SYLLABUS

MASTER OF SCIENCE

PHYSICS

JODHPUR NATIONAL UNIVERSITY

JODHPUR

Master of Science PHYSICS

PREVIOUS

Paper I	**Classical Mechanics and Mathematical Methods in Physics**
Paper II	**Classical Electrodynamics**
Paper III	**Quantum Mechanics and Atomic & Molecular Physics**
Paper IV	**Electronics, Numerical Methods and Computer Programming**

FINAL

Paper V	**Advanced Quantum Mechanics & Quantum field Theory**
Paper VI	**Nuclear Physics**
Paper VII	**Solid state Physics**
Paper VIII	**Solid State Electronics**
Paper IX	**Industry Based Environmental Studies**

Paper I **Classical Mechanics and Mathematical Methods in Physics**

UNIT I

Holonomic and non- holonomic constraints, D'Alembert's principle, generalized coordinates. Lagarngian, Lagrange's equation and its applications, velocity dependent, potential in Lagrangian formulation, generalized momentum, Legendre transformation, Hamiltonian, Hamilton's Canonical equation, calculus of variation and its application to simple problems, Hamilton's variational principle.

UNIT II

Derivation of Lagrange's and Hamilton's canonical equations from Hamilton's variational principle, extension of Hamilton's principle to non- conservative and non- holonomic systems, method of Lagrange's multipliers, conservation principle and Noeither's theorem, conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space respectively.

UNIT III

Canonical transformation, Integral invariants of Poincare, Lagrange's and Poisson brackets as canonical invariants, Equation of motion in Poisson bracket formulation, Infinite simal canonical transformation and generators of symmetry, Liouville's theorem, Hamilton Jacobi equation and its applications.Action- angle, variables adiabatic invariance of action angle variables, Kepler problem in action angle variables, theory of small oscillations in Lagrangian formulation, normal coordinates and its application, orthogonal transformation, Eulerian angles, Euler theorem, eigen values of the inertia tensor, Euler equations, Force free motion of rigid body.

UNIT IV

Fourier transforms: Fourier integrals, Fourier's transform and inversion theorem, Fatling theorem, application of integral transforms to pulse propagation, Discrete Fourier transform, Fast Fourier transform, Laplace transform, Laplace transform of derivatives and integrals, derivatives integrals of Laplace transform, Laplace transform of periodic function, inverse Laplace transform, convolution theorem, impulsive functions, application of Laplace transform in solving linear differential equation with constant coefficients and with variable coefficients, linear partial differential equations.

UNIT V

Analytic functions, Cauchy- Riemann conditions, Harmonic function, elementary complex functions and their properties, branches of multi valued function, mapping Z and Z complex integration, definite integrals, Cauchy Gaursat's theorem, Cauchy integral theorem, Indefinite integrals, Cauchy integral formula, derivatives of analytic functions, Morera's theorem, Fundamental theorem of algebra, analytic continuation.

Taylor's series, Laurent's series, integration and differentiation of power series, zeros of analytic functions, singular point, residues, Cauchy residue theorem, poles evaluation of improper integrals, Jordan's lemma integration around a branch point.

References

1. Classical Mechanics: Goldstein
2. Classical Mechanics: L.P. Landau & H. M. Lifshitz
3. Classical Mechanics: A. Ray Chaudhary
4. Complex Variables & Functions: Churchill, Brown, Varchy
5. Applied Mathematics for Engineers and Physicist: Pipes & Harvill

Paper II Classical Electrodynamics

UNIT I

Electrostatics: Electric field, Gauss law, differential form of Gauss 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 Dirichlet or Neumann boundary conditions, formal solution of the electrostatics boundary value problem with Green’s function, Electrostatics potential energy and energy density, capacitance.

Boundary Value Problems in Electrostatics: Method of images, point charge in the presence of a grounded conducting sphere, point charges in the presence of a charged insulated conducting sphere, point charges near a conducting sphereat a fixed potential, conducting sphere in an uniform electric field by method of images, Green function for the sphere, general solution for potential, conducting spherewith Hemispheres at different potential, orthogonal functions and its expansion.

