SHIVAJI UNIVERSITY, KOLHAPUR.

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Accredited By NAAC with 'A' Grade
CHOICE BASED CREDIT SYSTEM

Syllabus For

M.Sc. Part -I Physics

SEMESTER I AND II

(Syllabus to be implemented from June, 2018 onwards.)

M.Sc. (Physics) (Semester-I)
Paper Code: CP-I
Paper title: Mathematical Physics
Total Credits: 4-credits

Mathematical Physics

Unit-I: Vector Spaces and matrices

Linear vector space (Rajput 123 – 126), Matrix multiplication – Inner product, direct product, Diagonal matrices, trace, matrix Inversion, Example of Gauss-Jordon Inversion, problems (Rajput 735 – 45, Iyengar 1.1 – 1.26). Eigenvalues and Eigenvectors, Properties of Eigenvalues and Eigenvectors, CaylyHamilton Theorem and applications, similar matrices and diagonalizable Matrices, Eigenvalues of some Special Complex Matrices, Quadratics forms, problems. (Iyengar 2.1 to 2.35).

Unit-II: Differential equations and Special functions

Solution for first order differential equation, Bernulli equation, exact equation, second order linear differential equation with constant and variable coefficient, Special functions (Hermite, Bessel, Laguerre and Legendre functions)generating functions, recurrence relation(Rajput 510 – 667),

Unit-III Fourier- Series, Integral, and Transform

Definition, Evaluation of Coefficients of Fourier Series (Cosine and Sine Series), Graphical representation of a square wave function, Complex form of Fourier Series, Fourier Integral-exponential form, Applications of Fourier Series analysis in Physics (Square wave, Full wave rectifier, Expansion of Raman Zeta function) (Rajput 527 – 561). Fourier transform, Inversion theorem, exponential transform Example: Full wavetrain, Uncertainty principle [Arfken 931-946]. Dirac delta function, derivative of δ-function and Laplace Transform of δ-function (Rajput 1467 – 1475).

Unit-IV: Numerical methods and elements of probability

Finite differences, numerical interpolation, numerical differentiation and integration, random variables, law of large numbers, averages, dispersion, standard deviation, variance, covariance and correlations, arithmetic mean and estimate of variance, theory of errors-qualitative (830-986)

Reference book:

1) Rajput B S, Mathematical Physics, Pragati Prakashan (Meerat) 1999
2) Iyengar S R K, Jain R K , Mathematical Methods, Narosa, 2006
3) Arfken And Weber, Mathematical Methods For Physicists 6th Edition, Academic Press, 2005
4) Mathematical Physics, Binoy Bhattacharyya, New Central Book Agency (P) Limited, 2010

M.Sc. (Physics) (Semester-I)
Paper Code: CP-II
Total Credits: 4-credits
Paper title: Classical Mechanics

Classical Mechanics

Unit I: Central Force Problem and Small oscillations (15)
Two body problem, The equation of motion and first integrals, Equation of orbit, Kepler's laws, Kepler's problem, General analysis of orbits, Stability of orbits, Artificial satellites, Rutherford Scattering: Differential scattering cross – section, Rutherford Formulae for scattering, Virial theorem. Small oscillations: Potential energy and equilibrium-one dimensional oscillator, general theory of small oscillations

Unit II: Variational principle and Hamiltonian Dynamics: (15)
Variational principle, Deduction of canonical equations from Variational principle, Principle of least action with proof, Hamilton's principle, Hamiltonian, Generalized momentum, Constant of motion, Hamilton's canonical equations of motion, , Applications of Hamilton's equations of motion.

Unit III: Canonical Transformations and Poisson's Brackets: (15)
Legendre transformations, Generating Functions, Illustrations of Canonical transformations, Condition for Canonical Transformation, Examples.
Poisson's Brackets, Poisson's theorem, Properties of Poisson's Brackets, Hamiltons Canonical equations in terms of Poisson's Brackets,
Hamiltons – Jacobi Theory, Solution of harmonic oscillator problem by HJ Method. Problems.

Unit IV: Special Theory of Relativity and relativistic mechanics: (15)
Special theory of relativity and its postulates , Galilean transformations, Lorentz transformations and its consequences, Minkowski Space, 4-Vectors, 4-Momentum, Lorentz Tensor, Addition of velocities, Mass- Energy relation, Force in relitivstic mechanics, Lagrangian formulation of relativistic mechanics, Particle accelerating under constant force, Hamiltonian formulation of relativistic mechanics, Particle in an EM field, Aberration of light from stars, Relativistic Doppler's Effect.

