DR. B. R. AMBEDKAR UNIVERSITY

SYLLABUS

PHYSICS

M. Sc. Previous & Final

2018

PHYSICS

M.Sc. (Previous)

Note—There shall be four written papers each of 100 marks and a practical examination of 200 marks. Each written paper shall consist of five units. At least two questions shall be asked from each unit and a candidate shall be required to answer any one question from each unit.

Paper I—Mathematical & Computational Methods in Physics

Unit I—Vector spaces and Matrices; linear independence; Bases; Dimensionality; Inner/product, Linear transformations; Matrices: Inverse; orthogonal and unitary matrices; Independent elements of a matrix; Eigenvalues & eigenvectors; Diagonalization; Complete orthonormal Sets of functions.

Unit II—Differential Equations and special Function: Second order linear ODES with variable coefficients: Solution by series expansion: Legendre, Bessel. hermite and Laguarre equations; Physical applications: Generating functions; recursion relations.

Unit III—Integral Transforms, Laplace transform; First and second shifting theorems; Inverse LT by partial fractions; LT of derivative and integral of a function; Fourier series; FS or orbitrary period. Half-wave expansion; Partial sums; Fourier integral and transformes; FT of delta function.

Unit IV—Methods for determination of zeroes of linear and non-linear algebraic equations and transcendental equations, convergence of solutions. Solution of simultaneous linear equations, Gaussian elimination, pivoting, iterative method. matrix inversion. Eigenvalues and eigenvectors of matrices, Power & Jacobi Method. Finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, Polynomial least squares and cubic spline fitting.

Unit V—Numerical differentiation and integration, Newton-Cotes formula, error estimates, Gauss method. Random variate. Monte carlo evaluation of integrals, Methods of importance sampling. Random walk and Metropolis method Numerical Solution of ordinary differential equations, Euler & Runge Kutta Methods, Predictor & corrector method. Elementary ideas of solutions of partial differential equations.

Paper II—Classical Mechanics & Statistical Mechanics

Unit I—Preliminaries; Newtonion mechanics of one and many particle systems; Conservation laws, work-energy theorem; open systems (with variable mass). Constraints; their Classification: D'Alembert's principle, generalized co-ordinates. Langrange's equations; gyroscopic forces; dissipative systems; Jacobi integral; guage invariance; generalized co-ordinates and momenta; integrals of motion; Symmetries of space and time with conservation laws; invariance under Galilean transformations.

Unit II—Rotating frames, inertial forces; terrestrial and astronomical applications of coriolis force. Central force; definition and characteristics; Two-body problem; closure and stability of Circular orbits; general analysis of orbits; Kepler's laws & equation; artificial satellites; Rutherford scattering. Principle of least action; derivation of equations of motion; variation and end points; Hamilton's principle and characteristic functions; Hamilton-Jacobi equation.

Unit III—Canonical transformation; generating functions; Properties; group property; examples; infinitesimal generators; Poisson bracket; Poisson theorems; angular momentum PBs; small oscillations; normal modes and coordinates. Foundations of Statistical mechanics; specification of states of a system, contract between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox.

Unit IV—Microcanonical ensemble, phase space, trajectories and density of states, Liouville's theorem, canonical and grand canonical ensembles, partition function, calculation of statistical quantities, Energy and density fluctuation. Density matrix, statistics of ensembles, statistics of indistinguishable particles, Maxwell-Boltzman, Fermi-Dirac and Bose Einstein statistics, properties of ideal Bose and Fermi gases, Bose-Einstein Condensation. 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.

Unit V—Landau theory of phase transition, critical indices, scale transformation and dimensional analysis. Correlation of space-time dependent fluctuations, fluctuations and transport phenomena, Brownian motion, Langevin theory, fluctuation dissipation theorem. The Fokker-Planck equation.

