M.Sc. Physics Syllabus
Scheme of Courses

Semester	Course Code	Title of the Course	No. of Credits	Core / Elective
Semester-I	SPM PHY01101C3104	Mathematical Methods in Physics	4	Core
	SPM PHY01102C3104	Classical Mechanics	4	Core
	SPM PHY01103C3104	Quantum Mechanics	4	Core
	SPM PHY01104C0246	Laboratory Experiments I	6	core
	SPM PHY01101E3104	Numerical Methods and Programming	4	Elective
	SPM PHY01102E3104	$\LaTeX$ for Science and Mathematics	4	Elective
	SPM PHY01103E3104	Modern Optics	4	Elective
Semester-II	SPM PHY01201C3104	Statistical Mechanics	4	Core
	SPM PHY01202C3104	Classical Electrodynamics	4	Core
	SPM PHY01203C3104	Electronics-I	4	Core
	SPM PHY01204C0246	Laboratory Experiments II	6	core
	SPM PHY01201E3104	Computational Physics	4	Elective
	SPM PHY01202E3104	Advance Quantum Mechanics	4	Elective
Semester-III	SPM PHY01301C3104	Atomic, Molecular Physics and Lasers	4	Core
	SPM PHY01302C3104	Nuclear Physics	4	Core
	SPM PHY01302C3104	Solid State Physics	4	Core
	SPM PHY01303C0246	Laboratory Experiments-III	6	Core
	SPM PHY01301E3104	Relativistic Quantum Mechanics	4	Elective
	SPM PHY01302E3104	Physics of Electronic Materials and Devices	4	Elective
	SPM PHY01303E3104	Electronic Communication	4	Elective
	SPM PHY01304E3104	Thin Films and Devices	4	Elective
Semester IV	SPM PHY01401C3104	Spectroscopy	4	Core
	SPM PHY01401E3104	Microprocessor and Microcontroller	4	Elective
	SPM PHY01402E3104	Physics of Nanomaterials	4	Elective
	SPM PHY01403E3104	Nuclear Physics: Interactions and Models	4	Elective
	SPM PHY01301C3104	PROJECT AND DISSERTATION	6	Core

NOTE: The above mentioned syllabus and course is subjected to changes as per future requirements.

Course Number :SPM PHY01101C3104

Mathematical Methods in Physics

1.Tensors: Coordinate transformations, scalars, contravariant and covariant vectors, definition of contravarient, mixed and covariant tensor of second rank, Addition, subtraction and contraction of tensors, quotient rule. Christoffel symbols, transformation of Christoffel symbols, covariant differentiation, Ricci's theorem, divergence, Curl and Laplacian tensor form, Stress and strain tensors, Hook's law in tensor form

2.Second Order Differential Equations and Special functions: Separation of variables-ordinary differential equations, singular points, series solutions leading to Legendre, Bessel, Hermite, Laguerre functions as solutions. Orthogonal properties and recurrence relations of these functions.Spherical harmonics and associated Legendre polynomials.Hermitepolynomials.Sturm-Liouville systems and orthogonal polynomials.Wronskian-linear independence and linear dependence.

3.Complex Variables: Functions of complex variable, Limits and continuity, differentiation, Analytical functions, Cauchy- Riemannn conditions, Cauchy Integral theorem, Cauchy integral formula, Derivatives of analytical functions, Liouville's theorem. Power series Taylor's theorem, Laurent's theorem.Calculus of residues –poles, essential singularities and branch points, residue theorem, Jordan's lemma, singularities on contours of integration, evaluation of definite integrals.

4.IntegralTransforms: Fourier Transforms: Development of the Fourier integral from the Fourier Series, Fourier and inverse Fourier transform: Simple Applications: Finite wave train, Wave train with Gaussian amplitude, Fourier transform of derivatives, solution of wave equation as an application. Convolution theorem. Intensity in terms of spectral density for quasi monochromic EM Waves, Momentum representation, Application of Fourier transform to diffraction theory: diffraction pattern of one and two slits. Laplace transforms and their properties, Laplace transform of derivatives and integrals, derivatives and integral of Laplace transform. Convolution theorem. Impulsive function, Application of Laplace transform in solving linear, differential equations with constant coefficient with variable coefficient andlinear partial differential equation.

1. George Arfken, Mathematical Methods for Physicists, Academic Press
2. L. A. Pipe, Applied Mathematics for Engineers and Physicists, McGraw Hill.
3. Merle C. Potter and Jack Goldberg, Mathematical Methods, Prentice Hall of India.
4. Fredrick W. Byron and Robert W. Fuller,Mathematics of Classical and Quantum Physics,DoverPublications.
5.KreyzigE.,Advanced Engineering Mathematics,
6.Riley K.F., Hobson M.P. and Bence S.J. Mathematical methods for Physicists and Engineers.

Course Number :SPM PHY01102C3104

Classical Mechanics

1.Newtonian mechanics of one and many particle systems, Simple pendulum with rigid support, Two connected masses with string passing over a pulley, Virtual work, Rolling mass inside and outside a circular ring,Constraints, holonomic and non-holonomic constraints, D'Alembert's Principle and Lagrange's Equation, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Extension of Hamilton's Principle for nonconservative and nonholonomic systems, Method of Lagrange's multipliers, Conservation theorems and Symmetry Properties, Noether's theorem. Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space.

2. Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivationof Hamilton's canonical Equation from Hamilton's variational principle. The principle of least action.

3. Canonical transformation, integral invariant of Poincare: Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouville's theorem, Hamilton-Jacobi equation and its application.

4. Action angle variable adiabatic invariance of action variable: The Kepler problem in action angle variables,theory of small oscillations in Lagrangian formulation, normal coordinates and its applications. Orthogonal transformation, Euler's theorem, Eigenvalues of the inertia tensor, Euler equations, force free motion of a rigid body.

