MSc Physics / Integrated MSc-PhD Physics Syllabus

First Semester

S.No	Subject Code	Subject Name	L	T	P	Credit	Hours /Week
1	MPY101	Mathematical Physics I	3	1	0	4	4
2	MPY102	Quantum Mechanics I	3	1	0	4	4
3	MPY103	Classical Mechanics	3	1	0	4	4
4	MPY104	Electronics	3	1	0	4	4
5	MPY105	Electromagnetic Theory	3	1	0	4	4
6	MPY191	Physics Laboratory	0	0	6	4	6
7	MSD181	Project and Seminar	0	0	0	1	-
8	MSD182	Skill Development	0	0	0	1	-
Total			16	4	10	26	27

Second Semester

S.No	Subject Code	Subject Name	L	T	P	Credit	Hours /Week
1	MPY201	Mathematical Physics II	3	1	0	4	4
2	MPY202	Quantum Mechanics II	3	1	0	4	4
3	MPY203	Condensed Matter Physics	3	1	0	4	4
4	MPY204	Nuclear and particle physics	3	1	0	4	4
5	MPY205	Computer Applications in Physics	3	0	2	4	5
6	MPY291	Physics Laboratory	0	0	6	4	6
7	MSD281	Project and Seminar	0	0	0	1	-
Total			15	5	6	25	26

Third Semester

S.No	Subject Code	Subject Name	L	T	P	Credit	Hours /Week
1	MPY301	Statistical Physics	3	1	0	4	4
2	MPY302	Atomic and Molecular Spectroscopy	3	1	0	4	4
3	***	Program Elective	3	0	0	3	3
4	***	Program Elective	3	0	0	3	3
5	MPY381	Project	0	0	6	6	6
6	MPY391	Physics Laboratory	0	0	6	4	6
7	MSD381	Project and Seminar	0	0	0	1	-
8	MSD382	Skill Development	0	0	0	1	-
Total			12	2	12	26	26

Fourth Semester

S.No	Subject Code	Subject Name	L	T	P	Credit	Hours /Week
1	***	Program Elective	3	0	0	3	3
2	***	Program Elective	3	0	0	3	3
3	MPY491	Grand Viva	0	0	0	1	3
4	***	Open Elective	3	0	0	3	3
5	MPY481	Project	0	0	12	12	12
6	MSD482	Project and Seminar	0	0	0	1	-
Total			12	0	12	23	24

MPY101 Mathematical Physics I (3-1-0)

Orthogonal and curvilinear coordinates. Scalar and vector fields, Vector differential operators: gradient, curl. divergence and Laplacian. Vector operators in curvilinear coordinates. Gauss' theorem. Green's theorem and Stokes' theorem (statements only): applications to physical problems. Tensors. Partial differential equations: applications in electrostatics, Laplace and Poisson equations: heat conduction, diffusion, elastic and electromagnetic waves. Wave equation. Solutions in rectangular, spherical polar and cylindrical polar coordinates. Boundary conditions. Linear vector spaces and representations. Matrices. Similarity transformations, diagonalization, orthogonality. Hermitian matrices. Elements of complex variables. Residue theorem and contour integration. Special functions: Bessel, Hermite, Legendre, Laugerre polynomials: generating functions and orthonormality. Dirac delta function and its representations. Fourier analysis. Fourier transforms, Laplace transforms and applications in physics.

References :

1. G. Arfken, Mathematical Methods for Physicists. Academic Press. 3rd Edition (1985).

2. L.A. Pipes & L.R. Harwill, Applied Mathematics for Physicists & Engineers, McGraw-Hill (1971).

3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers (1990)

4. C.R. Wylie and L.C. Barrett. Advanced Engineering Mathematics, 5th Edition, McGraw-Hill (1982).

5. M.R. Spiegel in Schaum's outline series, McGraw-Hill (1964). (i) Vector Analysis (ii) Complex Variables (iii) Laplace Transforms (iv) Matrices (v) Differential Equations (vi) Group Theory.

6. H.Cohen, Mathematics for Scientists and Engineers, Prentice Hall (1992).

MPY102 Classical Mechanics (3-1-0)

Degrees of freedom, generalised coordinates and velocities. Lagrangian, action principle, external action, Euler-Lagrange equations. Constraints. Applications of the Lagrangian formalism. Generalised momenta, Hamiltonian, Hamilton's equations of motion. Legendre transform, relation to Lagrangian formalism. Phase space, Phase trajectories. Applications to systems with one and two degrees of freedom. Central force problem, Kepler proble. Scattering in a central potential, Rutherford formula, scattering cross section. Noninertial frames of reference and pseudoforces: centrifugal Coriolis and Euler forces. Elements of rigid-body dynamics. Euler angles. The symmetric top. Small oscillations Normal mode analysis. Normal modes of a harmonic chain. Elementary ideas on general dynamical systems: conservative versus dissipative systems. Hamiltonian systems and Liouville's theorem. Canonical transformations, Poisson brackets. Action-angle variables. Special relativity: Internal frames. Principle and postulate of relativity. Lorentz transformations. Length contraction, time dilation and the Doppler effect. Velocity addition formula. Four- vector notation. Energy-momentum four-vector for a particle. Relativistic invariance of physical laws.

