various interdisciplinary areas.

Course Objective and Outcomes

CLASS: B.Sc.-1st Year

Subject:MECHANICS AND WAVE MOTION Subject Code: B-116

UNIT	MODULE	Specific Outcomes
I	Inertial reference frame, Newton's laws of motion, Dynamics of particle in rectilinear and circular motion, Conservative and Non -conservative forces, Conservation of energy, liner momentum and angular momentum, Collision in one and two dimensions, cross section.	To learn about conservation theorems.
II	Rotational energy and rotational inertia for simple bodies, the combined translation and rotational and motion of a rigid body on horizontal and inclined planes, Simple treatment of the motions of a top. Relations between elastic constants, bending of Beams and Torsion of Cylinder.	Learning about rotational motion.
III	Central forces, Two particle central force problem, reduced mass, relative and centre of mass motion, Law of gravitation, Kepler's laws, motions of planets and satellites, geo-stationary satellites.	Learning about planetary motion.
IV	Simple harmonic motion, differential equation of S. H. M. and its solution, uses of complex notation, damped and forced vibrations, composition of simple harmonic motion. Differential equation of wave motion, plane progressive waves in fluid media, reflection of waves, phase change on reflection, superposition, stationary waves, pressure and energy distribution, phase and group velocity.	To learn about oscillations.

CLASS: B.Sc.-1st Year

Subject: KINETIC THEORY AND THERMODYNAMICS(Code: B-117)

UNIT	MODULE
I	**Ideal Gas:** Kinetic model, Deduction of Boyle's law, interpretation of temperature, estimation of r.m.s. speeds of molecules. Brownian motion, estimate of the Avogadro number. Equipartition of energy, specific heat of monatomic gas, extension to di- and triatomic gases, Behaviour at low temperatures. Adiabatic expansion of an ideal gas, applications to atmospheric physics. **Real Gas:** Vander Waals gas, equation of state, nature of Van der Waals forces, comparison with experimental P-V curves. The critical constants, gas and vapour. Joule expansion of ideal gas, and of a Vander Waals gas, Joule coefficient, estimates of J-T cooling.
II	**Liquefaction of gases:** Boyle temperature and inversion temperature. Principle of regenerative cooling and of cascade cooling, liquefaction of hydrogen and helium. Refrigeration cycles, meaning of efficiency. **Transport phenomena in gases:** Molecular collisions, mean free path and collision cross sections. Estimates of molecular diameter and mean free path.Transport of mass, momentum and energy and interrelationship, dependence on temperature and pressure.
III	**The laws of thermodynamics:** The Zeroth law, various indicator diagrams, work done by and on the system, first law of thermodynamics, internal energy as a state function and other applications. Reversible and irreversible changes, Carnot cycle and its efficiency, Carnot theorem and the second law of thermodynamics. Different versions of the second law, practical cycles used in internal combustion engines. Entropy, principle of increase of entropy. The thermodynamic scale of temperature; its identity with the perfect gas scale. Impossibility of attaining the absolute zero; third law of thermodynamics. Thermodynamic relationships: Thermodynamic variables; extensive and intensive, Maxwell's general relationships, application to Joule-Thomson cooling and adiabatic cooling in a general system, Van der Waals gas, Clausius-Clapeyron heat equation. Thermodynamic potentials and equilibrium of thermodynamical systems,

	relation with thermodynamical variables. Cooling due to adiabatic demagnetization, production and measurement of very low temperatures.
IV	Blackbody radiation: Pure temperature dependence, Stefan-Boltzmann law, pressure of radiation, spectral distribution of Black body radiation, Wien’s displacement law, Rayleigh-Jean’s law, Plank's law the ultraviolet catastrophy.

Course Outcome: After completion of this course students would be able to comprehend ideal gases, real gases, thermodynamics and blackbody radiation.

CLASS: B.Sc.-1st Year

Subject: CIRCUIT FUNDAMENTALS AND BASIC ELECTRONICS (Code B-118)

UNIT	MODULE
I	Growth and decay of currents through inductive resistances, charging and discharging in R.C. and R.L.C. circuits, Time constant, Measurement of high resistance. A.C. Bridges, Maxwell’s and Scherings Bridges, Wien Bridge. THINLY, NORTON and Superposition theorems and their applications
II	Semiconductors, intrinsic and extrinsic semiconductors, n-type and p-type semiconductors, unbiased diode forward bias and reverse bias diodes, diode as a rectifier, diode characteristics, zener diode, avalanche and zener breakdown, power supplies, rectifier, bridge rectifier, capacitor input filter, voltage regulation, zener regulator. Bipolar transistors, three doped regions, forward and reverse bias, DC alpha, DC beta transistor curves.
III	Transistor biasing circuits: base bias, emitter bias and voltage divider bias, DC load line. Basic AC equivalent circuits, low frequency model, small signal amplifiers, common emitter amplifier, common collector amplifiers, and common base amplifiers, current and voltage gain, R.C. coupled amplifier, gain, frequency response, equivalent circuit at low, medium and high frequencies, feedback principles.

IV	Input and output impedance, transistor as an oscillator, general discussion and theory of Hartley oscillator only. Elements of transmission and reception, basic principles of amplitude modulation and demodulation. Principle and design of linear multimeters and their application, cathode ray oscillograph and its simple applications.

Course Outcome: After completion of this course students would be able to comprehend electronic devices.

CLASS: B.Sc.-2nd Year

Subject:PHYSICAL OPTICS AND LASERS(Code B-216)

UNIT	MODULE
I	**Interference of a light:** The principle of superposition, two-slit interference, coherence requirement for the sources, optical path retardations, lateral shift of fringes, Rayleigh refractometer and other applications. Localised fringes; thin films, applications for precision measurements for displacements. **Haidinger fringes:** Fringes of equal inclination. Michelson interferometer, its application for precision determination of wavelength, wavelength difference and the width of spectral lines. Twymann Green interferometer and its uses. Iriensity distribution in multiple beam interference, Tolansky fringes, Fabry-Perrot interferometer and etalon.
II	**Fresnel diffraction:** Fresnel half-period zones, plates, straight edge, rectilinear propagation. **Fraunhoffer diffraction:** Diffraction at a slit, half-period zones, phasor diagram and integral calculus methods, the intensity distribution, diffraction at a circular aperture and a circular disc, resolution of images, Rayleigh criterion, resolving power of telescope and microscopic systems, outline of phase contrast microscopy. **Diffraction gratings:** Diffraction at N parallel slits, intensity distribution, plane diffraction grating, reflection grating and blazed gratings. Concave grating and different mountings. Resolving power of a grating and comparison with resolving powers of prism and of a Fabry-Perrot etalon.

