**DEPARTMENT OF PHYSICS**
**HIMACHAL PRADESH UNIVERSITY**
**(NAAC Acredited Grade 'A' University)**
**SHIMLA-171005**

# Syllabus for Entrance Test of M.Sc. Physics

**Note: -** *(i) There will be 100 multiple choice questions of one mark each.*
*(ii) There shall be no negative marking.*

## 1. MECHANICS

Coordinate systems and motion of a particle, volume, velocity and acceleration in cartesian and spherical co-ordinate systems, solid angle, space time symmetry and conservation laws, frames of reference, inertial frames of reference, Galilean transformation and Galilean invariance, non-inertial frames, coriolis force and its applications, Foucault's pendulum.

Newton's law of Gravitation, various forces in nature, central and non-central forces, inverse square force, centre of mass, equivalent one body problem, reduced mass, angular momentum in central force field, equation of motion under a force law, equation of orbit and turning points, relationship between eccentricity and energy, Kepler's laws, rotational motion, angular velocity, angular momentum, torque, conservation of angular momentum, elastic and inelastic collisions, coefficient of restitution, elastic collisions in laboratory and centre of mass systems, velocities, angle and energies in elastic collisions in laboratory and centre of mass system, cross- section for elastic scattering, Rutherford scattering.

Special theory of relativity, concept of stationary universal frame of reference, Michelson- Morley experiment, postulates of special theory of relativity, Lorentz transformations, observers in relativity, relativity of simultaneity, length contraction, time dilation, relativistic addition of velocities, relativistic Doppler effect, variation of mass with velocity and mass energy equivalence, increase of mass in an inelastic collision, relativistic momentum and energies, transformations of momentum and energy, Minkowsky space. **(10 Marks)**

## 2. ELECTRICITY AND MAGNETISM

Scalar and vector product, gradient, divergence & curl and their significance, line, surface and volume integrals of vector fields, Gauss-divergence theorem, Stokes's theorem, Green's theorem.

Electrostatic force, electrostatic field, electric flux, Gauss' theorem of electrostatics, electric field due to a point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor, electrostatic potential, electrostatic potential energy, electric potential due to a dipole and quadrupole, electric potential energy, electric field as a gradient of a scalar potential, calculation of electric field due to a point charge and a dipole from potential, Poisson and Laplace equations, electric current and current density, continuity equation, Ohm's law.

Ampere's circuital law and its applications, Hall effect, divergence and curl of magnetic field, behavior of various substances in magnetic field, magnetic permeability and susceptibility and their interrelation, orbital motion of electrons and diamagnetism, electron spin and paramagnetism, ferromagnetism, domain theory of ferromagnetism, magnetization curve, hysterics loss.

Dielectrics, parallel plate capacitor with a dielectric, dielectric constant, polarization and polarization vector, displacement vector, Claussius – Mossotti equation, polarization of matter, atomic and molecular dipoles, induced dipole moment and atomic polarizability, electric susceptibility and polarization vector, Gauss' law, displacement vector, energy stored in a dielectric medium.

**(15 Marks)**

**3. ELECTROMAGNETIC THEORY**

Electromagnetic (EM) waves and its charcterstics, EM spectrum, Maxwell's equations and its physical interpretation, displacement current, Electromagnetic wave equation, Poynting vector, Poynting theorem, impedence of a dielectric to EM waves, EM waves in conducting medium and skin depth, EM waves velocity in a conductor and anomalous dispersion.

**(05 Marks)**

**4. THEMODYNAMICS AND STATISTICAL MECHANICS**

Basic ideas of statistical physics, probability, distribution of four distinguishable particles in two compartments of equal sizes, macro-states and micro-states, thermodynamic probability, distribution of *n* particles in two compartments, equilibrium state of a dynamic system, distribution of *n* distinguishable particles in *k* compartments of unequal sizes.

Phase space, classical statistics, Maxwell-Boltzmann statistics, Maxwell Boltzmann's law of distribution of molecular speeds, quantum statistics, indistinguishability of particles and its implications, Bose-Einstein statstics, Planck's law of radiation, Rayleigh-Jeans law, Wien's distribution law and Stefan's law, Fermi-Dirac statistics, free electrons gas, fermi level, fermi energy.