References :

1. H. Goldstein, Classical Mechanics, 2nd Edition, Narosa Pub. House (1989).

2. I. Percival and D. Richards, Introduction to Dynamics, Cambridge University Press (1987) [Chapters 4,5,6, 7 in particular. also parts of Chapter 1-3,9, 10].

3. D. Rindler, Special Theory of Relativity, Oxford University Press (1982).

MPY103 Quantum Mechanics- I (3-1-0)

Recapitulation of Basic Concepts: Wave packet: Gaussian wave packet; Fourier transform; Spreading of a wave packet; Fourier Transforms of δ and sine functions. Coordinate and Momentum space: Coordinate and Momentum representations; x and p in these representations; Parserval's theorem. Eigenvalues and eigenfunctions: Momentum and parity operators; Commutativity and simultaneous eigenfunctions; Complete set of eigenfunctions; expansion of wave function in terms of a complete set. One-dimensional problems: Square well problem (E > 0); Delta-function potential; Double-δ potential; Application to molecular inversion; Multiple well potential, Kronig-Penney model. Operator method in Quantum Mechanics: Formulation of Quantum Mechanics in vector space language; Uncertainty principle for two arbitrary operators; One dimensional harmonic oscillator by operator method. Quantum theory of measurement and time evolution: Double Stern-Gerlach experiment for spin- 1 2 system; Schr¨odinger, Heisenberg and interaction pictures. Three-dimensional problems: Three dimensional problems in Cartesian and spherical polar coordinates, 3-d well and Fermi energy; Radial equation of free particle and 3-d harmonic oscillator; Eigenvalue of a 3-d harmonic oscillator by series solution. Angular momentum: Angular momentum algebra; Raising and lowering operators; Matrix representation for j = 1 2 and j = 1; Spin; Addition of two angular momenta — Clebsch-Gordan coefficients, examples. Approximation Methods: Time independent perturbation theory: First and second order corrections to the energy eigenvalues; First order correction to the eigenvector; Degenerate perturbation theory; Application to one-electron system – Relativistic mass correction, Spin-orbit coupling (L-S and j-j), Zeeman effect and Stark effect. Variational method: He atom as example; First order perturbation; Exchange degeneracy; Ritz principle for excited states for Helium atom.

References :

1. E. Merzbacher, Quantum Mechanics, 2nd Edition, Wiley International Edition (1970).
2. V.K. Thankappan, Quantum Mechanics. Wiley Eastern (1985)
3. J.J. Sakurai, Modern Quantum Mechanics, Benjamin Cummings (1985).
4. R.P. Feynman, R.B. Leighton and M.Sands, The Feynman Lectures on Physics, Vol.3, Narosa Pub. House (1992).
5. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw-Hill (1977).

MPY104 Electronics (3-1-0)

Introduction to Integrated Circuits Differential amplifiers using Transistors Operational amplifiers: Features, Characteristics, Negative feedback configurations, Mathematical operations application circuits, Non-linear applications , Comparator, Regenerative comparator, Relaxation oscillator, Log and Antilog amplifiers , Multiplier, square and square-root circuits NE555, principle of operation and applications Introduction to Digital logic gates:Combinational circuits, Reduction using Karnaugh map, Implementation using universal gates, Arithmetic circuits, Binary BCD addition Decoders and encoders Multiplexers and demultiplexers their applications Flip-flops - types and implementation:Conversions, triggering, master/slave implementation Registers: Binary up down counters , Synchronous counters , Ring and Johnson counters Random sequence generators: 7-segment display devices, A to D and D to A converters Applications of digital circuits :Digital clock, stop-watch, frequency and period counter, digital voltmeter etc. Introduction to microprocessors: Brief outline of 8085 processor, Instruction set, Simple programming examples, Pick the largest number, Delay, Arithmetic operation with single and multiplier, Block move with overlapping memory address, Ascending and descending ordering

References :

1. Electronic Principles – 5th Edition, Albert Paul Malvino Tana Mc-Graw-Hill Publishing Company Ltd., New Delhi, 1993
2. Digital Principles and Applications – 5th Edition Albert Paul Malvino Donald P.LcachTata Mc-Graw-Hill Publishing Company Ltd., New Delhi, 1994
3. Microprocessor Architecture, Programming and its Applications with the 885/8080A latest edition, 5th edition Ramesh S.Gaonkar Wiley Eastern Ltd., New Delhi, Bangalore, Madras. , 2002
4. Digital Fundamentals – 9th edition, Thomas L.Floyd,Prentice Hall, July 13, 2005
5. Digital Design – 3rd edition, M.Morris Mano Prentice Hall, 2001
6. Digital Design – 4th edition, M.Morris ManoPrentice Hall, 2006.