UNIT II

Multipoles, Electrostatics of Macroscopic Media Dielectrics: 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, molecular polarizability and electric susceptibility, models for molecular polarizability, electrostatic energy in dielectric media. **Magnetostatics**: Differential equation of Magnetostatics and Ampere's law, vector potential and magnetic induction for a circular current loop, magnetic field of a localized current distribution, magnetic moment, force and torque on and energy of a localized current distribution in an external magnetic field, macroscopic equations, boundary conditions on B & H, methods of solving boundary value problems in magnetostatics, uniformly magnetized sphere in an external field, permanent magnetic shielding, spherical shell of permeable material in an uniform field.

UNIT III

Time Varying Fields, Maxwell's Equations, Conservation Laws: Energy in a magnetic field, vector and scalar potential, Gauge transformations, Lorentz Gauge, Coulomb Gauge, Green functions for the wave equation, derivation of the equations of macroscopic electromagnetism, Poynting's theorem and conservation of energy and momentum for a system of charged particles and E.M. fields, conservation laws for macroscopic media.
Plane Electromagnetic Waves and Wave Equation: Plane wave in a nonconducting medium, frequency dispersion characteristics of dielectrics, conductors and plasmas, waves in a conducting or dissipative medium, superposition of waves in one dimension, group velocity, Causality in the connection between D and E, Kramers- Kroning relation.

Unit IV

Magneto Hydrodynamics and Plasma Physics: Introduction and definitions, MHD equations, magnetic diffusion, viscosity and pressure, pinch effect, instabilities in a pinched plasma column, magneto hydrodynamic waves, plasma oscillations, short wavelength limit on plasma oscillations and Debye shielding distance.

Unit V

Radiation by Moving Charges: Lienard- Wiechart potentials 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.

References

1. Classical electrodynamics: J. D. Jackson
2. Classical Electricity and Magnetism: Panofsky &Philips
3. Introduction to Electrodynamics: Griffiths
4. Classical theory of fields: Landau & Lifishtiz
5. Electrodynamics of continuous Media: Landau & Lifishtiz

Paper III Quantum Mechanics and Atomic & Molecular Physics

UNIT I

States Amplitudes and Operators: States of a quantum mechanical system, representation of quantum mechanical states, properties of quantum mechanical amplitude, operators and change of state of a complete set of basic states, product linear operators, language of quantum mechanics, postulates, essential definition and consequent relations.

Observable and Description of Quantum System: Process of measurement, expectation values, time dependent of a quantum mechanical amplitude, Observables with no classical analogue, Spin dependence of quantum mechanical amplitude on position, the wave function, superposition of amplitudes, Identical particles.

Unit II

Transition Between Stationary States: Transition in two state system, Time dependent perturbation- The Golden rule, Phase space, Emission and absorption of radiation, Induced dipole transition and spontaneous emission of radiation, Energy width of a quasi stationary state.

The Co- ordinate Representation: Compatible observable, quantum conditions and uncertainty relations, co- ordinate representation of operators: position, momentum and angular momentum, time dependence of expectation values, The Schrodinger equation, energy quantization, periodic potential as an example.

UNIT III

Symmetries and Angular Momentum: Symmetry transformation and conservation laws, Invariance under space and time translations and space rotation; Conservation of momentum, energy and angular momentum. Angular momentum operators and their eigen values, Matrix representation of angular momentum operators and their eigen states, Coordinate representation of the orbital angular momentum operators and their eigen states (spherical harmonics), Composition of angular momentum. Clebsch- Gordon coefficient, Tensor operators and Wigner Echart theorem, Commutation relations J+, J-
and J with reduced spherical tensor operator, Matrix elements of vector operators, Time reversal invariance and vanishing of static electric dipole moment of stationary state