Reference Books:

1. Herbert Goldstein, Charles Poole, John Safko, Classical Mechanics, Perason Education
2. L.D. Landau and E.M. Lifshitz, Mechanics, Butterworth-Heinemann
3. A. Raychoudhary, Classical Mechanics, Oxford University Press
4. N. C. Rana and P. S. Joag Classical Mechanics, TataMcGraw Hill.
5. Ronald L. Greene, Classical Mechanics with Maple, Springer
6. Sommerfield A., Mechanics

Course Number :SPM PHY01103C3104

Quantum Mechanics

1.Linear spaces and Operators : Vector spaces, Linear independence, Bases, dimensionality, isomorphisms. Linear transformations, inverses, matrices, similarity transformations, Eigenvalues and Eigenvectors. Inner product, orthogonality and completeness, complete orthogonal set, Gramm-Schmidt orthogonalization procedure, Eigenvalues and Eigenvectors of Hermitian and Unitary transformations, diagonalization. Function space and Hilbert space. Complete orthonormal sets of functions.

2.Structure of Quantum mechanics: Postulates of QM, Hilbert space;Hermitian and unitary operators; Orthonormality, completeness andclosure. Dirac's bra and ketnotation.Matrix Representation and change of basis.Operators and observables, significance of eigenvector and eigenvalues, Commutation relation; Uncertianity principle for two arbitrary Operators.

3.Measurement in quantum mechanics, Double Stren-Gerlach experiment for spin 1/2 system. Expectation values, time dependence of quantum mechanical amplitude, observable with no classical analogue, super position of amplitudes, identical particles. Hamiltonian matrix and the time evolution of Quantum mechanical states, time independent perturbation of an arbitrary system, simple matrix examples of time independent perturbation, energy given states of a two state system, diagonalizing of energy matrix, time independent perturbation of two state system, the perturbative solution. Ammonia molecule as an example of two state system, weak field and strong field cases, general description of two state system, Pauli matrices.

4.Three dimensional problem in Spherical Polar coordinate. Hydrogen Atom. Orbitalangular momentum, angular momentum algebra, raising and lowering operators, Matrix representation for $j = 1/2$ and $j = 1$; spin; addition of two angular momentum, Clebsch-Gordan coefficients.

Reference Books

1. Ashok Das and A.C. Melissions, Quantum Mechanics Gordon and Breach Science Publishers.

2. P.A.M. Dirac, Lectures on Quantum Mechanics, Dover Publications

3. R.Shankar, Principles of Quantum Mechanics, Springer.

4. Albert Messiah, Quantum Mechanics, Dover Publications

5. L.I. Schiff, Quantum Mechanics, Mc-Graw Hill.

6. Claude Cohen Quantum Mechanics, Wiley

7. J.J. Sakurai, Modern Quantum Mechanics, Pearson Education.

8. E. Merzbecher: Quantum Mechanics, John Wiley.

Course Number :SPM PHY01104C0246

Laboratory Experiments

1. Ionization potential of Lithium
2. Zeeman Effect
3. Dissociation Energy of I_2 molecule
4. Hall Effect
5. Four Probe Method
6. Electron Spin Resonance
7. Telexometer
8. Experiment on high intensity monochromator
9. Faraday Effect
10. Frank-Hertz experment
11. Compton Effect
12. Atomic Spectra of two-Electron Systems

Students assigned the general laboratory work will perform at least eight (08) experiments of the above mentioned.

Reference :Worsnop and Flint , Experimental Physics.

Course Number : SPM PHY01101E3104

Numerical Methods and Programming

1.Fortran:
Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements,Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitiveand logical structures, Subroutines and functions, Operation with files, Operating systems, Creation ofexecutable programs.
2.Numerical Methods of Analysis:
Solution of algebraic and transcendental equations: Iterative, bisection and Newton-Raphson methods, Solutionof simultaneous linear equations: Matrix inversion method, Interpolation: Newton and Lagrange formulas,Numerical differentiation, Numerical Integration, Trapezoidal, Simpson and Gaussian quadrature methods,Least-square curve fitting, Straight line and polynomial fits, Numerical solution of ordinary differentialequations: Euler and Runge-Kutta methods.
3.Simulation:
Generation of uniformly distributed random integers, Statistical tests of randomness, Monte-Carlo evaluation ofintegrals and error analysis, Non-uniform probability distributions, Importance sampling, Rejection method,Metropolis algorithm, Molecular diffusion and Brownian motion as random walk problems and their Monte-Carlo simulation.

Short introduction to Programming using C and MatLab, class projects may be implemented in any language.

Reference Books:
1. Computational Methods in Physics and Engineering: Wong.
2. Computer Oriented Numerical Methods: Rajaraman.
3. Computer Programming in FORTRAN 77: Rajaraman.
4. Applied Numerical Analysis: Gerald.
5. A Guide to Monte Carlo Simulations in Statistical Physics: Landau and Binder.
6. Numerical Recipes: Teukolsky, Vetterling and Flannery.

Course Number: SPM PHY01102E3104

$\LaTeX$ for Science and Mathematics

Software installation, Markup Languages,$\LaTeX$ typesetting basics, $\LaTeX$ math typesetting, Tables and matrices, Graphics, Packages, User-definables, Document classes, textscbibTEX, beamer, flash cards / CV, Creating your own package, Project.