Paper III—Atomic and Molecular Physics

Unit I—Quantum states of one electron atoms-Atomic orbitals Hydrogen Spectrum. Pauli's Principle spectra of alkali elements-spin orbit interaction and fine structure in alkali spectra, Magnetic moment of an atom, Lande gactor, Transition rules L-S and J-J Coupling, Single and triple spectra in alkaline earth. Penetrating and non-penetrating orbits.

Unit II—Equivalent and non-equivalent electrons-Normal and anomalous Zeeman effect. Paschan Back effect, Stark effect, Pauli's Exclusion Principle and Periodic Table, Hyperfine structure. Magnetic quantum numbers.

Unit III—Types of molecules-Diatomic linear Symmetric top. assymetric top and spherical top molecules. Rotational spectra of diatomic molecules as a rigid rotator Energy levels and spectra of non rigid rotor intensity of rotational lines. Stark modulated microwave spectrometer (qualitative). Salient feature of Vibrational Spectra, Explanation Considering molecule as harmonic oscillator.

Unit IV—Nature of Raman effect, Experimental arrangement, Quantum theory of Raman effect, Pure rotational Raman Spectrum, Stokes and Antistoks lines, Raman Spectra and Molecular structure. Mechanism of Flourescent and Phosphores-cent Emission, Chemi Luminescence.

Unit V—Characteristics and continuous X-Ray spectra, Kossel's Explanation of characteristic X-Ray spectra, continuous X-Ray Spectra and its short Wave length limit, X-Ray Emission Spectra the Moseley Law X-Ray absorption spectra, Fine Structure of absorption edges, Fine structure in X-ray emission Spectra. Screening and Spin relativity, Doublets, X-Ray Spectra and Optical Spectra.

Paper IV—Electrodynamics and Plasma Physics

Unit I—Review of Four Vector and Lorentz Transformation in Four Dimensional Space, Electromagnetic Field tensor in Four Dimensions and Maxwell's equations, Dual field Tensor, wave Equation for vector and Scaler potential and solution Retarded Potential and Lienard Wilchert Potential, Electric and Magnetic field, due to a Uniformly Moving charge and An accelerated change, Linear and circular Acceleration and Angular Distribution of power radiated, Bremsstralling, Synchrotron Radiation and cerenkov Radiation, Reaction force of Radiation.

Unit II—Motion of Charged particle in Electromagnetic Field : Uniform E and B Field, Non uniform field, Diffusion Across Magnetic field, Time varying E and B field, Adiabatic invariants : First second third Adiabatic invariants.

Unit III—Potential in terms of charge distribution. Dipole interaction. The displacement vector. Boundry conditions. Electric field in a material medium. Polarisability, Clausins Mosotti relation Langevin's theory of dielectric polarisation Piezo Pyro and Ferro Electricity. Solution of Laplace's equation in spherical Coordinates by method of separation of variables Potentials of a point charges. A dielectric sphere in uniform field, charged ring.

Unit IV—Elementary Concepts : Derivation of moment Equations from Boltzman Equation, Plasma oscillation, Debye Shielding, Plasma Parameters, Magnetoplasma, Plasma confinement. Hydrodynamical Description of Plasma: Fundamental equations. Hydromagnetic waves : Magnetosonic and Alfven waves.

Unit V—Wave phenomena in Magnetoplasma : Polarization Phase Velocity, group Velocity, Cut offs Resonance for Electromagnetic wave propagating parallel and perpendicular to the Magnetic field, Propagation at finite Angle and CMA Diagram, Appleton Hartee formula and propagation through inosphere and Magnetosphere Helicon, whistler Faraday Rotation.

M. Sc. (Prev.) Physics

Practical

Every candidate shall perform at least 15 experiments.