Reversible and irreversible processes, laws of thermodynamics, thermoelectric effects, P-V diagrams, entropy, additive nature of entropy, law of increase of entropy, entropy and disorder, entropy of a perfect gas, heat death of the universe, Maxwell's thermodynamic relations and their applications, enthalpy, Gibbs, Helmholtz and internal energy functions, Clausius-Clapeyron equation, Joule-Thomson effect for liquification of helium, adiabatic demagnetization.

**(10 Marks)**

**5. WAVES AND OPTICS**

Simple harmonic motion (SHM), characteristics, phase relation between displacement, velocity and acceleration of a particle executing SHM, SHM in a mechanical oscillator (mass attached to a spring placed on horizontal frictionless surface), energy of a simple harmonic oscillator, solution of the differential equation of SHM, average kinetic energy, average potential energy and total energy.

Damped oscillations, differential equation of motion of one dimensional damped harmonic mechanical oscillator, types of damping, damped harmonic electric oscillator, damping constants, logarithmic decrement, relaxation time, the quality factor, power dissipation in a damped harmonic oscillator, relation between power dissipation energy and relaxation time of damped harmonic oscillator, forced oscillator, transient and steady behaviour of forced oscillator, power supplied to an oscillator and its variation with frequency, Q- value and band width, Q-value as an amplification factor, coupled oscillators, stiffness coupled pendulums.

normal co-ordinates and normal modes of vibration, inductance coupling of electrical oscillators.

Wave motion, type of waves, wave equation, characteristic impedance of a string, impedance matching, reflection and transmission of energy, standing waves on a string of fixed length, energy of a vibrating string, wave velocity and group velocity.

Electromagnetic nature of light, wave front, Huygens principle, interference, Young's double slit experiment, Lloyd's mirror and Fresnel's biprism, interference in thin films, parallel and wedge-shaped films, Newton's rings.

Michelson's interferometer, diffraction, Fraunhofer diffraction, diffraction grating, Fresnel diffraction, half-period zones, zone plate, polarization, Malus' law, double refraction, birefringence, Nicol prism, quarter wave plate and half wave plate, Brewster law, circular and elliptical polarized light. **(10 Marks)**

## 6. Atomic and Molecular Physics

Planck's constant, photons, photo-electric effect, Compton scattering, de-Broglie hypothesis, wave-particle duality, Davisson-Germer experiment, Rutherford model, Bohr's model of atom, quatum theory of hydrogen like atom.

X-rays, ionizing power, X-ray diffraction, methods of X-ray differaction, X-rays-Spectra: continuous and characteristic X-rays, Moseley law.

Electron angular momentum, space quantization, electron spin and spin angular momentum, Larmor's theorem, spin magnetic moment, Stern- Gerlach experiment, electron magnetic moment and magnetic energy, gyromagnetic ratio and Bohr Magneton, Zeeman effect, normal and anomalous Zeeman effect, Pauli's exclusion principle, symmetric and antisymmetric wave functions, fine structure, spin orbit coupling, spectral notations for atomic states, total angular momentum, spin-orbit coupling in atoms, L-S and J-J couplings.

Molecular spectra, rotational energy levels, selection rules and pure rotational spectra of a molecule, vibrational energy levels, selection rules and vibration spectra, rotation-vibration energy levels, selection rules and rotation-vibration spectra, determination of internuclear distance.

Raman effect, characteristics of Raman lines, Stoke's and Anti-Stoke's lines. complimentary character of Raman and infrared spectra.

Lasers, metastable states, spontaneous and stimulated emissions, optical pumping, population inversion, Ruby laser and He-Ne laser. **(10 Marks)**

## 7. BASICS OF QUANTUM MECHANICS

Basic postulates of quantum mechanics, properties of the wave function, interpretation of the wave function, probability density and probability current density, conditions for physical acceptability of wave functions, normalization, continuity and single-valuedness, linearity and superposition principles, eigenvalues and eigenfunctions, position, momentum and energy (Hamiltonian) operators, commutator of position and momentum operators, expectation values of position and momentum, time dependent Schrodinger equation, wave function of a free particle, time independent Schrodinger equation and its applications to particle in a box, step potential, square well potential and simple harmonic oscillator, Heisenberg uncertainty principle.