References

1. Guide to $\LaTeX$, Helmut Kopka
2. Resources from websites.

Course Number: SPM PHY01103E3104

Modern Optics

Fresnel Relations: Conductors, Thin Films: Reflection Model, Matrix Formalism, Coating Design, Fourier Optics: Wave Propagation, Fraunhofer Diffraction, Fresnel Diffraction, Spatial Filtering, Holography
Statistical Optics: Coherence, Interference and Visibility, Laser Physics: Overview, Gain Saturation, Light-Atom Interactions, Optical Gain and Pumping Schemes, Output Characteristics
Atom Optics: Light Shifts and Optical Forces, Atom-Photon interactions, Laser Cooling and Trapping
Fiber Optics: Mode Analysis, Loss and Dispersion
Photonic Bandgap Crystals: Kronig-Penney Model, Fabrication and Performance

References

1. Pedrotti, Pedrotti, and Pedrotti, Introduction to Optics
2. Fowles, Introduction to Modern Optics
3. Saleh and Teich, Fundamentals of Photonics
4. Hecht, Optics
5. Verdeyen, Laser Electronics
6. Siegman, Lasers

Course Number SPM PHY01201C3104

Statistical Mechanics

1.Elementary probability theory : Preliminary concepts, Random walk problem, Binomial distribution, mean values, standard deviation, various moments, Gaussian distribution, Poisson distribution, meanvalues. Probability density, probability for continuous variables.Extensive and intensive variables, laws of thermodynamics, Legendre transformations and thermodynamic potentials, Maxwell relations, applications of thermodynamics to (a) ideal gas, (b) magnetic material, and (c) dielectric material. The laws of thermodynamics and their consequences.

2.Statistical description of system of particles : State of a system, microstates, ensemble, basic postulates, behaviour of density of states, density of states for ideal gas in classical limit, thermal and mechanical interactions, quasi-static process. Statistical thermodynamics : Irreversibility and attainment of equilibrium, Reversible and irreversible processes. Thermal interaction between macroscopic systems, approach to thermal equilibrium, dependence of density of states on external parameters, Statistical calculation of thermodynamic variables.

3,Classical statistical mechanics : Microcanonical ensembles and their Equivalence, Canonical and grand canonical ensembles, partition function, thermodynamic variables in terms of partition function and grand partition function, ideal gas, Gibbs paradox, validity of classical approximation, equipartition theorem. Maxwell-Boltzmann gas velocity and speed distribution. Chemical potential, Free energy and connection with thermodynamic variables, First and Second order phase transitions; phase equilibrium.

4.Formulation of quantum statistics, Density Matrix, ensembles in quantum statistical mechanics, simple applications of density matrix. The theory of simple gases : Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac gases. Statistics of occupation numbers, Evaluation of partition functions, Ideal gases in the classical limit.
Ideal Bose system : Thermodynamic behaviour of an Ideal Bose gas, Bose-Einstein condensation. Thermodynamics of black body radiation, Stefan-Boltzmann law, Wien’s displacement law.Specific heat of solids (Einstein and Debye models). Ideal Fermi System : Thermodynamic behaviour of an ideal Fermi gas, degenerate Fermi gas, Fermi energy and mean energy, Fermi temperature, Fermi velocity of a particle of a degenerate gas.

Reference Books:
1. F. Reif, Fundamentals of Statistical and Thermal Physics, McGraw Hill.
2. K. Huang, Statistical Mechanics, John Wiley & Sons.
3. R. K. Pathria, Statistical Mechanics, Pergamon Press.
4. B. B. Laud Fundamentals of Statistical Mechanics, New Age.
5. Mark W. Zemansky and Richard H. Dittman, Heat and Thermodynamics, McGraw Hill.
7. L. D. Landau and E. M. Lifshitz, Statistical Physics, Butterworth-Heinemann.
8. Richard P. Feynman, Statistical Mechanics. Westview Press.

Course Number :SPM PHY01202C3104

Classical Electrodynamics

1.Electrostatics: Electric field, Gauss Law, Differential form of Gaussian 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 the Dirichlet or Neumann boundary Conditions, Formal Solutions of electrostatic boundary value problem with Green's function, Electrostatic potential energy and energy density, capacitance. Boundary Value Problems in Electrostatics: Methods of Images, Point charge in the presence of a grounded conducting sphere,point charge in the presence of a charged insulated conducting sphere, point charge near a conducting sphere at a fixed potential, conducting sphere in a uniform electric field by method of images, Green function for the sphere, General solution for the potential, conducting sphere with hemispheres at a different potentials, orthogonal functions and expansion.

2.Multipoles, electrostatics of Macroscopic Media Dielectric: 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.Molarpolarizability and electric susceptibility. Models for molecular polarizability, electrostatic energy in dielectric media

3. Time varying fields, Maxwell's equations, conservation laws:Energy in a magnetic field, vector and scalar potentials, Gauge transformations, Lorentz gauge, coulomb gauge, Green function 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 EM fields. Conservation laws for macroscopic media.

4. Lorentz' transformations; Group symmetries of Lorentz' transformations, Electromagnetic field tensor, Relativistic electrodynamics using potential, Four vector formalism, Relativistic energy and momentum, transformation of four potentials and four currents, Relativistic transformations of electro-magnetic fields, Maxwell's equations in covariant form. Invariance of electric charge, covariance of electrodynamics.

Reference Books:

1. J.D. Jackson: Classical Electrodynamics, Wiley
2. David J. Griffiths: Introduction to Electrodynamics, Benjamin Cummings
3. L.D. Landau and E.M. Lifshitz, Classical Theory of Electrodynamics, Addison-Wesley.
4. L.D. Landau and E.M. Lifshitz, Electrodynamics of Continuous Media,Addison-Wesley.
5. Wolfgang K. H. Panofsky and Melba Phillips, Classical Electricity and Magnetism, Dover Publications.