List of Experiments :

1. 'y' of glass plate by Cornu's method. 2. Viscosity of a fluid by rotation/Viscometer. 3. Velocity of Ultrasonic waves in a liquid. 4. 'γ' Biprism and to find thickness of mica sheet. 5. Refractive indices of gasses by Fabry Parot Etalon. 6. To study rotatory dispersion of quartz. 7. Verification of Fresnel's laws of reflection. 8. To analyse elliptically polarised light by Babinet Compensator. 9. B H Curve and hysteresis loss by ballistic Galvanometer. 10. To determine absolute capacity by B. G. 11. Michelson's interferometer 'γ' and Δγ, thickness of mica sheet. 12. Spectra calibration by constant deviation spectrometer. 13. Jamin's refractometer. 14. Study of Zeeman's effect. 15. Determination of Hall constants of metal. 16. Assembly of Power Supply. 17. L. C. R. at high frequencies. 18. Ripple factor for different electrical and electronic circuits. 19. Study of multivibrator circuits. 20. Verification of principle of digital transformation. 21. Assembly of ionic gates and their verifications by truth tables. 22. Study of basic circuits in the construction of computers. 23. Study of passive filters. 24. Study of active filters.

Distribution of Marks :

Practical (s)	100 marks
Viva-Voce	60 marks
Record	40 marks
Total	200 marks

PHYSICS

M.Sc. (Final)

Note—There shall be four written papers (Paper I and II shall be compulsory and the last two papers III (A) and IV (A) or Papers III (B) or IV (B), each of 100 marks and a practical of 200 marks. Each written paper shall consist of five units. At least two questions shall be asked from each Unit and candidate shall be required to answer any one question from each Unit.

Paper I—Quantum Machanics

Unit I—Operator Algebra and Hydrogen Atom : Linear operators, Null operator, Identity operator, Singular and Non-singular operator, Eigen functions and Eigen values orthogonal eigen functions, The operator formalism in quantum mechanics, Momentum operator, Hamiltonian operator, commutation in operators, Hermitian operator, Properties of Hermitian operator, Parity operator, Postulates of quantum mechanics, coordinate and momentum representation, superposition of eigen states, continuous spectrum, Equation of motion, Ehrenfest's theorem, simultaneous measurements and commuting operators, Schwartz inequality, Heisenberg uncertainty relation derived from operator, commutator algebra, Angular momentum operator, Commutation relation for Lx, Ly and Lz, Ladder operators. Completeness of eigen functions, Dirac-delta function, bra and ket notation, Matrix representation of an operator, Unitary transformation. The Schrodinger equation for spherically symmetric potentials, Degeneracy, Hydrogen atom, Radial equation, Eigen value, Radial Probability.

Unit II—Approximation Methods : Stationary perturbation theory, Non-degenerate case, First order perturbation, second order perturbation, Perturbation of an oscillator, Helium atom, Degenerate case, Removal of degeneracy in first and second order, First order Stark effect in hydrogen, Weak field Zeeman effect. The variational method, Expectation value of the energy, Ground state of Helium. Exchange degeneracy, Heitler-London theory of hydrogen molecule. W K B method and its applications.

Unit III—Scattering Theory and Time Dependent Perturbation, Scattering cross-section, Relation between angles, energies, etc., in laboratory and centre of mass system of co-ordinates, Normalisation of incoming wave, Differential scattering cross-section. Partial waves and phase shifts. Optical Theorem, Born approximation and its validity condition, Study of scattering from a square well potential, and a rigid sphere. Transition probability, Density of continuum states, Golden rule, Harmonic perturbation, Second order peturbation.

Unit IV—Identical particles and Relativistic wave equations : Physical meaning of identity, Distinguishability of identical particles, Symmetric and Antisymmetric wave functions, Construction from unsymmetrised function, Connection of spin and statistics, collision of identical particles with spin, Pauli Spin matrices. Schrodinger relativistic equation for free particles (Klein-Gordan Equation), Dirac relativistic equation, Free particle equation, Properties of Dirac matrices, Free particles solutions, Electron spin, Magnetic moment, Dirac equation of a central field of force, Spin-Orbit coupling, Solution for hydrogen atom, Negative energy states.