MPY105 COMPUTER APPLICATIONS IN PHYSICS (3-0-2)

Programming in MathCAD, MATLAB, Mathematica. Use of Origin, Curve Fitting, Extrapolation. Error analysis. Basics of Simulation techniques. Elements of C Programming Language: Algorithms and flowchart; Structure of a high level language program; Features of C language; constants and variables; expressions; Input and output statements; conditional statements and loop statements; arrays; functions; character strings; structures; pointer data type Numerical Methods: Roots of Polynomials, Solution of Linear simultaneous equations, matrix multiplication and inversion. Numerical integration. Statistical treatment of data, variance and correlations.

Books Recommended: 1. MatLAB by Rudrapratap, 2.Balaguruswamy, ANSI C. TMH. 2. Gottfried, Programming with C. Schaum series. 3. Tanenbaum, Operating system. Prentice Hall.

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MPY201 Mathematical Physics II (3-1-0)

Complex Variables Analytic functions of a complex variable. Cauchy-Riemann conditions. Power series. Cauchy’s integral theorem. Conformal mapping. Singularities: poles, essential singularities. Residue theorem. Contour integration and examples. Analytic continuation. Multiple-valued functions, branch points and branch cut integration. Partial Differential Equations Partial differential equations in Physics: Laplace, Poisson and Helmholtz equations; diffusion and wave equations. Applications. Integral transforms Laplace transforms and Fourier transforms. Parsevall’s theorem. Convolution theorem. Applications. Calculus of Variations Functionals. Natural boundary conditions. Lagrange multipliers. Rayleigh-Ritz method. Group theory Elements of group theory. Discrete groups with examples. Contionuos groups (Lie groups) [rotation group in 2 and 3 dimensions, U(1) and SU(2)]. Generators. Representations, Character tables for some point groups and the orthogonality theorem.

Text Books: 1. G. Arfken and H.J. Weber, Mathematical Methods for Physicists, Academic Press, 6th Edition, Indian Edition, (2005). 2. P. Dennerey and A. Kryzwicki, Mathematics for

Physicists, Dover (Indian Edition), (2005). 3. K.F. Riley, M.P. Hobson and S.J. Bence, Mathematical Methods for Physics and Engineering, Cambridge University Press (Cambridge Low-priced Edition) (1999).

References :

1. G. Arfken, Mathematical Methods for Physicists. Academic Press. 3rd Edition (1985).
2. L.A. Pipes and L.R. Harwill, Applied Mathematics for Physicists and Engineers, McGraw-Hill (1971).
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers (1990)
4. C.R. Wylie and L.C. Barrett. Advanced Engineering Mathematics, 5th Edition, McGraw-Hill (1982).
5. M.R. Spiegel in Schaum's outline series, McGraw-Hill (1964). (i) Vector Analysis (ii) Complex Variables (iii) Laplace Transforms (iv) Matrices (v) Differential Equations (vi) Group Theory.
6. H.Cohen, Mathematics for Scientists and Engineers, Prentice Hall (1992).

MPY202 Electromagnetic Theory (3-1-0)

Maxwell equations and electromagnetic waves. Maxwell equations (both differential and integral formulations). Boundary conditions on field vectors D, E, B and H. Vector and scalar potentials. Gauge transformations: Lorentz and Coulomb gauges. Green function for the wave equation. Poynting's theorem. Conservation laws for macroscopic media. Propagation of plane waves and spherical waves in free space, dielectrics and conducting media. Reflection and refraction of electromagnetic waves. Superposition of waves. Radiation from an oscillating dipole and radiation from an accelerating charge. Electromagnetic stress tensor. Wave Guides: Modes in rectangular and cylindrical wave guides (conducting and dielectric). Resonant cavities. Evanescent waves. Energy dissipation. Q of a cavity. Radiation from time-dependent sources of charges and currents Inhomogeneous wave equations and their solutions; Radiation from localised sources and multipole expansion in the radiation zone. Relativistic electrodynamics Equation of motion in an electromagnetic field; Electromagnetic field tensor, covariance of Maxwells equations; Maxwell's equations as equations of motion; Lorentz transformation law for the electromagnetic fields and the fields due to a point charge in uniform motion; Field invariants; Covariance of Lorentz force equation and the equation of motion of a charged particle in an electromagnetic field; The generalised momentum; Energy-momentum tensor and the conservation laws for the electromagnetic field; Relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field. Radiation from moving point charges. Lienard-Wiechert potentials; Fields due to a charge moving with uniform velocity; Fields due to an accelerated charge; Radiation at low velocity; Larmor's formula and its relativistic generalisation; Radiation when velocity (relativistic) and acceleration are parallel, Bremsstrahlung; Radiation when velocity and acceleration are perpendicular, Synchrotron radiation; Cherenkov radiation (qualitative treatment only). Thomson and Compton scattering

References :

1. J.D. Jackson, Classical Electrodynamics, Wiley Eastern, 2nd Edition (1975).
2. David J. Griffiths, Introduction to Electrodynamics, Prentice Hall of India, 2nd Edition, (1989).
3. J.R. Reitz., F.J. Milford and R. W. Christy, Foundations of Electromagnetic Theory, 3rd Edition, Narosa Pub. House (1979).