III	Polarization, Double refraction in uniaxial crystals, Nicol prism, polaroids and retardation plates, Babinet's compensator. Analysis of polarised light. Optical activity and Fresnel's explanation, Half shade and Biquartzpolarirneters.Matrix representation of plane polarized waves, matrices for polarizers, retardation plates and rotators, Application to simple systems.
IV	**Laser system:** Purity of a special line, coherence length and coherence time, spatial coherence of a source, Einstein's A and B coefficients, spontaneous and induced emissions, conditions for laser action, population inversion. **Application of Lasers:** Pulsed lasers and tunable lasers, spatial coherence and directionality, estimates of beam intensity; temporal coherence and spectral energy density.

Course Outcome: After completion of this course students would be able to understand various aspects of light.

CLASS: B.Sc.-2nd Year

Subject: ELECTROMAGNETICS(Code B-217)

UNIT	**MODULE**	**Specific Outcomes**

I	**Electrostatics -** Coulomb's law, Electric Field and potentials, Field due to a uniform charged sphere, Derivations of Poisson and Laplace Equations, Gauss Law and its application: The Field of a conductor. Electric dipole, Field and potential due to an electric dipole, Dipole approximation for an arbitrary charge distribution, Electric quadruple, Field due to a quadruple , Electrostatic Energy of a charged uniform sphere, Energy of a condenser. **Magnetostatics -** Magnetic field, Magnetic force of a current, Magnetic Induction and Biot- Savart Law, Lorentz Force, Vector and Scalar Magnetic potentials, Magnetic Dipole, Magnetomotive force and Ampere's Circuital theorem and its applications to calculate magnetic field due to wire carrying current and solenoid.	To learn about electrostatics andmagnetostatics.
II	**Electromagnetic Induction -** Laws of Induction, Faraday's laws and Lanz's Law. Mutual and Self Induction, Vector potential in varying Magnetic field, Induction of current in continuous media, Skin effect, Motion of electron in changing magnetic field , Betatron , Magnetic energy in field, Induced magnetic field (Time varying electric field), Displacement current, Maxwell's equations, Theory and working of moving coil ballistic galvanometer.	To learn about electromagnetic induction.
III	**Dielectrics -** Dielectric constant, polarization, Electronic polarization, Atomic or ionic Polarization Polarization charges, Electrostatic equation with dielectrics, Field, force and energy in Dielectrics. **Magnetic Properties of Matter -** Intensity of magnetization and magnetic susceptibility, Properties of Dia, Para and Ferromagnetic materials, Curie temperature, Hysteresis and its experimental determination.	To learn about dielectrics and magnetism in matter.
IV	E**lectromagnetic Waves -** The wave', equation satisfied .by E and B, plane electromagnetic waves in vacuum, Poynting's vector, reflection at, a plane boundary of dielectrics, polarization by reflection and total internal reflection, Faraday effect; waves in a conducting medium, reflection and refraction by the ionosphere.	To learn about electromagnetic waves.

CLASS: B.Sc.-2nd Year

Subject:ELEMENTS OF QUANTUM MECHANICS, ATOMICAND MOLECULAR SPECTRA (Code B-218)

UNIT	MODULE
I	**Matter Waves -** Inadequacies of classical mechanics, Photoelectric phenomenon, Compton effect, wave particle duality, de- Broglie matter waves and their experimental verification, Heisenberg's Uncertainty principle, Complementary principle, Principle of superposition, Motion of wave packets.
II	**Schrodinger Equation and its Applications -** Schrodinger wave equation Interpretation of wave function, Expectation values of dynamical variables, Ehrenfest theorem, Orthonormal properties of wave functions, One dimensional motion in step potential, Rectangular barrier, Square well potential, Particle in a box, normalization Simple Harmonic Oscillator.
III	**Atomic spectra -** Spectra of hydrogen, deuteron and alkali atoms, spectral terms, doublet fine structure, screening constants for alkali spectra for s, p. d, and f states, selection rules. Singlet and triplet fine structure in alkaline earth spectra, L-S and J-J couplings. Weak spectra: continuous X-ray spectrum and its dependence on voltage, Duane and Haunt's law. Characteristics X-rays, Moseley's law, doublet structure and screening parameters in X-ray spectra, X-ray absorption spectra.
IV	**Molecular spectra -** Discrete set of electronic energies of molecules, quantisation of vibrational and rotational energies, determination of internuclear distance, pure rotation and rotation- vibration spectra, Dissociation limit for the ground and other electronic states, transition rules for pure vibration and electronic vibration spectra.

Course Outcome: After completion of this course students would be able to comprehend electricity and magnetism.