Text and Reference Books:

1. Classical Mechanics, by H Goldstein (Addison Wesley 1980).
2. Classical Mechanics, by J.C. Upadhyaya (Himalaya Publishing House 2015).
3. Classical Mechanics, by N C Rana and P S Joag (Tata McGraw Hill 1991).
4. Introduction to Classical Mechanics, by R G Takwale and P S Puranik (Tata McGraw Hill 1999).
5. Classical Mechanics, by Gupta, Kumar and Sharma (Pragati Prakashan 2000).

M.Sc. (Physics) (Semester-I)
Paper Code: CP-III
Paper title: Quantum Mechanics-I
Total Credits: 4-credits

Quantum Mechanics-I

Unit-I: Wave Mechanical Concepts and General formalism **15**

Time dependent Schrodinger equation, interpretation of the wave function, Ehrenfest's theorem, time-independent Schrodinger equation, stationary states, admissibility condition on the wave function, Linear vector space, linear operator, eigenfunctions and eigenvalues, Hermitian operator, postulates of quantum mechanics, simultaneous measurability of observables, general uncertainty relations, Dirac's notation, equation of motion, momentum representation, Heisenberg method, matrix representation of wave function and operators, unitary transformation,

Unit-II: One and Three Dimensional Energy Eigenvalues Problems **15**

Square-Well potential with rigid walls and finite walls, square potential barrier, alpha emission, Bloch wave in a periodic potential, Kronig-Penney Square periodic potential, linear harmonic oscillator: Schrodinger method and operator method, free particle, particle moving in a spherical symmetric potential, system of two interacting particles, rigid rotator, hydrogen atom, hydrogenic orbitals,

Unit-III: Angular Momentum **15**

The angular momentum Operator, angular momentum commutation relation, eigenvalues and eigenfunctions of L^2 and L, general angular momentum, eigenvalues of J^2 and J_z, angular momentum matrices, spin angular momentum, spin vectors for spin-$\boxed{\frac{1}{2}}$ system, addition of angular moments,

Unit-IV: Time independent perturbation theory **15**

Basic concept, non-degenerate energy levels, anharmonic oscillator: first order correction, ground state of helium, effect of electric field on the ground state of hydrogen, degenerate energy levels, effect of electric field on the n=2 state of hydrogen, spin-orbit interaction

Reference Books:

1. Quantum Mechanics, Aruldhas G, Prentice Hall India Learning Private Limited, 2 edition (2008)
2. Quantum Mechanics: Theory and Applications, Ajoy Ghatak and S. Lokanathan, Macmillan publishers India, 5 edition (2004)
3. Introductory Quantum Mechanics (4th Edition), Richard Liboff, Pearson Education,4 edition (2004)
4. Introduction to Quantum Mechanics, J. Griffiths David ,Pearson Education, 2 edition (2015)
5. Quantum Mechanics, L I Schiff, McGraw-Hill,4 edition (2014)
6. Modern Quantum Mechanics, J J Sakurai, Pearson Education India; 2 edition, (2013)

M.Sc. (Physics) (Semester-I)
Paper Code: CP-IV
Paper title: Condensed Matter Physics
Total Credits: 4-credits

Condensed Matter Physics

Unit I Crystal Physics **15**

Crystalline state of solid, unit cell and bravias lattice (2D and 3D), bonding of common crystal structure, direction, position and orientation of planes in crystal, concept of reciprocal lattice, concept of Brillouin zones, closed packed structure, fourier analysis of the basis (structure factor), Bragg's law, comparison of X-ray, electron and neutron diffraction method.

Unit II Crystal Defects **15**

Types of defects, point defect, Schottky and Frenkel defect, equilibrium concentration of vacancies, color center, line defect, crew and edge dislocation, Berger's vector and circuit, role of dislocation in plastic deformation and crystal growth, observation of imperfection in the crystals.

Unit III Semiconducting and superconducting properties **15**

Semiconductor: Energy band gap, direct and indirect band gap, effective mass, intrinsic carrier concentration, conductivity of semiconductor, impurity level in doped semiconductor, Hall Effect. Superconductor : Critical temperature, effect of magnetic field, Meissner effect, type-I and type-II superconductor, London equation, coherence length, Josephson effect (flux quantization), BCS theory, introduction of high Tc superconductor.