Course Number :SPM PHY01203C3104

Electronics

Conduction Mechanism in Metals: Mobility and conductivity, Bound and free electrons,Enery distribution of electrons, Fermi level, The density of states, Thermionic emission.Conduction Mechanism in Semiconductors: Direct and indirect semiconductors,charge carriers concentrations, Drift of carriers in electric and magnetic fields, Diffusion ofcarriers, The contact potential.

Semiconductor-diode characteristics: Qualitative theory of P-N junction, Space charge ata junction, Forward and reverse bias junctions, Reverse bias breakdown, Zenerdiode.Bipolar Junction Transistors: Transistor current components, CB, CE, CCconfigurations, Input output characteristics, Early Effect, Graphical analysis of the CEconfiguration, Transistor hybrid model, h parameters, Analysis of a Transistor amplifier circuitusing h parameters, Measurement and graphical determination of h parameters, Hybrid πmodel, The π transistor model, Ebers-Moll model,Transistor biasing and thermal stabilization,The operating point, Bias stability.

Field Effect Transistors: Construction and characteristics of JFET, transfercharacteristic, The FET small signal model, Measurement of gm and rd, JFET fixed bias, Self biasand voltage divider configurations, Use of FET as voltage controlled resistor, JFET sourcefollower(common-Drain) configuration, JFET Common – Gate configuration, Depletion andenhancement type MOSFETs.

Reference

1.Solid State Electronic Devices by B.G. Streetman
2.Electronic Devices and Circuit Theory by R.L. Boylested and L. Nashelsky
3.Integrated Electronics by J. Millman and C.C. Halkias
4.Introduction to Semiconductor Devices by M. S. Tyagi
5.Electronic Devices and Circuits by Balbir Kumar and S.B. Jain

Course Number :SPM PHY01204C0246

Laboratory Experiments

1. Addition, Subtraction and Binary to BCD conversion
2. JK Flip-Flop and up-down counter
3. Transmission Line Experiment
4. Negative Feedback Experiment
5. Multivibrator
6. Differential Amplifier
7. Op-amps and its application
8. IC 555 Timer
9. Design of CE Amplifier
10. Design of Regulated Power Supply
11. Arithmetic Logic Unit
12. Receiver characteristics
13. Microwave characteristics and measurements
14. Nonlinear applications of Op amplifier
15. PLL characteristics and its applications
16. PAM, PWM and PPM Modulation and demodulation.
17. Arithmetic operations using microprocessors 8085 / 8086

Students assigned the general laboratory work will perform at least twelve (12) experiments from the above mentioned.

Course Number :SPM PHY01201E3104

Computational Physics

Stochastic Processes :Theory of random walks and simulation of random walks in one, two and three dimensions. Elementary ideasand simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion andfractional Brownian motion.

Percolation theory: Percolation theory and simulation by Hoshen-Kopelman algorithm; Application to simple lattice models inPhysics

Simulations of physical modelsElementary ideas of: (a) Time-average and Molecular dynamics: Dynamical equations and physical potentials;Verlet algorithm (b) Ensemble average and Monte Carlo methods; Metropolis algorithm. Introduction to thesimulations of: (a) Ising model in magnetism (b) Bak-Tang-Wiesenfeld model in studies of self-organizedcriticality

Combinatorial optimization problemsClassification of problems; examples of optimization problems: traveling salesman problem (TSP) andsatisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique.

References

1. Understanding Molecular Simulation (Academic Press), D. Frenkel& B. Smit
2. Introduction to Percolation Theory (Taylor-Francis), D. Stauffer
3. Equilibrium Statistical Physics (World Scientific), M. Plischke& B. Bergersen
4. Numerical Recipes in C: The Art of Scientific Computing (Cambridge University Press), W.H. Press,
B.P. Flannery, S.A. Teukolsky and W.T. Vetterling

Course Number :SPM PHY01202E3104

Advanced Quantum Mechanics

Symmetry in Quantum mechanics: Symmetry Operations and Unitary Transformations, conservation principles, space and time translation, rotation, space inversion and time reversal, symmetry and degeneracy.

Identical particles: Meaning of identity and consequences; Symmetric and anti-symmetric wavefunction; incorporation of spin, symmetric and antisymmetricspinwave functions of two identical particles, slater determinant, Pauli exclusion principle.

Time Independent Approximation Methods: Non-degenerate perturbation theory, degenerate case, Stark effect, Zeeman effect and other examples, variational methods, WKB method, tunneling.
Time-dependent Perturbation Theory: Interaction Picture;Constant and harmonic perturbations; Fermi Golden rule; Sudden and adiabatic approximations. Beta decay as an example.

Scattering Theory: Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering.
Density Matrices: Basic definition and some properties. Pure and Mixed states.

Reference Books:

1. S Flugge, Quantum Mechanics, Springer
2. Claude Cohen-Tannoudji, Bernard Diu, FrankLaloe, Quantum Mechanics, Wiley
3. Albert Messiah, Quantum Mechanics, Dover Publications
4. R.Shankar, Principles of Quantum Mechanics, Springer.
5. L.I. Schiff, Quantum Mechanics, Mc-Graw Hill.
6. J.J. Sakurai, Modern Quantum Mechanics, Pearson Education.
7. E. Merzbecher: Quantum Mechanics, John Wiley.

Course Number :SPM PHY01301C3104

Atomic & Molecular Physics and Lasers

1.Atomic Structure and Atomic Spectra: Rutherford's Model and concept of stability of atom, Bohr's model, Sommerfeld's model, Stern-Gerlach experiment for electron spin, Revision of quantum numbers, exclusion principle, electronic configuration, Hund's rule Gross structure of energy spectrum of hydrogen atom. Non degenerate first order perturbation method, relativistic correction to energy levels of an atom, atom in a weak uniform external electric field – first and second order Stark effect, calculation of the polarizability of the ground state of hydrogen atom and of an isotropic harmonic oscillator; degenerate stationary state perturbation theory, linear Stark effect for hydrogen atom levels.