CLASS: B.Sc.-3rd Year

Subject: RELATIVITY AND STATISTICAL PHYSICS(Code B-316)

UNIT	MODULE
I	**Relativity -** Reference systems, inertial frames, Galilean invariance and conservation laws, propagation of light, Michelson-Morley experiment; search for ether. Postulates for the special theory of relativity, Lorentz transformations, length contraction, time dilation, velocity addition theorem, variation of mass with velocity, mass-energy equivalence, particle with a zero rest mass.
II	**Statistical physics** **The statistical basis of thermodynamics:** Probability and thermodynamic probability, principle of equal a prior probabilities, probability distribution and its narrowing with increase in number of particles. . The expressions for average properties. Constraints; accessible and inaccessible states, distribution of particles with a given total energy into a discrete set of energy states.
III	**Some universal laws:** The ji- space representation, division of i- space into energy sheets and into phase cells of arbitrary size, applications to one-dimensional harmonic oscillator and free particles. Equilibrium before two systems in thermal contact, bridge with macroscopic physics. Probability and entropy, Boltzmann entropy relation. Statistical interpretation of second law of thermodynamics. Boltzmann canonical distribution law and its applications; rigorous form of equipartition of energy.
IV	**Maxwellian distribution of0 speeds in an ideal gas:** Distribution of speeds and of velocities, experimental verification, distinction between mean, r.m.s. and most probable speed values. Doppler broadening of spectral lines. **Transition to quantum statistics:** 'h' as a natural constant and' its implications, cases of particle in a one-dimensional box and one-dimensional harmonic oscillator, Indistinguishability of particles and its consequences, Bose-Einstein, and Fermi-Dirac distributions, photons in black body chamber, free electrons in a metal, Fermi level and Fermi energy.

Course Outcome: After completion of this course students would be able to understand relativity and statistical mechanics.

CLASS: B.Sc.-3rd Year

Subject: SOLID STATE AND NUCLEAR PHYSICS(Code B-317)

UNIT	**MODULE**	**Specific Outcomes**
I	**Crystal Structure -** Lattice translation vectors and lattice, Symmetry operations, Basis and Crystal structure, Primitive Lattice cell, Two-dimensional lattice types, systems, Number of lattices, Point groups and plane groups, Three dimensional lattice types, Systems, Number of Lattices, Points groups and space groups. Index system for crystal planes Miller indices, Simple crystal structures, NaCI, hcp, diamond, Cubic ZnS; and hexagonal , Occurrence of Nonidealcrysal structures, random stacking of polyprism, glasses. **Crystal Diffraction and Reciprocal Lattice -** Incident beam, Bragg law, Experimental diffraction method, Laue method, Rotating crystal method, Powder method, Derivation of scattered 'wave amplitude, Fourier analysis, Reciprocal lattice vectors, Diffraction conditions, Ewald method, Brillion zones, Reciprocal lattice to sc, bcc and face lattices , Fourier analysis of the basis and atomic form factor.	To learn about lattices and X-Ray diffraction.
II	**Crystal Bindings -** Crystal of inert gases, Van der Walls-London interaction, repulsive interaction, Equilibrium lattice constants, Cohesive energy, compressibility and bulk modulus, ionic crystal, Madelung energy, evaluation of Madelung constant, Covalent crystals, Hydrogen-bonded crystals, Atomic radii. **Lattice Vibrations -** Lattice Heat capacity, Einstein model, Vibrations of monatomic lattice, derivation of dispersion relation, First brillouin zone,	Understanding crystal bindings and lattice vibrations.

	group velocity, continuum limit, Force constants, Lattice with two atoms per primitive cell, derivation of dispersion relation, Acoustic and optical modes, Phonon momentum. Free electron theory, Fermi energy, density of states, Heat capacity of electron gas, Paramagnetic susceptibility of conduction electrons, Hall effect in metals. Origin of band theory, Qualitative idea of Bloch theorem, Kronig-Penney model, Number of orbitals in a band, conductor, Semi-conductor and insulators, Effective mass, Concept of holes.	
III	**Nuclear Physics** **1. General Properties of Nucleus:** Brief survey of general Properties of the Nucleus, Mass defect and binding energy, charges, Size, Spin and Magnetic moment, Bainbridge mass spectrograph. **2. Nuclear Forces:** Saturation phenomena and Exchange forces, Deutron ground state properties. **3. Nuclear Models:** Liquid drop model and Bethe Weiszacker mass formula, Single particle shell model (only the level scheme in the context of reproduction of magic numbers). **4 Natural Radioactivity:** Fundamental laws of radioactivity, Soddy-Fajan's displacement law and law of radioactive disintegration, Basic ideas about α, β and ϒ decay.	Understanding nuclear properties.
IV	**1. Nuclear Reactions:** Nuclear reactions and their conservation laws, Cross section of nuclear reactions, Theory of fission (Qualitative), Nuclear reactors and Nuclear fusion. **2. Accelerators and detectors:** Vande Graff, Cyclotron and Synchrotron, Interaction of charged particles and gamma rays with matter (qualitative), GM counter, Scintillation counter and neutron detectors.	To learn about nuclear reactions and elementary particles.

	3. Elementary Particles: Basic classification based on rest mass, Spin and half life, particle interactions (gravitational, Electromagnetic, week and strong Interactions).	

CLASS: B.Sc.-3rd Year

Subject: SOLID STATE ELECTRONICS(Code B-318)

UNIT	MODULE
I	Diffusion of minority carriers in semiconductor, work function in metals and semiconductors Junctions between metal and semiconductors, Semiconductor and semiconductor, p.n. Junction, Depletion layer, Junction Potential Width of depletion layer, Field and Capacitance of depletion layer, Forward A.C. and D.C. resistance of junction, Reverse Breakdown. Zener and Avalanche diodes, Tunnel diodes, Point contact diode, their importance at High frequencies, LED photodiodes, Effect of temperature on Junction diode Thermistors.
II	Transistor parameters, base width modulation, transit time and life-time of minority carriers, Base- Emitter resistance Collector conductance, Base spreading resistance, Diffusion capacitance, Reverse feedback ratio, Equivalent circuit for transistors, Basic model, hybrid model and Y parameter equivalent circuit, Input and output impedances.
III	Current and Voltage gain, Biasing formulae for transistors, Base bias, emitter bias and mixed type bias and mixed type biasing for small and large signal operation. Transistor circuit application at law frequencies, their AC and DC equivalent for three different modes of operation, Large signal operation of transistors, Transistor Power amplifiers, Class A and B operation, Maximum power output Effect of temperature, heat sinks, thermal resistance Distorsion in amplifiers, cascading of stages, Frequency response, Negative and positive feedback in transistor amplifiers.