4. P. Lorrain and D. Corson, Electromagnetic Fields and Waves. CBS Publishers and Distributors (1986).
5. B.H. Chirgwin, C. Plumpton and C. W. Kilmister, Elementary Electromagnetic Theory, Vols.1, 2 and 3" Pergamon Press (1972).

MPY203 Quantum Mechanics II (4-1-0)

WKB Approximation: Quantisation rule, tunnelling through a barrier, qualitative discussion of α-decay. Time-dependent Perturbation Theory: Time dependent perturbation theory, interaction picture; Constant and harmonic perturbations — Fermi's Golden rule; Sudden and adiabatic approximations. Scattering theory: Laboratory and centre of mass frames, differential and total scattering cross-sections, scattering amplitude; Scattering by spherically symmetric potentials; Partial wave analysis and phase shifts; RamsauerTownsend effect; Relation between sign of phase shift and attractive or repulsive nature of the potential; Scattering by a rigid sphere and square well; Coulomb scattering; Formal theory of scattering — Green's function in scattering theory; Lippman-Schwinger equation; Born approximation. Symmetries in quantum mechanics: Conservation laws and degeneracy associated with symmetries; Continuous symmetries — space and time translations, rotations; Rotation group, homomorphism between SO(3) and SU(2); Explicit matrix representation of generators for j = 1/ 2 and j = 1; Rotation matrices; Irreducible spherical tensor operators, Wigner-Eckart theorem; Discrete symmetries — parity and time reversal. Identical Particles: Meaning of identity and consequences; Symmetric and antisymmetric wavefunctions; Slater determinant; Symmetric and antisymmetric spin wavefunctions of two identical particles; Collisions of identical particles. Relativistic Quantum Mechanics: Klein-Gordon equation, Feynman-St¨uckelberg interpretation of negative energy states and concept of antiparticles; Dirac equation, covariant form, adjoint equation; Plane wave solution and momentum space spinors; Spin and magnetic moment of the electron; Non-relativistic reduction; Helicity and chirality; Properties of γ matrices; Charge conjugation; Normalisation and completeness of spinors.

References :

J.J. Sakurai Modern Quantum Mechanics, Benjamin / Cummings (1985).
2. P.A.M. Dirac, The Principles of Quantum Mechanics, Oxford University Press (1991).
3. L.D.Landau and E.M. Lifshitz, Quantum Mechanics -Nonrelativistic Theory, 3rd Edition, Pergamon (1981).
4. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill (1977).
5. J. Bjorken and S. Drell, Relativistic Quantum Mechanics, McGraw-Hill (1965).
6. A. Messiah, Quantum Mechanics, Vols. 1 and 2, North Holland (1961)

MPY204 Condensed Matter Physics (3-1-0)

Classification of condensed matter: crystalline, noncrystalline, nanophase solids, liquids. Crystalline solids: Bravais lattices, crystal systems, point groups, space groups and typical structures. Crystal symmetry and macroscopic physical properties: tensors of various ranks:

pyroelectricity, ferroelectricity, electrical conductivity, piezoelectricity and elasticity tensors. Propagation of elastic waves in crystals and measurement of elastic constants. Diffraction of waves by crystals: X-rays, neutrons, electrons. Bragg's law in direct and reciprocal lattice. Structure factor. Principles of diffraction techniques. Brillouin zones. Types of binding. Ionic crystals: Born Mayer potential. Thermochemical Bom-Haber cycle. Van der Waals binding: rare gas crystals and binding energies. Covalent and metallic binding: characteristic features and examples. Lattice dynamics: monoatomic and diatomic lattices. Born-von Karman method. Phonon frequencies and density of states. Dispersion curves, inelastic neutron scattering. Reststrahlen Specific heat. Thermal expansion. Thermal conductivity. Normal and Umklapp processes. Free electron theory of metals. Thermal and transport properties. Hall effect Electronic specific heat. Bloch functions. Nearly free electron approximation. Formation of energy bands. Gaps at Brillouin zone boudaries. Electron states and classification into insulators, conductors and semimetals. Effective mass and concept of holes. Fermi surface. Cyclotron resonance. Semiconductors: carrier statistics in intrinsic and extrinsic crystals, electrical conductivity. Liquid crystal: thermotropic and lyotropic. Nematics and sematics: applications. Amorphous/glassy states.

References :

1. Charles Kittel, Introduction to Solid State Physics, Wiley, 5th Edition (1976).
2. A.J. Dekker. Solid State Physics, Prentice Hall, (1957)
3. N.W. Ashcroft and N.D. Mermin, Solid State Physics, Saunders College Publishing (1976).
4. J.S. Blakemore,Solid State Physics, 2nd Edition, Cambridge University Press. (1974).
5. Mendel Sachs, Solid State Theory, McGraw-Hill (1963)
6. Harald bach and Hans Luth, Solid-State Physics, Springer International Student Edition, Narosa Pub. House, (1991).