UNIT IV

Hydrogen Atom: Gross structure energy spectrum probability distribution of radial and angular (l=1, 2), Wave functions (no derivation), Effect of spin, relativistic correction to energy levels and fine structure, magnetic dipole interaction and hyperfine structure, the Lamb shift (only a qualitative description). Interaction with External Fields:Non degenerate first order stationary perturbation methods, Atom in a weak uniform external electric field and first and second order Stark effect, Calculation of the polarizability of the ground state of H- atom and of an isotropic harmonic oscillator, Degenerate stationary perturbation theory, Linear Stark effect for H- atom levels, Inclusion of spin orbit and weak magnetic field, Zeeman effect, Strong magnetic field and calculation of interaction energy.

UNIT V

Systems with Identical Particles: Indistinguishability and exchange symmetry, Many particles wave function and Pauli's exclusion principle, Spectroscopic terms for atoms, The Helium atom, Variational method and its use in the calculation of ground state and excited state energy, Helium atom, Hydrogen
molecule, Hitler London methods for H2 molecule, WKB method for one dimensional problem, Application to bound states (Bohr Sommerfield quantization) and the barrier penetration (Alpha decay problems).

References

1.Quantum Mechanics-A Modern Approach : Ashok Das & A.C. Melissions
2. Quantum Mechanics: P.A.M. Dirac
3. Quantum Mechanics (2^{nd} ed.): E. Merzbecker
4. Quantum Mechanics- Non relativistic theory: L.P. Landau &H. M. Lifshitz
5. Quantum Mechanics: Thankapann (New Age International pub.)

Paper IV **Electronics, Numerical Methods and Computer Programming**

Unit I

Linear Small Signal and Direct Coupled Amplifier:- R.C. Coupled C.E. Amplifier and its response in different frequency ranges, effect of cascading expression of bandwidth in low and high frequency ranges, emitter follower, tuned amplifier(small signal) single and double tuned amplifiers, Differentials amplifier, common mode rejection ratio, operational amplifier and its basic applications. Wave Shaping Circuits:Exponential circuit response, differentiation and integration by R.C. and L.R circuits, clipping or limiting circuit, clamping circuit, general feature of a time base signal, thyratron sweep circuits, circuits to improve linearity, Miller and Boot strap sweep circuits.

Unit II

Logic and Integrating Circuits: Boolean algebra, binary counting, counting to a base other then two, binary counter, conversion of binary counter in a decade counter, Decoder, logic gates : NOT, OR, AND, NAND and their circuits, Micro-electronic devices, basic concepts about fabrication and characteristics of integrated circuits.
Multivibrators: Astable, monostable, and bistable multivibrators, frequency of a stable vibrator, frequency control and synchronization, triggering of bistable, Blocking oscillator.

Unit III

Errors in Numerical Analysis: Computer arithmetic, sources of errors, Round off errors, Errors analysis, Condition and stability, Approximation, functional and errors analysis, The method of Undetermined coefficients.
Interpolation: Interpolation, Finite differences, Gauss central difference formula, Newton's formula for interpolation, Lagrange's interpolation formula, Double

interpolation, Numerical differentiation, Newton and Starling's formula, Solution of linear systems, Direct and iterative, Eigen value problems.

Unit IV

Solution of Non- Linear Equation: Bisection method, Newton's Method, Modified Newton's method, Method of integration, Newton's method and method of integration for a system of equations, Newton's method for the case of complex roots, Integration of functions: Trapezoidal and Simpson's rules, Gaussian quadrature formula, singular integrals, Double integration.

Unit V

Integration of Ordinary Differential Equation: Predictor Corrector method, Runga-Kutta methods, Simultaneous and higher order equations, Numerical integration and differentiation of Data, Least squares approximation, computer simulation, Monte Carlo method, Curve fitting.

One Advanced Level Language:

BASIC: Variable expressions, jumping, branching and looping statements, input/output statements, sub- routing commands for plotting a graph statement for handling input /output files, programming of simple problems.