IV	Field effect transistors and their characteristics, biasing of FET, use in preamplifiers , MOSFET and their simple uses. **Power Supplies:** Electronically regulated low and high voltage power supplies, Inverters for battery operated equipments. **Miscellaneous:** Basic linear integrated circuits, phototransistors, Silicon Controlled rectifiers, Injunction transistor and their simple uses.

Course Outcome: After completion of this course students would be able to understand solid state electronics devices.

CLASS: M.Sc. I (SEM)

Subject: MATHEMATICAL PHYSICS (CODE:H-1027)

UNIT	MODULE	Specific Outcomes
I	**Polynomials-** Legendre, Hermite and Laguerre polynomials and their generating functions. Recurrence relations and special properties of Pn(x) as solution of Legendre differential equation, Rodrigues formula, orthogonality of Pn(x) , associated Legendre polynomials (Introdution only).	To learn about differential equations and special function.
II	Bessel function of first kind, generating function, recurrence relations, Jn(x) as solution of Bessel differential equation, Expansion of Jn(x) when n is half and odd integer, Integral representation.	Learning Bessel differential equation and its solution.
III	**Complex Variable:** Function of a complex variable, Cauchy Riemann conditions, Cauchy's integral theorem (without proof), Cauchy's integral formula, Cauchy's Residue theorem, singular points and evaluation of definite integrals of the type	Learning contour integrals.

	∫02π f(sinθ, cosθ)dθ, ∫-∞∞ f(x) dx, ∫-∞∞ f(x) eiaxdx	
IV	**Integral Transforms:** Laplace Transform, First and second shifting theorems, Inverse LT by partial fractions, LT of derivative and integral of a function, Solution of initial value problems by using LT,	Learning use of Laplace transform to solve differential equation.
V	**Fourier Series and Fourier Transform:** Fourier series, Half range expansion, Arbitrary period, Fourier integral and transforms, FT of delta and Gaussian function.	Learning F ourier series and transform.

CLASS: M.Sc.I (SEM)

Subject: CLASSICAL MECHANICS (Code : H-1028)

UNIT	MODULE
I	Preliminaries: Newtonian mechanics of a particle, Mechanics of a system of particles, Constraints; their classification, D'Alembert's principle, Virtual work, generalized coordinates and derivation of Lagrange's equations, Velocity-Dependent potentials and the Dissipation function, Applications of Lagrangian formulation: Simple Pendulum with rigid support, Two connected masses with string passing over a pulley.
II	Variational Principles and Lagrange's Equations: Hamilton's principle, Some techniques of the calculus of variations, Derivation of Lagrange's equation from Hamilton's principle, advantages of variational principle formulation, Principle of least action.
III	Two body central force problem: Reduction to the equivalent one-body problem, Motion in a central force field, The Virial theorem, The inverse square law of force, The motion in central force in the Kepler problem.

IV	Hamiltonian equations of motion: Legendre transformations and Hamilton equations of motion, Cyclic coordinates and conservation theorems, Canonical transformation generating functions, Properties, Poisson bracket, Poisson theorem, Relation of Poisson brackets, Hamilton Jacobi method
V	Small oscillations: Concept of small oscillations, Expression of kinetic energy and potential energy for the problem of small oscillations, Frequencies of free vibration, and Normal coordinates.

Course Outcome: After completion of this course students would be able to learn about the motion of a particles, conservation principles involving momentum, angular momentum and energy and understand that they follow the fundamental equation. Understand the Lagrangian and Hamiltonian formulation.

CLASS: M.Sc.I(SEM)

Subject: QUANTUM MECHANICS-I (Code-H-1029)

UNIT	MODULE
I	**Wave Mechanics:** Dual nature of matter and radiation, Schrodinger equation, Principle of superposition, Motion of wave packets, Uncentainty principle, Fundamental postulates of wave mechanics, Eigenvalues and eigenvectors, Probabilistic interpretation, normalization of bound and continuum state wave functions,Expectation values of dynamical variables, Coordinate and momentum representation, Hermitian operator, Commutator algebra and uncertainty relation, Three dimensional potential well and Hydrogen atom.
II	**Representation and Transformations:** State vectors, Hilbert Space, Dirac notations, Dynamical and linear operators in matrix form, Linear harmonic oscillator in matrix formulation, Space and time displacements, Rotation generators, Transformations of dynamical variables, Symmetry and conservation laws. Symmetric and anti symmetric wave-functions and Pauli exclusion principle.
III	**Approximate Methods:** Time independent first and second order perturbation theory for non-degenerate and degenerate levels, Variational method and its application for Helium atom. Stark effect, Dipole polarizability of ground state Hydrogen atom, Zeeman Effect.

IV	**Angular momentum:** Commutation relations involving angular momentum operators, the eigenvalue spectrum, Matrix representation of J , Addition of angular momentum, Clebsch-Gordon coefficients, Spin angular momentum, Spin wave functions, Addition of spin and orbital angular momentum.
V	**Scattering Theory:** Laboratory and centre-of-mass systems, scattering by potential field, scattering amplitude, differential and total cross sections, phase shift, Lippmann-Schwinger equation, First Born approximation.

Course Outcome: After completion of this course students would be able to understand quantum mechanics.

CLASS: M.Sc.I (SEM)

Subject: ELECTRONICS DEVICES (Code-H-1030)