MPY205 Nuclear and Particle Physics (3-1-0)

Nuclear Properties : Basic nuclear properties: nuclear size, Rutherford scattering, nuclear radius and charge distribution, nuclear form factor, mass and binding energy, Angular momentum, parity and symmetry, Magnetic dipole moment and electric quadrupole moment, experimental determination, Rabi's method. Two-body bound state: Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron, rms radius, spin dependence of nuclear forces, electromagnetic moment and magnetic dipole moment of deuteron and the necessity of tensor forces. Two-body scattering: Experimental n-p scattering data, Partial wave analysis and phase shifts, scattering length, magnitude of scattering length and strength of scattering, Significance of the sign of scattering length; Scattering from molecular hydrogen and determination of singlet and triplet scattering lengths, effective range theory, low energy p-p scattering, Nature of nuclear forces: charge independence, charge symmetry and iso-spin invariance of nuclear forces. β-decay: β-emission and electron capture, Fermi's theory of allowed β-decay, Selection rules for Fermi and Gamow-Teller transitions, Parity non-conservation and Wu's experiment. Nuclear Structure: Liquid drop model, Bethe-Weizsacker binding energy/mass formula, Fermi model, Shell model and Collective model. Nuclear Reactions and Fission: Different types of reactions, Quantum mechanical theory, Resonance scattering and reactionsBreit-Wigner dispersion relation; Compound nucleus formation and break-up, Statistical theory of nuclear reactions and evaporation probability, Optical model; Principle of detailed balance, Transfer reactions, Nuclear fission: Experimental features, spontaneous fission, liquid drop model, barrier penetration, statistical model, Super-heavy nuclei. Nuclear Physics in other areas (Qualitative ideas only): Nuclear Astrophysics: nucleo-synthesis and abundance of elements, neutron star. Nuclear medicine: diagnostic and therapeutic. Particle Physics: Symmetries and conservation laws, Hadron classification by isospin and hypercharge, SU(2) and SU(3): Groups, algebras and generators; Young tableaux rules for SU(2) and SU(3); Quarks; Colour; Elementary ideas of electroweak interactions and standard model.

References :

1. M.A. Preston: Physics of the Nucleus
2. M.K. Pal: Theory of Nuclear Structure
3. R.R. Roy and B.P. Nigam: Nuclear Physics
4. S.N. Ghoshal: Atomic and Nuclear Physics (Vol. 2)
5. D.H. Perkins: Introduction to High Energy Physics
6. D.J. Griffiths: Introduction to Elementary Particles

MPY301 Statistical Physics (3-1-0)

Systems with a very large number of degrees of freedom: the need for statistical mechanics. Macrostates, microstates and accessible microstates. Fundamental postulate of equilibrium statistical mechanics. Probability distributions. Microcanonical ensemble, Boltzmann's formula for entropy. Canonical ensemble, partition function, free energy. calculation of thermodynamic quantities. Classical ideal gas. Maxwell-Boltzmann distribution, equipartition theorem. Paramagnetism, Langevin and Brillouin functions, Curie's law. Quantum statistics: systems of identical, indistinguishable particles, spin, symmetry of wavefunctions, bosons, Pauli's exclusion principle, fermions. Grand canonical ensemble. Bose-Einstein and Fermi-Dirac distributions. Degeneracy. Free electron gas, Pauli paramagnetism. Blackbody radiation. Bose-Einstein condensation. Einstein model of lattice vibrations. phonons, Debye's theory of the specific heat of crystals. Phase diagrams, phase equilibria and phase transitions. Mean-fjeld theory of liquid-gas transition (Van der Waals model) and ferromagnet-paramagnet transition (Weiss' molecular field theory). Heisenberg exchange interaction and the origin of ferromagnetism. Elementary ideas on Ising and Heisenberg models of ferromagnetism.

References :

1. D. Chandler, Introduction to Modern Statistical Mechanics, Oxford University press (1987).
2. C.J. Thompson, Equilibrium Statistical Mechanics, Clarendon Press (1988).
3. F. Reif, Fundamentals of Statistical and Thermal Physics, International Student Edition, McGraw-Hill (1988). 4. K. Huand, Statistical Mechanics, IJ\Iiley Eastern (1988).
5. L.D.. Landau and E.M. Lifshitz, Statistical Physics (Par1I), 3rd Edition, Pergamon Press (1989).
6. F. Reif, Statistical Physics (Berkeley Physics Course, Vol.5), McGraw Hill (1967).
7. F. Mandl, Statistical Physics, 2nd edition, ELBS & Wiley (1988)
8. E.S.R. Gopal, Statistical Mechanics and Properties of Matter MacMillan India (1988).
9. R. Kubo. Statistical Physics -Problems and Solutions, North Holland (1965).
10. Y.K. Lim, Problems and Solutions in Thermodynamics and Statistical Mechanics, World Scientific (1990).