Unit IV Dielectric and Magnetic properties **15**

Dielectric: Polarization mechanism, dielectric constant, Lorenz cavity field, Clausius-Mossotti equation, theory of diamagnetism, ferroelectricity and piezoelectricity, type of ferroelectric and piezoelectric. Magnetic: Classification of magnetic material, Langevin theory of diamagnetism, paramagnetism and ferromagnetism, theory of diamagnetism- Heisenberg exchange interaction theory (ferro- antiferro- and ferrimagnetism), Weiss theory of ferromagnetism.

Reference Books:

1. Introduction to solid state physics - C. Kittel, 8th edn, John Wiley & Sons. Inc., New York (1976).
2. Solid state physics by A. J. Dekker, MacMillan India Ltd. (1986).
3. Solid state physics - N. W. Ashcroft and N. D. Mermin, HRW International edn. (1976).
4. Solid state physics – S. O. Pillai. New Age International Publication.-2002
5. Solid State Physics - H. C. Gupta- Vikas Publishing House, New Delhi-2002
6. Electronic Properties of Materials- R. E. Humel, 2nd edn. Springer International(1994)
7. Solid State Physics – J. S. Blakemore, 2nd edn. Cambridge University Press(1985)

Syllabus for M. Sc (Physics) Choice Base Credit System
(Under Academic Flexibility Scheme)
M.Sc. (Physics) (Part-I) CORE PAPER (COMPULSORY)
M.Sc. (Physics) (Part-I) (Semester-I)

LAB-I

Laboratory/ Practical Course-I (two experiment and certified journal-4-credits)

1. Hall Effect
2. L.V.D.T.
3. Neutron Diffraction
4. Fabry-Parrot etalon
5. Crystal Structure
6. (F.C.C.& B.C.C.)
7. Lattice Dynamics
8. Temperature Transducer
9. Heat Capacity
10. Staircase Ramp Generator
11. Negative Feedback Amplifier
12. Astable Multivibrators
13. Monostable Multivibrators
14. Stefan's Constant
15. B-H Curve
16. Thermal & electrical conductivity of copper
17. Mathematica- Numerical, algebraic and trigonometric problems
18. Statistical data analysis
19. Numerical differentiation using Python
20. Numerical Integration using Python

LAB-II

Laboratory/ Practical Course-II (Seminar & certified seminar report 2-credits +Tutorials on practical 2-credits)

M.Sc. (Physics) (Semester-II)
Paper Code: CP-V
Paper title: Quantum Mechanics-II
Total Credits: 4-credits

Quantum Mechanics-II

Unit-I: Variational Method and WKB approximation **15**

The variational principle, Rayleigh-Ritz method, variational method for excited states ,the Hellmann-Feynman theorem, ground state of helium and deuteron, the WKB method, the connection formulas, validity of WKB method, barrier penetration

Unit-II: Time-Dependent perturbation theory **15**

First order perturbation, harmonic perturbation, transition to continuum states (Fermi-Golden rule), semi-classical theory of radiation: absorption and emission of radiation, electric dipole and forbidden transitions, Einstein's A and B coefficients, selection rules, application to theory of scattering, adiabatic approximation, the sudden approximation

Unit-III: Scattering theory **15**

Scattering cross-section, scattering amplitude, partial wave, scattering by central potential: partial wave analysis, scattering by hard sphere, scattering by square well, Breit-Wigner formula, scattering length, expression for phase shifts, integral equation, the Born approximation, scattering by screened Coulomb potential, validity of Born approximation,

Unit-IV: Identical particle and Relativistic wave equation **15**

Identical particle: Indistinguishable particles, Pauli principle, inclusion of spin, spin functions for two electrons, spin functions for three electrons, spin statistics connection, scattering of identical particles, Laboratory and center coordinate of mass system,

Relativistic wave equation: Klein-Gordon Equation and its interpretation, Dirac's equation for a free particle

Reference Books:

1. Quantum Mechanics, Aruldhas G, Prentice Hall India Learning Private Limited, 2 edition (2008)
2. Quantum Mechanics: Theory and Applications, Ajoy Ghatak and S. Lokanathan, Macmillan publishers India, 5 edition (2004)
3. Introductory Quantum Mechanics (4th Edition), Richard Liboff, Pearson Education,4 edition (2004)
4. Introduction to Quantum Mechanics, J. Griffiths David ,Pearson Education, 2 edition (2015)
5. Quantum Mechanics, L I Schiff, McGraw-Hill,4 edition (2014)
6. Modern Quantum Mechanics, J J Sakurai, Pearson Education India; 2 edition, (2013)