Paper V Advanced Quantum Mechanics & Quantum field Theory

Unit I

Scattering (Non- relativistic): Differential and total scattering cross section, solution of scattering problem by the method of partial wave analysis, expansion of a plane wave into a spherical wave and scattering amplitude, optical theorem applications: scattering from the delta potential, square well potential and hard sphere, scattering of identical particles, energy dependence and resonance scattering, Breit Wigner formula, quasi stationary state, Lippman Schwinger equation and the Green's function approach for scattering problem, Born approximation and its validity for scattering problem, Coulomb scattering problem under first Born approximation in elastic scattering.

Unit II

Relativistic Formulation and Direct equation: Attempt for relativistic formulation of quantum theory, Klein- Gordon equation, probability density and probability current density, solution of free particle K.G.equation in momentum representation, interpretation of negative probability 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 equations, orthogonality & completeness relation for Dirac spinors, interpretation of negative energy solutions & hole theory.

Unit III

Symmetries of Dirac Equation: Lorentz boost, Lorentz covariance of Dirac equation, Proof of covariance & derivation of Lorentz transformation matrix and rotation matrices for Dirac spinors, projection operators involving four momentum & spin, parity (P), charge conjugation (C), time reversal (T) and CPT operators for Dirac spinors, bilinear covariant and their transformation behavior under Lorentz transformation, P, C, T & CPT, expectation values of coordinate & velocity involving only positive energy solutions, Zitter Bewegung, Klein paradox.

Unit IV

Quantum Field Theory: Scalar and vector fields, Classical Lagrangian field theory, Euler Lagrange's equation, Lagrangian density for electromagnetic field, occupation number representation for simple harmonic oscillator, linear array of coupled oscillators, second quantization of systems of identical bosons, second quantization of real Klein- Gordan field and complex Klein- Gordan field, meson propagator, second quantization of systems of identical bosons.

Unit V

Occupation number representation for Fermions, second quantization of the Dirac field, Fermion propagator the e. m interaction & gauge invariance, covariant quantization of the free electromagnetic field, photon propagator.
S-Matrix: S-matrix expansion, Wick's theorem, diagrammatic representation in configuration space, momentum representation, Feynman rules of QED, Feynman diagrams of basic processes, Application of s-matrix formalism, Coulomb scattering, Bhabha scattering, Moller scattering, Compton scattering and Pair production.

References

1. Quantum mechanics, A modern approach- Ashok Das & A.C. Melissions (Gordon & Breach Science Publishers).

2. Quantum Mechanics (second edition)- E. Merzbeker (John Wiley)
3. Relativistic Quantum Mechanics- Bjorken & Drell (Mc Graw hill)
4. Advanced Quantum Mechanics- J.J. Sakurai (John Wiley & Sons)
5. Quantum mechanics- Thankpapn V.K. (Wiley Eastern ltd. New Delhi)

Paper VI Nuclear Physics

Unit I

Two Nucleon System and Nuclear Forces: General nature of the force between nucleons, saturation of nuclear force, charge independence & spin dependence, general forms of two nucleon interaction, central, non- central & velocity dependent potential, analysis of the ground state (3S1) ofdeuteron using a square well potential, range depth relationship, excited states of deuteron, discussion of the ground state of deuteron under non central forces.

Unit II

Nucleon- Nucleon Scattering & Potentials: Partial wave analysis of two neutron-proton scattering at low energy assuming a central potential with square well shape, concept of the scattering length, Coherent scattering of neutrons by protons in (ortho & para) hydrogen molecule, conclusion of these analysis regarding scattering lengths, range & depth of the potential, effective range theory (in neutron- proton scattering) and shape independence of nuclear potential, A qualitative discussion of proton- proton scattering at high energy, hard core potentials and Red hard core and soft core potentials, main features of the One Boson Exchange Potential (OBEP) (no derivation).