MPY302 Atomic and Molecular Spectroscopy (3-1-0)

General discussion in Hydrogen spectra, fine structure, relativistic correction to spectra of hydrogen atom, Lamb shift, effect of magnetic field on the above spectra, Zeeman and Paschen-Back effect. Spectra of divalent atoms: Singlet and triplet states of divalent atoms, L-S and j-j coupling, branching rule, magnetic field effects, Breit's scheme, Spectra of Multi-valent atoms ideas only; complex spectra, equivalent electrons and Pauli exclusion principle. Hyperfine structure in spectra of monovalent atoms, origin of X-rays spectra, screening constants, fine structure of X-ray levels, spin-relativity and screening doublet-laws, non-diagram lines, Auger effect. Lasers in Spectroscopy: Broadening of spectral lines, Doppler-free spectroscopy, excitation spectroscopy, ionization spectroscopy, Tera Hertz spectroscopy with innovative applications. Born-Oppenheimer approximation and separation of electronic and nuclear motions in molecules. Band structures of molecular spectra. Microwave and far infrared spectroscopy : Energy levels of diatomic molecules under rigid rotator and non-rigid rotator models. Selection rules. Spectral structure. Structure determination. Isotope effect. Rotational spectra of polyatomic molecules. Stark effect. Infrared spectra : Energy levels of diatomic molecules under simple harmonic and anharmonic (no deduction necessary for this one) models. Selection rules and spectral structures. Morse potential energy curves. Dissociation energies. Isotope effect. Rotational – vibrational coupling. Parallel and perpendicular modes. Symmetry properties of molecular wave functions and nuclear spins. Raman spectroscopy. Rotational, Vibrational, Rotational-Vibrational Raman spectra. Stokes and anti stokes Raman lines. Selection Rules. Spectral structures. Nuclear spin and its effect on Raman spectra. Vibrational spectra of poly atomic molecules. Normal modes. Selection rules for Raman and infrared spectra. Complementarity of Raman and infrared specra. Electronic spectra of diatomic molecules: (a) Vibrational band structure. (b) Rotational structure of electronic spectra. P-, Q- and R- branches. Band head formation and shading of bands. (c) Intensity distribution in the vibrational structure of electronic spectra and Franck Condon principle. Hydrogen molecule ion and molecular orbitals. Valence Bond approach in hydrogen molecule. Coulomb and exchange integrals. Electronic structures of simple molecules. Chemical bonding. Hybridizations. Basic aspects of photo physical processes: radiative and non-radiative transitions; fluorescence and phosphorescence; Kasha's rules. Nuclear Magnetic resonance spectroscopy. Electron spin resonance spectroscopy. Fourier transform spectroscopy. Photo acoustic spectroscopy. Photo electron spectroscopy. Mossbauer spectroscopy.

References :

1. B.H. Bransden and C.J. Joachain: Physics of Atoms and Molecules
2. C. Cohen-Tannoudji, B. Dier, and F. Laloe: Quantum Mechanics vol. 1 and 2
3. R. Shankar: Principles of Quantum Mechanics
4. C.B. Banwell: Fundamentals of Molecular Spectroscopy
5. G.M. Barrow: Molecular Spectroscopy
6. J.D. Graybeal: Molecular Spectroscopy
7. M.C. Gupta: Atomic and Molecular Spectroscopy
8. A. Thorne, U. Litzen and J. Johnson: Spectrophysics
9. Hertzberg. , Molecular Spectroscopy,

DEPARTMENTAL ELECTIVES

MPY001 Group Theory (3-0-0)

1. Abstract group theory: Definition. Group postulates. Finite and infinite groups, order of a group, subgroup; rearrangement theorem, multiplication table. Cosets, Lagrange's theorem. Order of an element.. Conjugate elements and classes. Invariant subgroups, factor groups. Generators. Isomorphism and homomorphism. Cyclic and other distinct groups. Permutation and alternating groups. Cayley's theorem. 2. Representation theory: Definition of representation. Faithful and unfaithful representations. Invariant subspaces and reducible representations. Reducible and irreducible representations. Schur's lemmas, great orthogonality theorem and its geometrical interpretation. Character. First and second orthogonality theorems of characters and its geometrical interpretation. Regular representation, celebrated theorem and its implication. Projection operators; determination of basis functions. Direct product groups and their representations Direct product representations and their reduction. Construction of character tables of simple groups. 3. Continuous group: Infinite groups. Discrete and continuous groups, mixed continuous group. Topological and Lie groups. Axial rotation group SO(2). Rotation group SO(3). Special Unitary groups SU(2) and SU(3) and their application in Physics. 4. Application in Physics Group of Schrodinger equation. Reduction due to symmetry. Perturbation and level splitting. Selection rules. Zeeman effect.

MPY002 Laser Physics (3-0-0)

Introduction. Physics of interaction between Radiation and Atomic systems including: stimulated emission, emission line shapes and dispersion effects. Gain saturation in laser media and theory of FabryPerot laser. Techniques for the control of laser output employing Qswitching, mode-locking and mode-dumping. Optical cavity design and laser stability criteria. Description of common types of conventional lasers. Physics of semiconducting optical materials, degenerate semiconductors and their Homojunctions and Hetrojunctions. Light emitting diodes (LED's), junction lasers. Characteristics of diode laser arrays and applications.