M.Sc. (Physics) (Semester-II)
Paper Code: CP-VI
Paper title: Statistical Mechanics
Total Credits: 4-credits

Statistical Mechanics

Unit I: Contact between Statistics and Thermodynamics: 15

Fundamental postulate of equilibrium statistical mechanics, Basic concepts – Phase space, ensemble, a priori probability, Liouville's theorem (Revision). Fluctuations of physical quantities, Statistical Equilibrium

Thermodynamic Laws and their consequences, Thermodynamic Functions – Entropy, Free energy, Internal Energy, Enthalpy (definitions), Contact between statistics and thermodynamics – Entropy in terms of microstates, Gibb's paradox, Sackkur-Tetrode formula.

Unit II: Classical Statistical Mechanics: 15

Micro canonical Ensemble– Micro canonical distribution, Entropy and specific heat of a perfect gas, Entropy and probability distribution.

Canonical Ensemble– Canonical Distribution, partition function, Calculation of free energy of an ideal gas, Thermodynamic Functions, Energy fluctuations.

Grand Canonical Ensemble– Grand Canonical distribution, Thermodynamic Functions, Number and Energy fluctuations.

Unit III: Quantum Statistics of ideal quantum gases and Brownian motion: 15

Quantum Statistics:

Distinction between MB, BE and FD distributions, Quantum distribution functions –

Bosons and Fermions and their distribution functions, Boltzmann limit of quantum gases, Partition function.

Ideal Bose gas, Bose -Einstein Condensation, Phonon gas, Liquid He4: Second Sound.

Ideal Fermi gas: Weakly and strongly degenerate, Electron gas: Free electron theory of metals, Pauli paramagnetism, white dwarfs

Brownian motion: Einstein-Smoluchowski theory, Langevin theory, Approach to equilibrium: Fokker-Planck equation, the fluctuation-dissipation theorem.

Unit IV: Phase Transitions, and Critical Phenomenon 15

Phase Transitions, Conditions for phase equilibrium, First order Phase Transition: Clausius - Clayperon equation, Second order phase transition, The critical indices, Weakly Interacting Gases, Weiss Molecular theory of paramagnetism, The Ising Model of a Ferromagnetism

Text and Reference books:

1. Statistical Mechanics Theory and Applications, S K Sinha, Tata McGraw-Hill, (1990).
2. Introduction to Statistical mechanics, B B Laud, Macmillan, N Delhi, (1981).
3. Statistical Mechanics by R K Pathria, Pergamon press (1972).
4. Statistical and thermal Physics F Reif, McGraw-Hill (1965).
5. Statistical Physics, L D Landau and E M Lifshitz, Pergamon press (1958).

M.Sc. (Physics) (Semester-II)
Paper Code: CP-VII
Total Credits: 4-credits
Paper title: Electrodynamics

Electrodynamics

Unit I: Maxwell's Equations and E.M. Waves: (15)

Maxwell's Equations: microscopic and macroscopic forms (revision), conservation of the bound charge and current densities, E.M. wave equations in waveguide of the arbitrary cross section: TE and TM modes; Transmission lines and wave guides, rectangular and circular waveguides Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction.

Unit II: Time –Dependent Potentials and Fields: (15)

Scalar and vector potentials: coupled differential equations, Gauge transformations: Lorentz and Coulomb Gauges, Retarded Potentials, Lienard –Wiechert Potentials, Fields due to a charge in the arbitrary motion. Dispersion relations in plasma.

Unit III: Radiation from Accelerated Charges and Radiation Reaction: (15)

Fields of charge in uniform motion, applications to linear and circular motions: cyclotron and synchrotron radiations, Power radiated by point charge – Larmor's formula, Angular distribution of radiated power, Cerenkov radiation and Bremsstrahlung (qualitative treatments). Radiation Reaction: criteria for validity, Abraham –Lorentz formula, Physical basis of radiation reaction – self force.