UNIT	MODULE
I	**Conduction Mechanism in Semiconductors:** Classification of semiconductors - Elemental and compound semiconductors, Direct band and indirect band gap semiconductors, Charge carriers in extrinsic semiconductors, Carrier concentrations; The Fermi Level, electron and hole concentrations at equilibrium, temperature dependence of carrier concentrations, drift of carriers in electric and magnetic fields; conductivity and mobility, drift and resistance, effect of temperature and doping on mobility, The Hall effect, Diffusion of carriers in semiconductors; diffusion processes, diffusion and drift of carriers, diffusion and recombination, The continuity equation.
II	**Semiconductor-diode characteristics:** Qualitative theory of P-N junction, The Contact Potential, Space charge at a junction, Capacitance of p-n junctions, Forward and reverse bias junctions, Reverse bias breakdown, Zener diode, Tunnel diode.
III	**Bipolar Junction Transistors:** Transistor current components, The transistor as an Amplifier, CB, CE, CC configurations, Input output characteristics, Early Effect, Graphical analysis of the CE configuration, Transistor hybrid model, h parameters, Analysis of a Transistor amplifier circuit using h parameters, Hybrid π model, Ebers-Moll model, Transistor biasing and thermal

	stabilization.
IV	**Field Effect Transistors:** Construction and characteristics of JFET, transfer characteristic, The FET small signal model, Measurement of gm and rd, JFET fixed bias, Self bias and voltage divider configurations, JFET source follower (common-Drain) configuration, JFET Common – Gate configuration, Depletion and enhancement type MOSFETs.
V	**Feedback Amplifiers:** Classification of Amplifiers, Feedback concept, Ways to introduce negative feedback in Amplifiers, Effect of negative feedback, Method of analysis of a feedback amplifier, Volatge-series feedback, Current-series feedback, Volatge-shunt feedback, Current-shunt feedback, Nyquist criterion for stability of feedback amplifiers.

Course Outcome: After completion of this course students would be able to understand electronic devices.

CLASS:M.Sc.II(SEM)

Subject:QUANTUM MECHANICS-II(Code-H-2027)

UNIT	**MODULE**
I	**Time dependent Perturbation Theory :**First order perturbation, Interaction of an atom with electromagnetic field, Transition probabilities, Fermi Golden rule, Dipole approximation.
II	**Induced and Spontaneous radiations:** Einstein A and B coefficients, Induced and spontaneous emissions of radiations, their applications in the construction of gas and solid lasers.
III	**Quantum Theory of Radiation:** Classical radiation field, Fourier decomposition and radiation oscillators, Creation, annihilation and number operators, Photon states, Quantized radiation field, Basic matrix elements for emission and absorption, Spontaneous emission in the dipole approximation, Plank's radiation law.

IV	**Relativistic Equations:** Klein-Gordon equation and its plane wave solution, Probability density in KG theory, Difficulties in KG equation, Dirac equation for a free electron, Dirac matrices and spinors, Plane wave solutions, Charge and current densities, Existence of spin and magnetic moment from Dirac equation of electron in an electromagnetic field.
V	**Dirac Equation:** Dirac equation for central field with spin orbit interaction, Energy levels of Hydrogen atom from the solution of Dirac equation, Covariant form of Dirac equation.

Course Outcome: After completion of this course students would be able to understand advanced topics of quantum mechanics.

CLASS: M.ScII(SEM)

Subject: STATISTICAL MECHANICS(Code-H-2028)

UNIT	MODULE
I	**Foundation of Statistical Mechanics & Ensembles:** Phase space, concept of Ensemble, Ensemble average, Liouville's theorem, equation of motion and Liouville's theorem, Canonical Ensemble, Microcanonical Ensemble, Grand Canonical Ensemble, partition functions.
II	**Statistical Quantities:** Calculation of statistical quantities, Energy and density fluctuations, Entropy of an ideal gas using microcanonical Ensemble, Gibb's paradox, Sackur- Tetrode equation.
III	Postulates of quantum statistical mechanics, Density matrix, Statistics of indistinguishable particles, Maxwell-Boltzmann, Fermi- Dirac and Bose- Einstein Statistics, properties of ideal Bose and Fermi gases, Bose- Einstein condensation.
IV	Cluster expansion for a classical gas, virial equation of state, ising model, mean-field theories of the ising model in three, two and one dimensions, Exact solutions in one-dimension. Landau theory of phase transition, critical indices, scale transformation and dimensional analysis.

V	**Fluctuations:** Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem, The Fokker-Plank equation.

Course Outcome: After completion of this course students would be able to comprehend the topics of statistical mechanics which are important tools for modern research.

CLASS: M.Sc. II (SEM)

Subject:ELECTEODYNAMICS AND PLASMA PHYSICS(Code:H-2029)

UNIT	MODULE	Specific Outcome
I	Electrostatics: Electrostatic fields in matter; Dielectrics, Polarization, Field inside a dielectric, Electric displacement, Linear dielectrics. Laplace's and Poisson Equations, Methods of images, point charge near an infinite conducting plane, Point charge in the presence of grounded conducting sphere, Point charge in presence of charged insulated sphere.	To learn about electric field and potential in various cases.
II	Magnetocstatics: Magnetic vector potential, Magnetostatic fields in Matter: Magnetization, field of a magnetized object, magnetic field inside matter, linear and non linear magnetic media.	Learning about magnatic field and magnetization of material.
III	Time-Varying Fields: Maxwell's displacement current, Maxwell's equations, Maxwell's equations in terms of vector and scalar potentials, Poynting theorem, Lienard- Wiechert potentials due to a point charge, Fields of a point charge in motion, Power radiated by an accelerated charge, Larmor's formula and its relativistic generalization.	Learning Maxwell's equations.

IV	Plane Electromagnetic Wave: Reflection, Refraction of electromagnetic waves at an interface between dielectrics, Fresnel's relation polarization by reflection and total internal reflection, Plain electromagnetic waves in free space, dielectrics and conducting media	To learn about eletctromagnetic waves.
V	Plasma: Definition of plasma ,Concept of temperature, Debye shielding, Criteria for plasma, Single-particle motions in E and B fields, Magnetic mirrors and plasma confinement, Plasma as fluid, the fluid equation of motion, Equation of continuity and equation of state, Waves in plasmas, Plasma oscillations, Plasma frequency ωp, Electron plasma waves, ion waves, Electron and ion oscillations perpendicular to **B** and parallel to **B,** Cutoffs and resonances.	To learn about plasma.

Course Outcome: After completion of this course students would be able to understand electrodynamics and plasma physics.