2.Orbital magnetic dipole moment, spin-orbit interaction energy, Hartree theory, LS coupling, origin of spectral lines, selection rules, some features of one-electron, two-electron spectra and X-ray spectra, fine spectra, hyperfine structure, Zeeman effect. Lamb shift (only qualitative description).

Molecular Structure: The nature of chemical bonds, valence bond approach and molecular orbital approach for molecular bonding (for H_2 molecule). Bonding and antibonding orbitals, pi- bonds, sigma -bonds, different kinds of bonding mechanism, Madelung constant, hybridization, bonding in hydrocarbons.

3.Molecular spectra: Rotational levels in diatomic and polyatomic molecules, vibrational levels in diatomic and polyatomic molecules, diatomic vibrating rotator, Born-Oppenheimer approximation, symmetry of the molecules and vibrational levels, experimental aspects of vibrational and rotational spectroscopy of molecules, polarization of light and Raman effect, Raman Spectroscopy.

4.Lasers:Requisites for producing laser light, Role of Plane and Confocal cavity resonators, Longitudinal and transversecavity modes, Mode selection, Q-switching and Mode locking, Generation of Ultra short Pulse

Reference Books:
1. Physics of Atoms and Molecules: Bransden and Joachain.
2. Lasers - Theory and Applications: K. Thyagrajan and A.K. Ghatak.
3. Introduction to Atomic Spectra: H.E. White.
4. Introduction to Atomic Spectra: HG Kuhn.
5. Robert Eisberg and Robert Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley.
6. Arthur Beiser, Perspectives of Modern Physics, McGraw Hill.
7. Gerhard Herzberg Molecular Spectra and Molecular Structure, Krieger Pub Co.
8. C. N. Banwell, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.

Course Number :SPM PHY01302C3104

Nuclear Physics

Introductry Concept of Nuclei: Nuclear angular momentum, Nuclear magnetic dipolemoment and Electric quadruple moment, Parity quantum number, Statistics of nuclear particles,Isobaric spin concept, Systematic of stable nuclei.
Nuclear Disintegration: Simple theories of decay, Properties of neutrino, Nonconservationof parity and Wu’s experiment in beta decay, Electron capture, Internalconversion.
Inter Nucleon Forces: Properties and simple theory of the deuteron ground state, Spindependence and tensor component of nuclear forces, Nucleon- nucleon scattering at lowenergy, Charge- independence of nuclear forces, Many - nucleon systems and saturation ofnuclear forces, Exchange forces, Elements of meson theory.
Nuclear Structure and Models: Fermi gas model, Experimental evidence for shellstructure in nuclei, Basic assumption for shell model, Single- particle energy levels in centralpotential, Spin-orbit potential and prediction of magic numbers, Extreme single- particle model,Prediction of angular momenta, Parities and magnetic moment of nuclear ground states, Liquiddrop model, Semi- empirical mass formula, Nuclear fission, The unified model.
Particle Physics: Properties and origin, Elementary particles, Properties, classification,type of interactions and conservation laws, Properties of mesons, Resonance particles, Strangeparticles and Strangeness quantum number, Simple ideas of group theory, Symmetry andconservation laws, CP and CPT invariance, Special symmetry groups SU (2) and SU (3)classification of hadrons, Quarks, Gell-Mann- Okubu mass formula.

Reference:

1.Nuclear Physics by Roy & Nigam
2.Introduction to nuclear Physics by H. Enge
3.Theoretical Nuclear Physics by J.M. Blatt and V.F. Weisskopf
4.Theoretical nuclear and Subnuclear Physics by J.D. Walecka
5.Particle Physics An introduction by M.Leon
6.Group Theory in Subnuclear Physics by F.I. Stancu
7.Introduction to Particle Physics by R. Ones.

Course Number: SPM PHY01303C3104

Solid State Physics

Structure and Symmetry:

Structural description of liquids and solids (amorphous and crystalline), External symmetryelements and concept of point groups, Direct periodic lattices, Basic concept of aperiodicity,Reciprocal lattice and diffraction conditions and its relation with Brillouin zones, Intensity ofBragg scattering from a unit cell and extinction conditions.

Lattice Vibrations:

Interatomic forces and lattice dynamics of crystals with up to two atoms per primitive basis,Quantization of elastic waves.

Electronic Properties of Solids:

Electrons in periodic potential, Band Theory, Tight Binding, Cellular and Pseudo potentialmethods, Symmetry of energy bands, density of states, Fermi surface, De Haas van Alfeneffect,Elementary ideas of quantum Hall effect, Cyclotron resonance and magnetoresistance,Introduction to superconductivity.

Reference :

1. Introduction of Solids: L.V. Azaroff
2. Crystallography Applied to Solid State Physics: A.R. Verma and O.N. Srivastava
3. Principels of Condensed Matter Physics: P.M. Chaikin and T.C. Lubensky
4. Solid State Physics-Structure and Properties of Materials : M.A. Wahab
5. Solid State Physics: N.W. Ashcroft and N.D. Mermin.