Unit III

Nuclear shell Model: Single particle & collective motions in nuclei, assumption & 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 and their comparison with experimental data, configuration mixing, single particle transition probability according to the shell model, selection rules, approximate estimates for transition probability and Weisskopf units, nuclear isomerism.

Unit IV

Nuclear Gamma & Beta Decay: Electric & Magnetic multipole moments and gamma decay probabilities in nuclear system (no derivation), reduced transition probability, selection rules: internal conversion & zero- zero transition.General characteristics of weak interactions, Nuclear beta 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 transition : ft-values, general interaction Hamiltonian for beta decay with parity conserving and non conserving terms, forbidden transition, experimental verification of parity violation.

Unit V

Interaction of Neutrons, EM Radiation and Charged Particles with Matter: Law of absorption and attenuation coefficients, slowing down & law for neutron capture photoelectric effect, Compton Scattering, pair production, Klein Nishima cross section for polarized & unpolarized radiation, angular distribution of scattered photon & electrons, energy loss of charged particles due to ionization, Bremsstrahlung energy, target and projectile dependence of all three processes range energy curves straggling.

References

1. Theoretical Nuclear Physics: J.M. Blatt & V.E. WeissKipf.
2. Introductory Nuclear theory: L.R.B. Elton, ELBS Publs. London 1959.
3. Nuclear physics: B.K. Agarwal, Lok Bharti Prakashn. Allahabad 1989.
4. Nuclear Structure: M. K. Pal, Affiliated East West Press, 1982.
5. Nuclear physics: R.R. Roy & B.P. Nigam. Willy Basten, 1979

Paper VII Solid state Physics

Unit I

Lattice Vibrations and Thermal Properties: Lattice specific heat, theoretical estimates of Einstein and Debye temperatures, Wave mechanics of phonons, Creation and annihilation operators, Elastic waves and lattice vibration in one dimensional crystal, Long range forces and the reciprocal lattice method, Lattice vibration of a diatomic linear chain, Dispersion relation for three dimensional crystals, Born- Von Karmon boundary conditions and density of states, Experimental observation of phonon frequencies, equation of state of the crystal lattice, Thermal Conductivity of insulators.

Unit II

Theory of Metals: Fermi Dirac Distribution Function, density of states, temperature dependence of Fermi energy, Specific heat, Boltzmann equation and mean free path, relaxation time and scattering processes, thermal conductivity and electrical conductivity (using F- D statistics). Widemann- Franz ratio, susceptibility, Drude's theory of light absorption in metals, Hall effect.

Unit III

Semiconductors: Law of mass action, calculation of impurity conductivity, ellipsoidal energy surfaces in Si and Ge, Hall effect recombination mechanism, Optical transitions and Shockley Read theory, excitons, photoconductivity, photo luminescence.

Nano- Science and Nano- Technology: Introduction to nano- science, nano-technology and nano- materials, evolution of nano- technology from micro-technology.

Imperfection in solids: Point, line planer and defects, colour centers, F- Centre and aggregate centers in alkali halides, John Teller effect, Single crystal growth, crystal whiskers.

Unit IV

Magnetism: Larmor diamagnetism, paramagnetism, Curie Langevin classical theory, Quantum theory of paramagnetism, susceptibility of rare and transition metals, Ferromagnetism: Weiss theory Quantum theory of Ferromagnetism, origin of domains, Bloch Walls, Anti ferromagnetism, Ferrites, Magnons, magnetic resonance, Nuclear magnetic resonance, magnetic materials. **Superconductivity**: Electromagnetic Properties, Thermal properties, isotope effect and electron phonon interaction, microscopic theory of superconductivity, Mc Millan's formula (no derivation), High temperature superconductivity in cuprates, fullerenes (basic ideas), Organic supper conductors (basic ideas), Superconducting tunneling, application of super conductivity.