CLASS:M.ScII(SEM)

Subject:ATOMIC& MOLECULAR PHYSICS(Code: H-2030)

UNIT	MODULE
I	Quantum Mechanical Treatment of one-electron Atom, Spin-Orbit interaction and fine structure of hydrogen atom, Spectra of alkali elements. Singlet and triplet States of Helium.
II	**Many electron atoms:** Central field approximation, Thomas-Fermi field, Atomic wave function, Hartree and Hartree –Fock approximations, Spectroscopic Terms: L S and J J coupling schemes for many electron atoms, Introduction of Zeeman Effect, Paschen effect and Stark effect, Electric dipole and Electric Quadrupole.
III	Born - Oppenheimer approximation, Heitler-London theory of H2, LACO treatment of H2+ and H2, Classification of Molecules, Types of Molecular Spectra and Molecular Energy States: Pure Rotational Spectra, Vibrational-Rotational Spectra, Raman Scattering, Selection rules, Isotope effect, Classification of electronic states, Coupling of rotational and electronic motions, Electronic spectra: Franck-Condon principle.

IV	Infrared Spectroscopy, General description and working of infra-red Spectrophotometer, Raman spectroscopy, Raman Spectrometer.
V	Photoelectron Spectroscopy, Photoelectron Spectrometer, Nuclear Magnetic Resonace, Chemical Shift, NMR Spectrometer, Electron Spin Resonance (Introduction and their principles only), ESR Spectrometer.

Course Outcome: After completion of this course students would be able to understand atomic and molecular spectra and its important applications.

CLASS:M.Sc.III(SEM)

Subject:SPECIAL PAPER-II (ELECTRONICS)(Code-H-7030)

UNIT	MODULE	Specific Outcomes
I	**Microwave Devices:** Klystrons amplifiers,velocity modulation, Basic principles of two cavity klystrons, Multicavityclystron amplifier and Reflex klystron oscillator, Magnetrons, principles of operation of magnetrons and Travelling wave tube (TWT). Transferred electron devices, Gun effect, Principles of operations, modes of operation, Read diode, IMPATT diode, and TRAPATT diode.	Learning about various resonators.
II	**Amplitude Modulated Systems:** Frequency translation, method of frequency translation, recovery of the base band signal, Amplitude modulation, Maximum allowed modulation, The square law demodulation, Spectrum of an amplitude modulated signal, Modulators and Balanced modulators, Single side band modulation, Methods of generating as SSB signal, Vestigial side band modulation, Multiplexing.	To learn about amplitude modulation.
III	**Frequency Modulated Systems:** Angle modulation, Phase and frequency modulation, Relationship between phase and frequency modulation, Phase and frequency deviation, Spectrum of an FM signal, Sinusoidal modulation, Bandwidth of a sinusoidally modulated FM	To learn about frequency modulation.

	signal, FM generation, Parameter variation method, Armstrog system.	
IV	**Transmission and Radiation of signals:** Primary line constants, phase velocity and line wavelength, Characteristic impedance, Propagation Coefficient, Phase and group velocities, Standing waves, Lossless line at radio frequencies, Voltage standing wave ratio, Slotted line measurements at radio frequencies, Transmission lines as circuit elements, Smith chart, Single and double Stub matching, Time domain reflectometry, Telephone lines and cables, Radio frequency lines.	To learn about transmission and radiation.
V	**Fiber optic communications:** Principles of light transmission in a fiber, Propagation within a fiber, Effect of index profile on propagation, Modes of propagation, Single mode propagation, Losses in fibres, Dispersion, Fiber optic communication systems.	Learning about fiber optics.

CLASS:M.Sc.III(SEM)

Subject:CONDENSED MATTER PHYSICS(Code:H-3027)

UNIT	MODULE
I	**Crystal Physics and Defects in Crystals:** Crystalline solids, unit cell and direct lattice, Bravais lattice in two dimensions (plane lattice) and three-dimensional (space lattice), Closed packed structures.
II	Interaction of X-rays with matter, Absorption of X-rays, X-ray diffraction, The Laue, powder and rotating crystal methods, The reciprocal lattice and its important properties and applications, Diffraction intensity, Atomic scattering factor, Geometrical structure factor.
III	**Crystal imperfections:** Point defects, line defects and planer (stacking) faults. Estimation of dislocation density from X-ray diffraction measurements. The observation of imperfections in crystals: electron microscopic techniques.

IV	**Electronics Properties of Solids:** Electrons in a periodic lattice: Bloch theorem, The Kronig-Penny Model, Effective mass of an electron, Tight-binding approximation, Cellular and pseudopotential methods, Fermi surface: Fermi surface and Brillouin zones, Anomalous skin effect, Cyclotron resonance, de Hass van Alphen effect, Magnetoresistance, Hall effect in semiconductors **Superconductivity:** Elements of BCS theory, Flux quantization, Meissner effect, Critical temperature, Persistent current.
V	**Ferromagnetism:** Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, Ferromagnetic domains, The Bloch-wall, Spin waves and magnons, Curie- Weiss law for susceptibility, Ferri and antiferro-magnetic order.

Course Outcome: After completion of this course students would be able to comprehend important topics in condensed matter physics.

CLASS:M.Sc.III(SEM)

Subject:NUCLEAR AND PARTICLE PHYSICS (Code:H-3029)

UNIT	**MODULE**	**Specific Outcomes**
I	**Introductory Concept of Nuclei:** Binding energy and Binding energy per nucleon, Nuclear angular momentum, Nuclear magnetic dipole moment and Electric quadruple moment, Parity quantum number, Statistics of nuclear particles, Isobaric spin concept, Systematic of stable nuclei.	Learning properties of nucleus.
II	**Nuclear Disintegration:** Simple theories of decay, Properties of neutrino, Non-conservation of parity and Wu's experiment in beta decay, Electron capture, Internal conversion.	Learning nuclear decyas.