Unit V—Quantum theory of radiation, Formulation in terms of transition probability, Matrix elements of the perturbation, Transition probability for absorption, Transition probability for emission, Einstein coefficients. Angular momentum, Integral and Half-integral angular momentum, Spin eigen functions, Conservation rules, Coupling of two angular momenta, Clebsch-Gordon cofficients.

Paper II—Nuclear and Particles Physics

Unit I—Nuclear Interaction and Nuclear Reactions : Nucleon-Nucleon Interaction, Exchange forces and tensor forces; Meron Theory of Nuclear forces, Nucleon-nucleon scattering, Effective Range Theory, Spin dependence of nuclear forces, charge independence and charge symmetry of nuclear forces, Isospin formalism, Yukawa interaction. Direct and compound nuclear reaction mechanism Cross-sections in terms of partial wave amplitudes-Compound Nucleus, Scattering matrix, Reciprocity Theorm, Breit Wigner one level formula-Resonance scattering.

Unit II—Nuclear Models : Liquid drop model, Bohr Wheeler Theory of fission, Experimental evidences for shell effects, shell model, Spin Orbit coupling, Magic Numbers, Angular momenta and parity of ground of nuclear ground states, Qualitative discussion and estimates of transition rates-Magnetic moments and schmidt lines-Collective model of Bohr and Mottelson.

Unit III—Nuclear Decay : Beta decay, Fermi Theory of beta decay-shape of the beta spectrum-Total decay rate-Angular Momentum and parity selection rules-comparatives half lines Allowed and Forbidden Transitions-Selection rules Parity violation. Two component theory of nutrino decay. Detection and properties of neutrino-Gamma decay-Multipole Transition in nuclei-Angular momentum and parity selection rules-Internal conversion Nuclear Isomerism.

Unit IV—Particle Detectors and Accelerators : (a) Detecting Instruments (Electrical) Ionization Chambers, Solid state detection, G.M. Counter, Scintillation counter. (b) Wilson cloud chamber, Diffusion cloud chamber Bubble chamber.

Accelerators : (a) Proton Synchrotron (Variable field and variable Frequency) (b) Electron Synchrotron and Betatron.

Unit V—Elementary Particle Physics : Types of Interaction between elementary particles-Hadrons and leptons-Symmetry and conservation Laws-Elementary ideas of CP and CPT invariance, Classification of hadron-Lie algebra, SU (2) SU (3) multiplects-Quark model-Gell Mann-Okubo mass formula for Octel and decuplet hadron-Charm, bottom and top quarks.

Paper III—(a) Integrated Circuits and Digital Electronics (Spl. Electronics) Integrated Electronics

Unit I—Introduction to Operational Amplifier, Basic Parameters, Applicability of OP-Amp in analog computation, OP Amp as Voltage Follower, Adder, Subtracter, Integrator, Differentiator, log amplifier Antilog amplifier. Analog multimeter & Divider circuit, RMS circuit Function fitting and Time function generation.

Unit II—Active Filters, comparator, Multivibrator, Schmitt Trigger, Sample and hold circuit, Triangular wave generator, Voltage controlled Oscillator, Phase locked loop, Voltage to Frequency and Frequency to voltage converter, A/D and D/A converter circuit, 555 Timer. Noise in Ics.

Digital Electronics

Unit III—Number System, Codes (Grey Code, ASCII code and BCD Code), Basic circuit logic Gate, DTL, RTL, TTL and ECL logic circuits, Analysis and system of combination logic circuit, Karnaugh map, Pairs, Quads and Octaves.

Unit IV—Arithmetic Logic circuits, Half adder, Full Adder, Half Subtracter and Full Subtracter, Controller, Inverter and adder subtracter circuits, Data processing circuits, Multiplexers, Demultiplexers, Encoder and Decoder (1 to 16 Decoder, BCD Decoder and LED decoder).

Unit V—Introduction to Flip-flop, R-S, D, T, J-K and Master slave flip flops, synchronous and asynchronous counters, mod counters, Ring Counter Serial and Paralled shift registers. Introduction to semiconductors memories, RAM, ROM, EPROM and three addressing techniques.