MPY003 Laser Systems and Applications (3-0-0)

Review of laser theory, properties of laser radiation, and laser safety; Common laser systems : Ruby-, Nd:YAG- and Nd:Glass lasers, diodepumped solid state laser, Er-doped silica fiber laser, Ti:Sapphire laser, He-Ne, CO_2 and Ar-ion lasers, excimer-, dye-, X-ray- and free-electron lasers; Semiconductor lasers : Double heterostructure–and quantumwell lasers, VCSEL, DFB- and DBR lasers; Application of lasers in data storage, communication and information technology : CD players, DVDs, laser printers, bar-code scanners, and optical communication; Surface profile and dimensional measurements using diffraction and its variations; High-power laser applications: marking, drilling, cutting, welding, and hardening; laser fusion; Laser Doppler velocimetry, LIDAR, laser spectroscopy, medical applications of lasers.

MPY004 Fiber Optics (3-0-0)

Fiber numerical aperture, Sources of signal attenuation and dispersion, Step and graded index multimode fibers, including plastic fibers LP modes in optical fibers: Single-mode fibers, mode cutoff and mode field diameter, Pulse dispersion in single-mode fibers: dispersion-tailored and dispersion-compensating fibers. Birefringent fibers and polarization mode dispersion. Fiber bandwidth and dispersion management, Erbiumdoped fiber amplifiers and lasers; Isolators, Fiber fabrication techniques. Fiber characterization techniques including OTDR, Connectors, splices and fiber cable.

MPY005 Applied Optics (3-1-0)

Scalar waves, Diffraction integral, Fresnel and Fraunhofer diffraction, Single slit-Multiple slits-Circular aperture diffraction, Zone plate, Resolving power, Gaussian beam, Coherence theory, Interferometry, Laser Speckles, Basics of Fourier transformation (FT) operation, definition of spatial frequency, Transmittance functions, FT operation, Definition of spatial frequency, Transmittance functions, FT by diffraction and by lens, Spatial filtering-basics, Types of filters, Abbe-Porter experiment, Phase contrast microscope, Matched filter, Holographic principles, Onaxis and off-axis hologram recording and reconstruction, Hologram types, Few applications, Wave propagation in anisotropic media, Polarized light, Uniaxial crystals, polarizing components, Guided wave optics-basics, Fiber optics.

MPY006 Theory and Applications of Holography (3-0-0)

Basics of holography, in-line and off-axis holography; Reflection, white light, rainbow and wave guide holograms; Theory of plane holograms, magnification, aberrations, effects of non-linearity, band-width and source size; Volume holograms: coupled wave theory, wavelength and angular selectivity, diffraction efficiency; Recording medium for holograms: silver halides, dichromatic gelatin, photoresist, phoconductor, photorefractive crystals, etc.; Applications : microscopy; interferometry, NDT of engineering objects, particle sizing; holographic particle image velocimetry; imaging through aberrated media, phase amplification by holography; optical testing; HOEs: multifunction, polarizing, diffusers, interconnects, couplers, scanners; Optical data processing, holographic solar concentrators; antireflection coatings; holo-photoelasticity; Colour holography: recording with multiple wavelength; white light colour holograms; Electron holography, acoustic and microwave holography and some typical applications, computer holography, digital holography.

MPY007 Plasma Physics (3-0-0)

Introduction to plasma, Debye shielding, Single particle motion in E and B fields, Magnetic confinement, Plasma oscillations, Waves in unmagnetized plasmas, Solitons, Two stream instability, Rayleigh Taylor instability, Vlasov equation and Landau damping, Waves in magnetized plasmas (fluid theory), Plasma production & characterization, Plasma processing of materials, Laser driven fusion, Cerenkov free electron laser, Applications to astrophysics and astronomy.

MPY008 Electronic Properties of Materials (3-0-0)

Drude and Sommerfeld theories of metals, Effect of periodic lattice potential, Magnetic behaviour-exchange interaction and magnetic domains, Ferrimagnetic order, ferrites and garnets, hard and soft magnets, single domain magnets, spin waves, surface magnetism, dielectric constants of solids and liquids, Claussius-Mossoti relation, dielectric dispersion and losses, piezo, ferro-and pyroelectricity, optical constants, atomistic theory of optical properties, quantum mechanical treatment, band transitions, dispersion, plasma oscillations.

MPY009 Science & Technology of Thin Films (3-0-0)

Physical Vapor Deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys, Raoult's law; e-beam, pulsed laser and ion beam evaporation, Glow Discharge and Plasma, Sputtering–mechanisms and yield, dc and rf sputtering, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Hybrid and Modified PVD- Ion plating, reactive evaporation, ion beam assisted deposition, Chemical Vapor Deposition - reaction chemistry and thermody-namics of CVD; Thermal CVD, laser & plasma enhanced CVD, Chemical Techniques - Spray Pyrolysis, Electrodeposition, SolGel and LB Techniques, Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, amorphous thin films, Epitaxy–homo, hetero and coherent epilayers, lattice misfit and imperfections, epitaxy of compound semiconductors, scope of devices and applications.