III	**Inter Nucleon Forces:** Properties and simple theory of the deuteron ground state, Spin dependence and tensor component of nuclear forces, Nucleon- nucleon scattering at low energy, Charge- independence of nuclear forces, Many – nucleon systems and saturation of nuclear forces, Exchange forces, Elements of meson theory.	To learn about nuclear forces.
IV	**Nuclear Structure and Models:** Fermi gas model, Experimental evidence for shell structure in nuclei, Basic assumption for shell model, Single- particle energy levels in central potential, Spin-orbit potential and prediction of magic numbers, Extreme single- particle model, Prediction of angular momenta, Parities and magnetic moment of nuclear ground states, Liquid drop model, Semi- empirical mass formula, Nuclear fission, The unified model.	Learning nuclear models.
V	**5.Particle Physics:** Properties and origin, Elementary particles, Properties, classification, type of interactions and conservation laws, Properties of mesons, Resonance particles, Strange particles and Strangeness quantum number, Simple ideas of group theory, Symmetry and conservation laws, CP and CPT invariance, Special symmetry groups SU (2) and SU (3) classification of hadrons, Quarks, Gell-Mann- Okubu mass formula.	Learning classification of elementary particles and symmetries.

CLASS:M.ScIII(SEM)

Subject:SPECIAL PAPER-I (ELECTRONICS)(Code-H-7027)

UNIT	MODULE
	Operational Amplifier Basic and Application: Review of Feedback, Linear Circuit, Op-Amp Basic, Inverting and Non-inverting amplifiers, Unity follower, Summing amplifiers, Integrator, Differentiator, Op- Amp Specifications- DC Off-set parameter, Frequency parameters, Imperfection in Op- Amplifier application- multiple stage gain, Voltage summing and subtraction, Current controlled voltage ource, Voltage controlled current source, Rectifiers and Limiters, Comparators and Schmitt Triggers, Active filters.

	Digital Logic Gates: Symbols and truth tables, Classes of digital integrated circuits (Diode logic, DTL, TTL, ECL, MOSFET, CMOS), Transistor- Transistor Logic (TTL), Single Input TTL Inverter (transfer characteristic), Multi- collector transistors, Propagation delays, Diode Logic, DTL NAND Gate (transfer characteristic, noise immunity, fan out), Emitter Coupled Logic (transfer characteristic of OR/NOR gate, practical implementation, MOSFET Logic- Review of MOSFET, MOSFET Inverter with active load, MOSFET NOR and NAND gates, Complementary MOS (CMOS)- CMOS inverter, CMOS NOR and NAND, Power dissipation in CMOS, Advantages/Disadvantages of CMOS.
	Digital Electronics and Logic Gate: Binary, Octal, Hexadecimal number system, Base conversion system, Bipolar junction and Field Effect transistor as switches, Basic digital logic gates (OR, AND and NOT, NOR, NAND and Exclusive OR), XOR gate, Boolean laws and theorem, Sum of Product (SOP) and Peroduct of Sum (POS) method, Karnaugh map, pair, quad and octave, POS simplification, min-term, max-term.
	Application of Digital Logic Gate: Half adder and Full adder circuit, multiplexers, demultiplexer, **Flip- Flop and Registers-** RS Flip Flop, D- Flip Flop, T- Flip Flop, JK- Flip Flop, JK Master- Slave Flip Flop, Astable, Monostable and Bi-stable multivibrator, types of registers, serial-in-serial out, serial-in-parallel out, parallel-in-serial out, parallel-in parallel out, **Counters and Convertors-** asynchronous and synchronous counter, Mod-3 and Mod-5 counters, shift counters, Digital-to Analog Converters-D/A converter, ladder network, A/D converters.
	Microprocessor-Intel 8085 microprocessor architecture, interfacing devices, BUS timing, instruction set, simple illustrative program.

Course Outcome: After completion of this course students would be able to comprehend OP-AMP and digital electronics.

CLASS:M.Sc.IV(SEM)

Subject:COMPUTATIONAL METHOD AND PROGRAMMING(Code-H-4027)

UNIT	MODULE	**Specific Outcome**
I	**Computational methods:** Methods for determination of zeros of linear and nonlinear algebraic equations and transcendental equations, Bisection method, Muller's method, Quotient-difference method, Newton-Raphson method Solution of simultaneous linear equations, consistency of a system of linear equation, Gaussian elimination, LU decomposition method, matrix inversion, Jacobi iterative method, Gauss-Seidel method, convergence of Gauss-Seidel method	To learn about method to find roots.
II	Diagonalization of matrices, Eigen values and eigenvectors of matrices, Power and Jacobi method. Finite differences, Newton's formula for interpolation, Gauss, Stirling, Bessel's, Everett's formulae, Divided differences, Newton's general interpolation formula, Lagrange's interpolation formula.	To learn about matrices and interpolations.
III	Numerical differentiation, Numerical integration, Trapezoidal rule, Simpson 1/3 and 3/8 rules, Boole's and waddles rules, Newton-Cote's formula, Euler-Maclaurin formula, Gauss quadrature formula. Method of Least square curve fitting, straight line and quadratic equation fitting, curve fitting of curves y =axb, y =aebx, xya= b and y = abx, curve fitting by sum of exponentials, data fitting with cubic splines.	Learning differentiation and curve fitting.
IV	Numerical solution of ordinary differential equations, Euler, Picard and Runge-Kutta methods, Predictor and corrector method, elementary ideas of solutions of partial differential equations, solution of Laplace equation	To learn methods to solve differential equations.
V	**Programming:** elementary information about digital computer principles, compilers, interpreters and operating systems, Fortran programming, flow charts, integer and floating point, arithmetic expressions, built in functions, executable and non executable statements, IF statements, GO TO statements,	Learning Fortran programing.

	DO loop and implied DO loop, simple computer programmes.	