Paper III (b)—Condensed Matter Physics I

Unit I—Crystal Physics and defects in crystals : Crystalling solids, unit cells and direct lattice, two and three dimensional Bravais lattices, closed packed structure. Interaction of X-rays with matter, absorption of X-ray, Elastic scattering from a perfect lattice. The reciprocal lattice and its applications. The Laue, powder and rotating crystal methods, Crystal structure factor and intensity of diffraction maxima. Point defects, line defects and planer (stacking) faults. The role of dislocations in plastic deformation and crystal growth. The observation of imperfections in crystals.

Unit II—Electronic and magnetic Properties of solids : Electrons in a periodic lattice : Bloch theorem, band theory, classification of solids, Effective mass, Tight bonding, cellular and Pseudopotential methods. Fermi surface, de Hass van Alfen effect, cyclotron resonance, magnetoresistance, quantum Hall effect. Weiss Theory of ferromagnetism, Spin waves and magnous curie-weiss law for susceptibility Ferri and antiferro-magnetic order. Domains and Block-Wall energy.

Unit III—Lattice dynamics and optical properties of solids : Inter atomic forces and lattice dynamics of simple metals, ionic and covalent crystals, Optical phonons and dielectric constants. In-elastic neutron scattering. Mossbauer effect, Debye-Waller factor. Anharmonicity, Thermal expansion and thermal conductivity. Interaction of electrons and phonons with Photons. Direct and indirect transitions. Absorptions in insulators, Polaritons, one Phonon absorption, optical properties of metals, skin effect.

Unit IV—Electron-Phonon interaction and Super conductivity : Interaction of electrons with acoustic and optical phonons; Polarons. Super conductivity ; manifestations of energy gap. Critical temperature, persistents currents, Meissner effect. Cooper pairing due to phonons, BCS theory of Superconductivity, Ginzsburg-Landau theory : d-c Josephson effect, a-c Josephson effect. Vortice and type II Superconductors, High temperature superconductors.

Unit V—Crystal Symmetry and X-ray crystallography : External symmetry elements of crystals, concept of point groups. Influence of symmetry on physical properties : Electrical conductivity, Space groups, Experimental determination of space groups, Analytical indexing : Ito's method, Accurate determination of Lattice parameters-Least Square method. Applications of powder method, Oscillation and Buerger's precession methods.

Paper IV—Electronic Communication System (Spl. Electronics)

Unit I—Analog & Digital Communication : Amplitude Modulation, Modulation and Demodulation Techniques, Frequency Modulation, Narrow band and wide band Frequency modulation, PLL as frequency demodulator, Phase modulation. Equivalence between AM, FM & PM modulation Digital modulation, Sampling and quantization, pulse code modulation, ASK, FSK PSK and DPSK, Frequency Division and time division multiplexing.

Unit II—Microwave Electronics : Generation of microwave by reflex klystron and semiconductor gun diode, Waue-guide and cavity resonator, Microwave antenna, Microwave detector, VSWR, power and dielectric measurement. Isolator Directional Coupler, Magic Tee.

Unit III—Satellite & Radar Communication : Satellite orbit, Satellite frequencies, Synchronous satellite, Satellite communication link Factor affecting satellite communication, Transponders. Basic radar system, Pulsed radar, Moving target indicator radar, CW radar, radar cross section Radar display, PPI duplexer radar antenna, Modern radar.

Unit IV—TV and Antenna System : TV system and standard, TV band width and channels, Interlaced scanning and video camera tube, TV transmeter and receiver, Colour television. Antenna system Short electric doublets radiation from one pole and dipole arials, Antenna Parameters, Antenna arrays, Folded dipole application, Yagi antenna, Parasitic antenna, Parabolic reflectors.

Unit V—Fiber Optic Communication : Wave propagation in an isotropic media, Transmission and fiber losses in fiber, Dispersion, optical wave guide, optical fiber source and detector, Coupler, Modern telephone optic mux.