MPY010 Physics of Nanomaterials (3-0-0)

Physics of low-dimensional materials, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Surface plasmon, Size and surface dependence of physical, electronic, optical, luminescence, thermo-dynamical, magnetic, catalysis, gas sensing and mechanical properties. Physical and chemical techniques for nanomaterial synthesis, Assembling and self organization of nanostructures, Nanoscale manipulation, Nanotube and wire formation, Importance of size distribution control, size measurement and size selection.

MPY011 Biophysics (3-0-0)

General Biophysics 1. PH Meter: Standardization of pH meter, Preparation of Buffers, 2. pH titration curve of acid-base 3. Determination values of Iso-electric point: Amino acids, proteins, phosphoric acids. 4. Viscosity: Determination of viscosity of biofluids and chemicals 5. Colorimeter: Verification of Beer'sLambert law, determiantion of absorption maxima of color compounds, determination of molecular extinction coefficient. 6. Estimation of percent purities of dyes and inorganic compound

MPY012 Astrophysics and Cosmology (3-0-0)

Introduction to Astrophysics and Astronomy, Celestial coordinate systems (Sun-Earth system, Galactic Coordinate system). Stellar Structure and Evolution: i) Star formation, Stellar Magnitudes, Classification of stars, H-D classification, Saha Equation of ionization, Hertzsprung-Russel (H-R) diagram. ii) Gravitational energy, Virial theorem, Equations of stellar structure and evolution. iii) Pre-main sequence evolution, Jeans criteria for star formation, fragmentation and adiabatic contraction, Evolution on the main sequence, Post main sequence evolution, Polytropic Models: Lane-Emden equation, simple stellar models: Eddington's model and Homologous model, Convective and Radiative stars, Pre-main sequence contraction: Hayashi and Henyey tracks. Nuclear Astrophysics: Thermonuclear reactions in stars, pp chains and CNO cycle, Solar Neutrino problem, subsequent thermonuclear reactions, Helium burning and onwards, nucleosynthesis beyond iron, r- and s- processes. Stellar Objects & Stellar Explosions: Qualitative discussions on: Galaxies, Nabulae, Quasars, Brown dwarfs, Red Giant Stars, Nova, Supernova. Gravitational Collapse and relativistic Astrophysics: Newtonian theory of stellar equilibrium, White Dwarfs, Electron degeneracy and equation of States, Chandrasekhar Limit, Mass-Radius relation of WD. Neutron Stars, Spherically symmetric distribution of perfect fluid in equilibrium. Tolman-Oppenheimer-Volkoff (TOF) equation, Mass-Radius relations of NS. Pulsars, Magnetars, Gamma ray bursts. Black holes, Collapse to a black hole (Oppenheimer and Snyder), event horizon, singularity. Accretion disks: Formation of Accretion Disks, Differentially rotation systems in Astrophysics, Disk dynamics, Steady Disks, Disk formation in close binary systems through mass transfer, Accretion onto compact objects (Black Holes and Neutron Stars).

Books Recommended: 1. Textbook of astronomy an astrophysics with elements of cosmology, V.B.Bhatia, Narosa publishing house, 2001. 2. Astrophysics – Stars and Galaxies, K. D. Abhyankar, University Press, 2001. 3. Theoritical Astrophysics (Vols.I,II,III) – T. Padmanavan (CUP) 4. Black Holes, White Dwarfs and Neutron Stars – S.L.Shapiro and S.A.Teukolsky (John Wiley, 1983)

Laboratory

MPY 191

1. Study of multivibrator
2. Michelson Interferometer
3. Study of Filter Circuits
4. Microprocessor – I (Basic Experiments)
5. Microprocessor – II (Advanced Experiments)
6. Study of Magneto-resistance
7. To study the Faraday effect and Verdert constant of the given material.
8. Determination of e/m of an electron
9. Determination of Planck's Constant
10. To study the effect of magneto-striction of a given material.

MPY 291

1. Study of Amplitude Modulation
2. Study of Optical Fiber and determination of Numerical Aperture
3. Determination of Velocity of Ultrasonic Wave
4. Study of S.C.R.
5. Study of Hall Effect
6. Determination of Band-Gap of a Semiconductor
7. Determination of Lande g - factor
8. Study of Lattice Dynamics
9. Calibration of Condenser
10. Study of Hall Effect at elevated temperatures

MPY 391

1. Study of Dielectric constant and determination of Curie temperature
2. Study of Iodine Spectra
3. Study of P-N junction at elevated temperatures
4. Determination of spot size and the angle of divergence of a given laser source.
5. Measurement of absorption coefficient of a material (supplied) using laser light.
6. Determination of numerical aperture of a fiber by measuring the diameter of laser beam.
7. Design and study of an ECL OR-NOR circuit.
8. Design and study of an active band pass filter.
9. Design and study of an active phase sifter.

10. Design and study of a current controlled oscillator.