CLASS:M.Sc.IV(SEM)

Subject:PHYSICS OF NONOMATERIALS(Code-H-4028)

UNIT	MODULE
I	**Introduction to Nanostructure Materials:** Nanoscience& nanotechnology, Size dependence of properties, Moor's law, Surface energy and Melting point depression of nanoparticles, Free electron theory (qualitative idea) and its features, Idea of band structure, insulators, semiconductors and conductors, Energy band gaps of semiconductors, Effective masses and Fermi surfaces, Localized particles, Donors, Acceptors and Deep traps, Mobility, Excitons, Density of states, variation of density of states with energy and size of crystal.
II	**Quantum Size Effect:** Quantum confinement, Nanomaterials structures, Quantum well, Quantum wire and Quantum dot, Fabrication techniques.
III	**Characterization techniques of Nanomaterials:** Determination of particle size, XRD (Scherrer's formula), Increase in width of XRD peaks of nanoparticles, Shift in absorption spectra peak of nanoparticles, shift in photoluminescence peaks, Electron microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe microscopy (SPM), Scanning Tunneling Electron Microscopy (STEM) and Atomic Force Microscopy (AFM).
IV	**Synthesis of Nanomaterials:** Key issues in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches, Cluster beam evaporation, Ball Milling, Chemical vapor deposition, capping agents, Carbon nanotubes (CNT)-Synthesis, Properties and Applications.

Course Outcome: After completion of this course students would be able to comprehend nanomaterials.

CLASS:M.Sc.IV(SEM)

Subject:SPECIAL PAPER-IV (ELECTRONICS)(Code-H-8030)

UNIT	MODULE
I	**Materials for Integrated Circuits** Classification of IC, CMOS Process Overview , Electronic grade silicon , Crystal growth ,Czeehralski and float zone crystal growing methods, Silicon shaping lapping , Polishing and wafer preparation,
II	**Hot Processes-I: Oxidation and Diffusion** Oxidation of silicon, oxide deposition by thermal dry oxidation and wet oxidation method Diffusion Process, Diffusion Coefficient, Fick's 1st and 2nd Laws of Diffusion, Vacancy – Impurity interactions, Dopants and Dopant Sources , Doping by Diffusion, ion implantation, Diffusion Process Control, Diffusion Systems, Implantation Technology, Selective Implantation, Junction depth, Channeling, Lattice Damage, Annealing ,Dopant Diffusion and Related Operations: Equipment for Diffusion and Related Operations.
III	**Thin Films: Metals and Nonmetals** Vacuum Science and Technology, Evaporation theory and electron beam evaporation, evaporation system, idea of DC and R.F. sputtering system, Physical vapor deposition methods, Design construction of vacuum coating units, Chemicals Vapor Deposition, Reactors for Chemical Vapor Deposition, CVD Applications, Epitaxy methods for thin film deposition, Vapor-Phase Epitaxy,
IV	**Photolithography, Photoresist Processing and Etching** Wafer Cleaning methods, Wafer Preparation method: Vapor HMDS Treatment for adhesion improvement of photoresist, photoresist coating methods, soft backing of photo resist, post exposure backing of photo resist, Negative photoresist, Positive photoresist, Contrast and sensitivity of photoresist, Chemical Modulus Transfer Function (CMTF) of Photoresist, Resist Exposure (single, bi-layer and multi level photoresist exposure) and Resist Development, Hard Baking and Resist curing, Photolithographic Process Control. Photolithography: An Overview, lithography, Raleigh criterion for resolution, Photolithography source, Resolution and numerical aperture, Photolithographic methods: Contact, proximity and projection and their resolution limit, Photo mask and mask Alignment, Limitations of optical lithography, Concept of phase-shift mask, Idea of

	electron beam lithography, Electron optics, Idea of an X-ray lithography and x-ray mask, Wet chemical dry etching for material removal, Reactive plasma etching, Ion milling,
V	**Interconnections and Contacts and Packaging and Yield** Ohmic Contact Formation, Contact Resistance, Electromigration, Diffused Interconnections, Polysilicon Interconnections, Buried Contacts, Butted Contacts, Silicides, Multilayer Contacts, Liftoff Process, Multilevel Metallization. Testing, Die Sepration, Die Attachment, Wire Bonding, Packages, Flip-Chip Process, Tape-Automated-Bonding Process, Yield, Uniform and Nonuniform Defect Densities.

Course Outcome: After completion of this course students would be able to understand advanced topics in electronics.

CLASS:M.Sc.IV(SEM)

Subject:SPECIAL PAPER-III (ELECTRONICS)(Code-H-8027)

UNI	MODULE

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I	**Digital communication:** Elements of a digital communication system, sampling theorem – Low Pass and Band Pass signals, Pulse Amplitude Modulation, Natural sampling. Flat – top sampling, Other forms of Pulse Modulation, Pulse Code Modulation, uniform and non-uniform Quantization of signals, Quantization error, Differential PCM, Delta Modulation, Adaptive Delta Modulation.
II	**Digital Modulation techniques:** Principle of Binary Phase Shift Keying (BPSK), Generation and Reception of BPSK, Bandwidth of BPSK Signal , Differential Phase Shift Keying (DPSK); DPSK Transmitter and Receiver, Bandwidth of DPSK Signal, Quadrature Phase Shift Keying (QPSK); QPSK transmitter and Receiver, Bandwidth of QPSK Signal, Binary Frequency Shift Keying (BFSK), BFSK Transmitter and receiver, Amplitude Shift Keying (ASK).
III	**Random Variables, Probability Distributions, Random Processes,** Mathematical representation of Noise: Sources of noise. Frequency domain representation of noise, effect of filtering on the probability density of Gaussian noise, Spectral components of noise, Response of a narrowband filter to Noise, effect of a filter on the power spectral density of noise, Superposition of noises, Mixing involving noise, Linear Filtering of Noise.
IV	**Data Transmission:** Baseband signal receiver, probability of error Optimum filter probability of error for Optimum receiver, Matched filter, Impulse response of Matched filter, probability of error of a Matched filter Correlation.
V	**Satellite Communication:** Introduction to Satellite Systems, Types of Satellites, Frequency Allocations, Satellite orbits; orbit fundamentals, Orbit shape, Height of Geostationary orbit, Law governing satellite motion; Kepler's Laws, Antenna Look Angles determinations, Orbital Elements, Orbit Perturbations, Inclined Orbits, Global Positioning Systems, Satellite link power budget equation, system Noise, carrier to noise ratio for uplink and downlink, combined uplink and downlink carrier to noise ratio.

Course Outcome: After completion of this course students would be able to understand digital communication, few topics in probability theory, data transmission and satellite communication.