Unit V

Quantum Statistics and Elementary Excitations of Electron Gas: Simple harmonic oscillator, Annihilation and creation Operators, coupled oscillators, linear chain, Bosons, Fermions, second Quantization, Hamiltonian for two particles,Fermions Boson Interaction, Landau theory of Fermi liquids.

Group theory: Group. Group Multiplications table, Representation of group (i) Representation of the triangle group (ii) Representation of the space group of a crystal.(iii) Normal modes of vibration of O3 molecule.

References

1. Intermediate Quantum theory of solids- A.D. E .Animalu, (Prentice Hall).
2. Solid state Physics- Kittel, (John Wiley 7th ed.).
3. Quantum theory of Solids- Kittel, (John Wiley).
4. Solid State Physics Source books- S.P. Parker, (Mc. Graw Hill).
5. Solid State Physics- Harrison, (Benjamin Press).

Paper VIII Solid State Electronics

Unit I

Semiconductor Physics: Energy band diagrams of actual semiconductors likes Si, Ge and GaAs, impurity doping and impurity energy levels, Calculation of Fermi level and conductivity of semiconductors, Injection of carriers, diffusion, Drift and continuity equation (band to band), trap assisted and Auger recombination, low injection and high injection, quasi Fermi levels.

Unit II

Poly crystalline and Amorphous Semiconductors: Semiconductor surfaces, surface charge and surface barrier, poly crystalline semiconductor, properties of grain boundaries, poly silicon as gate material, electrical conduction in amorphous semiconductors, mobility edge band, details and dangling band States.

Unit III

Semiconductor Diodes: PN junction, Depletion region capacitance, current voltage relation, recombination in space charge region and diode ideality factor, junction breakdown and avalanche multiplication, a- c response, diffusion capacitance, switching properties, reverse recovery, PINB diode hetro junctions, metal semiconductor barrier, Schottky thermionic and diffusion currents and measurement of barrier height.

Unit IV

Bipolar Transistors and Thyristors: General characteristics of Bipolar junction transistors, voltage rating, factors controlling current gain, frequency performance, power transistors, switching of bipolar transistor, basic concept of PNPN structures, thyristor’s turn on, turn off and power consideration triacs.

Unit V

JFETS, MESFETS and MOSFETS: JFET modeling including saturation velocity effects, GaAs MESEFT, MOS diodes, surface space charge regions, suface states, MOSEFT, surface space charge region under no equilibrium condition channel conductance, basic characteristics, current voltage and device parameters.

References

1.Semiconductor Physics- K Seeger, Springer- Verlag
2.Solid state and Semiconductor Physics- John p. McKinley, Harper & Row
3.Semi- Conductors Devices- G Mnnes, Integrated Electronics Van Nostrand
4.Physics ofSemiconductor Devices- S. M. Sze. Wiley

Paper IX Industry Based Environmental Studies

UNIT – 1

Environment – Definition – Scope – Structure and function of eco system's procedures, consumers and decomposers – energy flow in the ecosystem – ecological succession – food chain, food web and ecological pyramids - concepts of sustainable development.

UNIT – 2

Natural resources: Renewable – air, water, soil, land and wildlife resources. Non-renewable – mineral, coal, oil and gas. Environmental problems related to the extraction and use of natural resources.

UNIT – 3

Biodiversity – Definition – values – consumption use, productive social, ethical, aesthetic and option values threats to biodiversity – Hotspots of bio diversity – conservation of bio-diversity: In-situ Ex-situ. Bio-wealth – national and global level.

UNIT – 4

Environmental pollution : Definition – causes, effects and mitigation measures – Air pollution, Water pollution, Soil pollution, Noise pollution, Thermal pollution – Nuclear hazards – solid wastes acid rain – climate change and global warming environmental laws and regulations in India – Earth summit.

UNIT – 5

Population and environment – Population explosion – Environment and human health – HIV / AIDS – Women and child welfare – Resettlement and

Rehabilitation of people, role of information technology in environmental health – Environmental awareness.