Course Number :SPM PHY01304C0246

Laboratory Experiments

1. PCM / delta modulation and demodulation
2. Fiber optic communication
3. Experiments on MUX, DEMUX, Decoder and shift register
4. D/A converter interfacing and frequency / temperature measurement with microprocessor 8085 / 8086
5. A/D converter interfacing and AC/DC voltage / current measurement using microprocessor 8085/8086
6. PPI 8251 interfacing with microprocessor for serial communication.
7. Assembly language program on P.C
8. Alpha Sepctroscopy with Surface Barrier Detector
9. X-Ray Fluorescence
10. Compton Scattering: Energy Determination
11. Compton Scattering: Cross-Section Determination
12. Study of Rutherford Scattering
13. Verification of Hartmann formula for prism spectrogram
14. Measurement of optical spectrum of an alkali atom
15. Emitter of electric discharge through air in an evacuated tube
16. Measurement of optical spectrum of alkaline earth atoms
17. Measurement of Band positions and determination of vibrational constants of AlO molecule
18. Measurement of Band positions and determination of vibrational constants of N_2 molecule
19. Measurement of Band positions and determination of vibrational constants of CN molecule
20. Determination of characteristic parameters of an optical fiber
21. Measurement of Raman spectrum of CCl_4.

Students assigned the general laboratory work will perform at least twelve (12) experiments from the above mentioned.

Course Number :SPM PHY01301E3104

Relativistic Quantum Mechanics

Identical Particles:
Permutation symmetry, symmetrization postulates, self-consistent field approximation, Slater determinant,HartreeFock method.

Relativistic Quantum Mechanics:
Klein Gordon equation, Dirac equation, negative energy solutions, antiparticles, Dirac hole theory, Feynmaninterpretation of antiparticles, Gama-matrics and their properties, Convariance of Dirac equation, Chargeconjugation, Parity & Time reversal invariance, Bilinear covariants, Plane wave solution, Two componenttheory of neutrino, Spin &Helicity, Relativistic Hydrogen atom problem.

Field Quantization:
Lagrangian density and equation of motion for field, Symmetries and conservation laws, Noether'stheorem,cononical quantization of scalar field, Complex scalar field, electromagnetic field and Dirac field, Problem inquanitizing electromagnetic field, Gupta &Bleuler method, Feynman rules (without derivation), Feynmandiagrams.

Reference:
1. Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
2. Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
3. A First Book on Quantum Field Theory: AmitabhaLahiri and P.B. Pal.
4. Introduction to QFT: F. Mandle and G. Shaw.
5. Modern Quantum Mechanics: J.J.Sakurai.
6. Principles of Quantum Mechanic: R. Shankar.

Course Number :SPM PHY01302E3104

Physics of Electronic materials and devices

Physical Mechanisms:
Crystal structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy Bandconsideration in solids in relation to semiconductors, Direct and Indirect bands in semiconductor, Electron/Holeconcentration and Fermi energy in intrinsic/Extrinsic semiconductor continuity equation, Carrier mobility insemiconductors, Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors(Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generationin semiconductors, Schokley Read theory of recombination, Switching in Electronic Devices.
Devices:
(i) Metal/Semiconductor Junction or (Abrupt P-N Junction), Current-voltage characteristics, C-Vmeasurements, Estimation of Barrier Height and carrier concentration from C-V characteristics,Surface/Interface States, Role of interface States in Junction Diodes.Field Effect devices, C-V characteristic of MIS diodes (Frequency dependence), Estimation ofInterface Trapped charges by capacitance conductance, method CCD (Charge Coupled Devices),MESFET, MOSFET.
(ii) Microwave Devices: Tunnel Diode, MIS Tunnel Diode, Degenerate and Non-degeneratesemiconductor, MIS Switch Diode, MIM Tunnel diode.IMPATT Diode.Characteristics, breakdown Voltage, Avalanche Region and Drift Region, Transferred Electrondevices.(iii) Photonic Devices: LED and LASER, Photo detectors, Solar-cells.

Reference:
1. Physics of Semiconductor Devices: S.M. Sze.
2. Semiconductor Devices Basic Principles: Jaspreet Singh.
3. Physics and Technology of Semiconductor Devices: A.S. Grove.
4. Metal/Semiconductor Schottky Barrier Junction and their Applications: B.L. Sharma.
5. Metal/Semiconductor Contact: Rhoderick.

Course Number :SPM PHY01303E3104

Electronic Communication

Digital communication: Pulse ‐ Modulation systems, sampling theorem ‐ Low ‐ Passand Band ‐ Pass signals, PAM, Channel BW for a PAM signal .Natural sampling. Flat ‐ topsampling. Signal recovery through Holding , Quantization of signals, Quantization error,Differential PCM, Delta Modulation, Adaptive Delta Modulation, CVSD .Digital Modulation techniques : BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK

Mathematical representation of Noise: Sources of noise. Frequency domainrepresentation of noise, effect of filtering on the probability density of Gaussian noise, spectralcomponent of noise, effect of a filter on the power spectral density of noise. Superposition ofnoises.Mixing involving noise.Linear filtering. Noise Bandwidth, Quadrature components ofnoise, Power spectral density of nc(t), ns(t) and their time derivatives.

Data Transmission: Baseband signal receiver, probability of error . Optimum filter .White noise.Matched filter and probability of error.Coherent reception.Correlation, PSK, FSK,Non- coherent detection of FSK.Differential PSK, QPSK, calculation of error probability forBPSK, BFSK, and QPSK.

Noise in pulse – code and Delta – modulation system: PCM Transmission, Calculationof Quantization noise, Output ‐ signal power, Effect of thermal noise in D M, Output signal ‐ to‐ noise ratio in PCM, DM, Quantization noise in DM, Effect of thermal noise in Deltamodulation , Output signal to noise ratio in DM .

Computer Communication Systems: Types of networks, Design features of acommunication network, examples TYMNET, ARPANET, ISDN, LAN.