Unit IV: **Electrodynamics and Relativity(15)**

The Special Theory of Relativity , Einstein's Postulates , The Geometry of Relativity , The Lorentz Transformations. , The Structure of Space time , Relativistic Mechanics , Proper Time and Proper Velocity, Relativistic Energy and Momentum , Relativistic Kinematics, Relativistic Dynamics, Relativistic Electrodynamics, Magnetism as a Relativistic Phenomenon, How the Fields Transform, The Field Tensor, Electrodynamics in Tensor Notation Relativistic Potentials

Text and Reference books:

1. Introduction to Electrodyanamics – D.J. Griffiths (Prentices- Hall 2002 (3rd edn)
2. Foundation of E.M. Theory- J.R. Reitz, F.J. Milford & R.W. Christy (Narosa Publication House 3rd edition 1993)
3. Classical Electrodynamics – J.D.Jackson (Wiley Eastern 2nd edition)
4. Classical Electrodynamics –S.P. Puri (Tata McGraw Hill 1990)
5. Electromagnetics, Laud B B,New Age International Private Limited; 3rd edition

M.Sc. (Physics) (Semester-II)
Paper Code: CP-VII
Total Credits: 4-credits
Paper title: Atomic & Molecular Physics

Atomic & Molecular Physics

Unit I: Atomic Spectra **15**

Quantum states of an electron in an atom, electron spin. spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, *ll*-coupling, *ss*-coupling, LS or Russell - Saunder's coupling; the Pauli exclusion principle, Coupling schemes for two electrons, Γ-factors for LS coupling, Lande interval rule, jjcoupling, branching rules, selection rules, Intensity relations.

Unit II: Effect of magnetic and electric field on atomic spectra **15**

The magnetic moment of the atom, Zeeman effect for two-electrons, Intensity rules for Zeeman effect, Paschen-Back effect for two electrons, Stark effect of hydrogen, weak field Stark effect in hydrogen, strong field Stark effect in hydrogen, origin of hyperfine structure, Inner shell vacancy, X- ray and Auger transitions, Compton effect, Principles of resonance Spectroscopy (ESR and NMR)

Unit III: Molecular spectra **15**

Molecular physics – covalent, ionic and Vander Waal's interaction, Classification of molecules: linear, symmetric tops, spherical tops, asymmetric tops; rotational spectra: the rigid diatomic molecule, the non-rigid rotator, spectrum of a non-rigid rotator, techniques and instrumentation of microwave spectroscopy, chemical analysis by microwave spectroscopy. the vibrating diatomic molecule: the energy of a diatomic molecule, the simple harmonic oscillator, the anharmonic oscillator, the diatomic vibrating-rotator, vibrational rotational spectra, techniques and instrumentation of infra-red spectroscopy, chemical analysis by infra-red spectroscopy.

Unit IV: Electronic and Nuclear spectra **15**

Electronic spectra of diatomic molecules, selection rules. electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation.
Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

Reference books

1) Introduction to Atomic Spectra – H.E. White, Mac-Graw Hill (1934).
2) Fundamentals of Molecular Spectroscopy, 4th Edition. – C.N. Banwell, Tata MacGraw Hill (2008).
3) Molecular Structure and Spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd. Spectra of Diatomic Molecules, Vol. I – G. Herzberg, N.J.D. van Nostrand (1950).
4) Spectroscopy, Vol. I, II and III – B.P. Straughan and S. Walker, Chapman and Hall (1976).
5) Introduction to Molecular Spectroscopy – G.M. Barrow, MacGraw Hill (1962).
6) Molecular Spectroscopy – J.M. Brown, Oxford University Press (1998).

Syllabus for M. Sc (Physics) Choice Base Credit System
(Under Academic Flexibility Scheme)
M.Sc. (Physics) (Part-I) CORE PAPER (COMPULSORY)
M.Sc. (Physics) (Part-I) (Semester-II)

LAB-III

Laboratory/ Practical Course-III (two experiment and certified journal-4-credits)

1. Fourier analysis
2. Passive filters
3. Solar cell
4. A.C. bridges
5. Thermal diffusivity of brass
6. Mutual inductance of coil
7. Series & parallel resonant circuits
8. Young's modulus
9. Mathematica: 2D & 3D plots
10. Band gap energy
11. Resistivity by four Probe
12. Thermoelectric power
13. Electron Spin Resonance
14. Crystal structure of thin film
15. Rydberg constant
16. Dissociation energy of iodine molecule
17. Magnetic susceptibility of ferric chloride solution
18. Plank's constant
19. Numerical solutions of simple first order differential equation using Python (Euler and Runge-Kutta 4^{th} order method)
20. Plotting simple functions using Python

LAB-IV

Laboratory/ Practical Course-IV (Seminar & certified seminar report 2-credits +Tutorials on practical 2-credits)