Paper IV (b)—Condensed Matter Physics II

Unit I—Exotic Solids : Structure and Symmetries of liquids, liquid crystals and amorphous solids. A periodic Solids and quasicrystals; Fibonaccy sequence, Penrose lattices and their extension to 3-dimension. Special carbon solids; fullerences and tubules. Electronic properties of tubules. Carbon nanotubule based electronic devices. Definition and properties of nanostructured materials. Methods of synthesis of nanostructured materials. Quantum size effect and its applications.

Unit II—Electrons in solids and surface states : Interacting electron gas : Hartree and Hartree Fock approximations, correlation energy. Screening, Plasma oscillations. Dielectric function of an electron gas in random phase approximation. Limiting cases and Friedel oscillation. Strongly-interacting Fermi system. Elementary introduction to Landau's quasi-particle theory of a Fermi liquid. Strongly correlated electron gas. Elementary ideas regarding surface states, metallic surfaces and surface reconstruction.

Unit III—Disordered systems : Point defects : Shallow impurity of states in semiconductors. Localized lattice vibrational states solids. Vacancies, interstitials and colour centres in ionic crystals. Disorder in condensed matter, substitutional, position and topographical disorder, short and long range order. Atomic correlation function and structural descriptions of glasses and liquids. Anderson model for random systems and electron localization, mobility edge.

Unit IV—Imperfection in crystals : Mechanism of plastic deformation in solids, stress and strain fields of screw and edge dislocations. Elastic energy of dislocation. Forces between dislocations, stress needed to operate Frank-Read source, dislocations in fcc, hcp and bcc lattices. partial dislocations and stacking faults in close-packed structures.

Unit V—Films and Surfaces : Study of surface topography by multiple-beam interferometry, conditions for accurate determination of step height and film thickness (Fizeau fringes). Electrical conductivity of thin films, difference of behaviour of thin films from bulk, Botzmann transport equation for a thin film (for diffused scattering), expression for electrical conductivity for thin films. Elementary concepts of surface crystallography scanning, tunnelling and atomic force microscopy.

M. Sc. (Final) Physics

PRACTICAL (Special Electronics)

List of Experiments for those offering III (A) and IV (A) papers :

Advance Electronics

1. Characteristics of Field Effect Transistor (FET) 2. Characteristics of Silicon Controlled Rectifier 3. Characteristics of Unijunction Transistor (UJT) 4. 'h' parameters of Bijunction Transistor (BJT) 5. Transistor Bias Techniques 6. Transistor Bias Stability 7. Study of Common Emitter (RCC) Amplifier 8. Study of FET Amplifier 9. Study of Feedback Amplifier 10. Study of Operational Amplifier 11. Study of Wien Bridge Oscillator 12. Study of Multivibrators 13. Study of Hartley Oscillator 14. Dielectric Constant by Ziecher Wire 15. Study of Voltage Power Supply with filters 16. Study of Current Power Supply with filters 17. Study of Zenner Regulated Voltage Power Supply

M. Sc. (Final) Physics

Condensed Matter Physics (Spl.)

Laboratory/Practical Course

[List of Experiments for those offering III (B) and IV (B)]

1. Measurement of lattice parameters and indexing of powder photographs. 2. Interpretation of transmission Laue photographs. 3. Determination of orientation of a crystal by back reflection Laue method. 4. Rotation/oscillation photographs and their interpretation. 5. To study the modulus of rigidity and internal friction in metals as a function of temperature. 6. To measure the cleavage step height of a crystal by multiple Fizeaue fringes. 7. To obtain multiple beam Fringers of equal chromatic order. 8. To determine magnetoresistance of a Bismuth crystal as a function of magnetic field. 9. To study hysteresis in the electrical polarization of a TGS crystal and measure the curie temperature. 10. To measure the dislocation density of a crystal by etching. 11. Conductivity of Germanium. 12. Four-Probe method 13. Hall effect 14. Study of Fluorescence materials 15. Study of Ferromagnetic materials.

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