Mobile Radio and Satellites: Time division multiple Access (TDMA), Frequency DivisionMultiple Access (FDMA), ALOHA, Slotted ALOHA, Carrier Sense Multiple Access (CSMA) Poissondistribution, Protocols, Cellular communications, Mobile communication via Satellites,Bandwidth consideration in INTERNET

Reference

1.Principles of Communication Systems, second Edition by Taub and Schilling
2.CommunicationSystems, third edition, by Simon Haykin

Course Number :SPM PHY01304E3104

Thin Films and Devices

Materials for Integrated Circuits
Classification of IC, CMOS Process Overview , Electronic grade silicon , Crystal growth,Czeehralski and float zone crystal growing methods, Silicon shaping lapping , Polishing andwafer preparation,

Hot Processes-I: Oxidation and Diffusion
Oxidation of silicon, oxide deposition by thermal dry oxidation and wet oxidation methodDiffusion Process, Diffusion Coefficient, Fick ’ s 1st and 2nd Laws of Diffusion, Vacancy – Impurityinteractions, Dopants and Dopant Sources , Doping by Diffusion, ion implantation, DiffusionProcess Control, Diffusion Systems, Implantation Technology, Selective Implantation, Junctiondepth, Channeling, Lattice Damage, Annealing ,Dopant Diffusion and Related Operations:Equipment for Diffusion and Related Operations.

Thin Films: Metals and Nonmetals
Vacuum Science and Technology, Evaporation theory and electron beam evaporation,evaporation system, idea of DC and R.F. sputtering system, Physical vapor deposition methods,Design construction of vacuum coating units, Chemicals Vapor Deposition, Reactors for ChemicalVapor Deposition, CVD Applications, Epitaxy methods for thin film deposition, Vapor-PhaseEpitaxy,

Photolithography, Photoresist Processing and Etching
Wafer Cleaning methods, Wafer Preparation method: Vapor HMDS Treatment for adhesionimprovement of photoresist, photoresist coating methods, soft backing of photo resist, postexposure backing of photo resist, Negative photoresist, Positive photoresist, Contrast andsensitivity of photoresist, Chemical Modulus Transfer Function (CMTF) of Photoresist, ResistExposure (single, bi-layer and multi-level photoresist exposure) and Resist Development, HardBaking and Resist curing, Photolithographic Process Control.Photolithography: An Overview, lithography, Raleigh criterion for resolution, Photolithographysource, Resolution and numerical aperture, Photolithographic methods: Contact, proximity andprojection and their resolution limit, Photo mask and mask Alignment, Limitations of opticallithography, Concept of phase-shift mask, Idea of electron beam lithography, Electron optics,Idea of an X-ray lithography and x-ray mask, Wet chemical dry etching for material removal,Reactive plasma etching, Ion milling,

Interconnections and Contacts and Packaging and Yield
Ohmic Contact Formation, Contact Resistance, Electromigration, DiffusedInterconnections, Polysilicon Interconnections, Buried Contacts, Butted Contacts,Silicides, Multilayer Contacts, Liftoff Process, Multilevel Metallization.Testing, Die Sepration, Die Attachment, Wire Bonding, Packages, Flip-Chip Process,Tape-Automated-Bonding Process, Yield, Uniform and Nonuniform Defect Densities.

Reference :
Integrated Electronics- Milliman and Taub
Microelectronics –Milliman and Gros
Thin Film Phenomena- K.L. Chopra
Hand Book of Thin Film- Marshel and Glang
VLSI Technology- S.M. Sze.

Course Number :SPM PHY01401C3104

Spectroscopy

Pure rotational spectra of diatomic molecules - Polyatomic molecules - Study of linear molecules and symmetric top molecules - Hyperfine structure and quadruple moment of linear molecules - Experimental techniques - Molecular structure determination - Stark effect - inversion spectrum of ammonia - Applications to chemical analysis.

Vibrational spectroscopy of diatomic and simple polyatomic molecules - Harmonic Oscillator - Anharmonic Oscillator - Rotational vibrators - Normal modes of vibration of Polyatomic molecules - Experimental techniques - Applications of infrared spectroscopy - H_2O and N_2O molecules - Reflectance spectroscopy.

Classical theory of Raman Scattering - Raman effect and molecular structure - Raman effect and crystal structure - Raman effect in relation to inorganic, organic and physical chemistry - Experimental techniques - Coherent anti-Stokes Raman Spectroscopy - Applications of infrared and Raman spectroscopy in molecular structural confirmation of water and CO_2molecules - Laser Raman Spectroscopy.

Theory of NMR - Bloch equations - Steady state solution of Bloch equations - Theory of chemical shifts - Experimental methods - Single Coil and double coil methods - Pulse Method - High resolution method - Applications of NMR to quantitative measurements. Quadruple Hamiltonian of NQR - Nuclear quadruple energy levels for axial and non-axial symmetry - Experimental techniques and applications.

Quantum mechanical treatment of ESR - Nuclear interaction and hyperfine structure - Relaxation effects - Basic principles of spectrographs - Applications of ESR method - Mossbauer Effect - Recoillness emission and absorption - Mossbauer spectrum - Experimental methods - Mossbauer spectrometer - Hyperfine interactions - Chemical Isomer shift -Magnetic hyperfine interactions - Electric quadruple interactions - Simple biological applications

References:

1. C.N. Banwell and E.M. Mc Cash, 1994, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw-Hill Publications, New Delhi.

2. G. Aruldas, 2001, Molecular Structure and Spectroscopy, Prentice - Hall of India Pvt.Ltd., New Delhi.

3. D.N. Satyanarayana, 2004, Vibrational Spectroscopy and Applications, New Age International Publications, New Delhi.

4. Raymond Chang, 1980, Basic Principles of Spectroscopy, Mc Graw-Hill Kogakusha

Course Number :SPM PHY01401E3104

Microprocessor and Microcontroler

8085 Architecture - Programmer's model - ALU - Registers and Flags - Stacks - Complete instruction set of Intel 8085 - State transition and timing diagrams - T States - Machine cycles - Instruction cycles - Addressing modes - Assembly language programs – Timing diagram for memory read and memory write cycles - time delay subroutines and delay calculations – maskable and Non-maskable Interrupts.