Quantum theory of hydrogen atom, Schrodinger equation for hydrogen atom in spherical polar coordinates, soltuions using separation of variables, principal, orbital and magnetic quantum numbers, electron probablity density, selection rules. **(10 Marks)**

**8. SOLID STATE PHYSCS**

Crystal structure and crystal bonding, lattice translation vectors, lattice with a basis, unit cell, Miller indices, reciprocal lattice, types of lattices, Brillouin zones, diffraction of X-rays by crystals, Bragg's law, Laue equations, atomic and geometrical factor, potential between a pair of atoms, Lennard-Jones potential, ionic, covalent and Vander – Waal's bonding, calculation of cohesive energy for ionic and inert gas system.

Lattice vibrations and phonons, linear monoatomic and diatomic chains, acoustical and optical Phonons, qualitative description of the phonon, spectrum in solids, specific heat, Dulong and Petit's law, Einstein and Debye theories of specific heat of solids.

Free electron theory of metals, Fermi gas, density of states, Fermi energy and Fermi velocity, electronic contribution to specific heat of metals, band theory of metals, Kronig Penny model, electrons in periodic structure, energy bands, energy gaps, effective mass of electron, electron mobility, metals, insulators and semiconductors.

Superconductivity, Meissner effect, Type I and Type II superconductors, London's equation and penetration depth, isotope effect, cooper pairs, BCS theory.

**(10 Marks)**

**9. BASIC CONCEPTS IN ELECTRONICS**

Semiconductros, *p-n* junctions, V-I characteristics, Zener diode, tunnel diode, LED and LCD, solar cell, half wave, full wave and bridge rectifier, filter circuits. Transistors, characteristics of a transistor in CB, CE and CC mode, field effect transistor, depletion and enhancement mode, MOSFET, amplifiers, principle of operation, emitter follower, feedback in amplifiers, negative feedback and stability.

Oscillators, Braukhausen criteria for oscillations, tuned collector, Hartley and Colpitts oscillators, phase shift oscillators, operational amplifiers, inverting and non-inverting amplifiers, operational amplifier as adder, subtractor, comparator, integrator and differentiator. **(05 Marks)**

**10. NUCLEAR AND PARTICLE PHYSICS**

General properties of nuclei, constituents of nucleus and their intrinsic properties, non-existence of electrons in nucleus, charge density, nuclear mass, nuclear force, binding energy, binding energy versus mass number curve, nuclear radius, angular momentum, parity, magnetic moment, quadrupole moments,

Liquid drop model, semi empirical mass formula and significance of various terms, nuclear stability, two nucleon separation energies, evidence for nuclear shell structure, nuclear magic numbers, nuclear shell model and its applications.

Radioactive decay, laws of radioactive decay, mean life and half life, alpha ($\alpha$) decay, theory of $\alpha$-emission, Gamow factor, Geiger-Nuttall law, beta-decay, energy kinematics for beta-decay, positron emission, electron capture, neutrino hypothesis, gamma decay, gamma ray emission and kinematics, internal conversion.

Nuclear reactions, types of reactions, conservation laws, kinematics of reactions, Q-value of reaction, nuclear fission, nuclear fusion, reaction rate, reaction cross section, compound and direct reactions, resonance reactions, Coulomb scattering.

Interaction of nuclear radiation with matter, Bethe-Bloch formula, Cerenkov radiation, detector for nuclear radiations, gas detectors, ionization chamber and GM counter, Scintillation detectors and construction of photo-multiplier tube, semiconductor detectors (Si & Ge) for charge particle and photon detection, Van-de Graaff generator, linear accelerator, cyclotron, synchrotron.

Four fundamental interactions: electromagnetic, weak, strong and gravitational interactions, classification of elementary particles, intrinsic quantum number associated with elementary particles: lepton number, baryon number, isospin, strangeness, hyper charge, GellMann-Nishijima relation, conservation laws, charge conjugation (C), parity (P), time reversal (T), CPT theorem, parity violation in weak interactions, particle symmetries.

Introduction to quarks, basic properties (charge, mass, spin, baryon number) of quark, quantum number of quarks, quark model, quark composition of meson and baryons, color quantum number.

Cosmic rays, origin of cosmic rays, primary and secondary cosmic rays, hard and soft components, the altitude effect, the latitude effect, east–west asymmetry, cosmic rays showers. **(15 Marks)**