Interfacing memory and devices – I/O and Memory mapped I/O – Simple polled I/O and Handshaking operations - Programmable keyboard / display interface 8279 - Programmable peripheral device 8255A - 8253 Timer Interface - Wave form generation (Square, triangular and ramp wave) - Programmable communication interface 8251 (USART).

Introduction – 8 and 16 bit Microcontroller families –Flash series – Embedded RISC Processor – 8051 Microcontroller Hardware – Internal registers – Addressing modes – Assembly Language Programming – Arithmetic, Logic and Sorting operations.

Interfacing I/O Ports, External memory, counters and Timers - Serial data input/output,Interrupts – Interfacing 8051 with ADC, DAC, LED display, Keyboard, Sensors and Steppermotor.

Embedded microcontroller system – types of embedded operating system – Micro chip PIC 16C6X /7X family – features – Architecture – Memory Organization – Register file map – I/O ports – Data and flash program memory – asynchronous serial port – Applications in communication and industrial controls.

References

1. R.S. Gaonkar, 1997, Microprocessor Architecture, programming and Application with the 8085, 3rd Edition, Penram International Publishing, Mumbai.

2. V.Vijayendran, 2002, Fundamentals of Microprocessor 8085 - Architecture, programming and interfacing, Viswanathan Publication, Chennai.

3. Kenneth J. Ayala – The 8051 Micro Controller Architecture, Programming andApplications. 3rd Edition ,Penram International

4. John B. Peatman, 2004, Design with PIC Microcontrollers, 71. R.S. Gaonkar, 1997, Microprocessor Architecture, programming and Application with the 8085, 3rd Edition, Penram International Publishing, Mumbai.

Course Number :SPM PHY01402E3104

Physics of Nanomaterials

Introduction to Nanostructure Materials: Nanoscience& nanotechnology ,Size dependence of properties, Moor’s law, Surface energy and Melting point (quasimelting) of nanoparticles,
Band structure of solids: Free electron theory (qualitative idea) and itsfeatures, Idea of band structure, insulators, semiconductors and conductors, Energyband gaps of semiconductors, Effective masses and Fermi surfaces, Localized particles,Donors, Acceptors and Deep traps, Mobility, Excitons, Density of states, Variation ofdensity of states with energy and Size of crystal.
Quantum Size Effect: Quantum confinement, Nanomaterials structures, Twodimensional quantum system, Quantum well, Quantum wire and Quantum dot,Fabrication techniques.
Synthesis of Nanomaterials: Key issue in the synthesis of Nanomaterials,Different approaches of synthesis, Top down and Bottom up approaches, Cluster beamevaporation, Ball Milling, Chemical bath deposition with capping agent, Carbonnanotubes (CNT)- Synthesis, Properties and Applications.
Characterization techniques of Nanomaterials: Determination of particle size,XRD (Scherrer’s formula), Increase in width of XRD peaks of nanoparticles, Shift inabsorption spectra peak of nanoparticles, Shift in photoluminescence peaks, ElectronMicroscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy(TEM), Scanning Probe Microscopy (SPM), Scanning Tunneling Electron Microscopy(STEM), and Atomic Force Microscopy (AFM).

References

1.Nanostructures&Nanomaterials, Synthesis, Properties & Applications by Guozhong Cao, Imperial College Press.
2.Introduction to Nanotechnology, by Charles P. Poole, Jr. Frank J. Owens, John Wiley & Sons Inc. Publication.
3.Quantum Wells, Wires and Dots by Paul Harrison, John Wiley & Sons Ltd.
4.Quantum Dot Hetrostructures, by D. Bimberg, M. Grundman, N.N. Ledenstov.
5.Introduction to Nanoscience and Nanotechnology by Hornyak G.L., Tibbals H.F., Dutta J., Moore J.J., CRC Press.
6.Carbon Nanotechnology by Liming Dai
7.Carbon Nanotubes: Properties and Applications by Michael J. O. Connell.

Course Number :SPM PHY01403E3104

NUCLEAR PHYSICS: INTERACTIONS AND MODELS

N-N interaction:
Phenomenological N-N Potentials (Soft core & hard core) and meson theoretical potentials, Polarization in N-Nscattering.Probing charge distribution with electrons, Form factors, Proton form factors, Qualitative ideas on deepinelastic electron-proton scattering, Bjorken scaling and the parton model, Quark structure of the nucleon.

Nuclear Models:
Single particle model of the nucleus, Angular momenta and parities of nuclear ground states, Qualitativediscussion and estimates of transition rates, Magnetic moments and Schmidt lines.Classification of shells, Seniority, Configuration mixing, Pairing Force theory, Simple description of Twoparticleshell model spectroscopy.Deformable liquid drop and nuclear fission, Collective vibrations and excited states, Permanentdeformation and collective rotations: Energy levels and electromagnetic properties of even-even and odd-Adeformed nuclei, Nilsson model and equilibrium deformation, Coulomb Excitation Studies, Behaviour ofNuclei at high spin, Back-bending.

Reference
1. Atomic and Nuclear Physics Vol. II: Ghoshal.
2. Nuclear Structure: Preston and Bhaduri.
3. Nucleon-nucleon Interaction: Brown and Jackson.
4. Introductory Nuclear Physics: S.S.M. Wong.
5. Nuclear Structure: M.K.Pal.

Course Number SPM PHY01402C0006

PROJECT AND DISSERTATION

The dissertation topics will be based on special papers or elective papers and topics of current interest. Adepartmental committee will distribute the topics according to the skill and merit of the students.