COURSES OF STUDYFOR THE
MASTER OF SCIENCE (M. Sc.) EXAMINATION
INAPPLIED PHYSICS
(w.e.f 2016-17)

Department of Physics
Veer Surendra Sai University of Technology,
Burla, Samblpur-768018, Odisha

Course Structure of 2-Year M.Sc (Applied Physics)

First Semester

1	MPH-1101	Classical Mechanics	4-0-0	4
2	MPH-1102	Mathematical Physics-I	4-0-0	4
3	MPH-1103	Quantum Mechanics-I	4-0-0	4
4	MPH-1104	Condensed Matter Physics-I	4-0-0	4
5	MPH-1107	Fortran Programming	4-0-0	4
6	MPH-1191	Physics Lab-I (General Physics)	0-0-3	2
7	MPH-1192	Programming Lab-I	0-0-3	2
			Total Credits	24

Second Semester

Sl. No.	Course Code	Name of the Course	L-T-P	Credits
1	MPH-1201	Statistical Mechanics	4-0-0	4
2	MPH-1202	Electrodynamics-I	4-0-0	4
3	MPH-1203	Quantum Mechanics-II	4-0-0	4
4	MPH-1204	Computational Techniques in Physics	4-0-0	4
5	MPH-1209	Basic Electronics	4-0-0	4
6	MPH-1291	Physics Lab-II (Electronics and Photonics)	0-0-3	2
7	MPH-1292	Programming Lab-II	0-0-3	2
			Total Credits	24

Third Semester

1	MPH-1301	Electrodynamics-II	4-0-0	4
2	MPH-1302	Mathematical Physics-II	4-0-0	4
3	MPH-1303	Condensed matter Physics II	4-0-0	4
4	MPH-1304	Atomic and Molecular Physics	4-0-0	4
5	MPH-1305	Nuclear & Particle Physics	4-0-0	4
6	MPH-1391	Physics Lab-III (Modern Physics)	0-0-3	2
7	MPH-1392	Seminar & Technical Writing-I	0-0-3	2
			Total Credits	24

Fourth Semester

1	MPH-1401	Experimental Techniques in Physics	4-0-0	4
2	MPH-1402	Elective-I	4-0-0	4
4	MPH-1403	Elective-II	4-0-0	4
5	MPH-1491	Physics Lab-IV (Advanced Physics Lab)	0-0-3	2
6	MPH-1492	Seminar & Technical Writing-II	0-0-3	2
7	MPH-1493	Project	0-0-6	6
8	MPH-1494	Comprehensive Viva-Voce	0-0-0	2
			Total Credits	24

List of Elective Courses(Theory)

Sl. No.	Name of the Course	L-T-P	Credits
1	Physics of Semiconductor Devices	4-0-0	4
2	Materials Science and Technology	4-0-0	4
3	Crystallography	4-0-0	4
4	Fibre Optics	4-0-0	4
5	Cosmology and Astrophysics	4-0-0	4
6	Nuclear Technology	4-0-0	4
7	Laser Physics	4-0-0	4
8	Nano Technology	4-0-0	4
9	Advanced Quantum Mechanics	4-0-0	4
10	Spectroscopy	4-0-0	4
11	Theory of Non-linear Dynamical systems	4-0-0	4

(G. Nath) (A. Acharya) (S. K. Patri) (S. Sengupta)

(A. K. Pattanaik) (D. P. Ojha) (S. Panigrahi) (P R Das)

MPH- 1101 **Classical Mechanics** **[4 0 0 4]**

Course Objectives: Classical Mechanics give the idea of the most fundamental of all physical sciences and subsequently relatively modern and challenging topic like chaotic dynamics at advanced level.

Module-I

Review: Application of Newton's Laws and Conservation Laws,Constraints: classification, Lagrangian dynamics: displacements classifications, D'Alemberts principle, Nature of forces of constraints,Virtual velocity , Variations, The fundamental equation of classical mechanics, Nature of given forces, given forces as functions of constraint forces, Kinetic energy, Energy relations in catastatic systems, The central principle, The principle of Hamilton, noncontemporaneous variations, Lagrange's principle of least action, Jacobi's principle of least action, Theory of generalized coordinates, Nature of generalized coordinates, the δ operator for generalized coordinates, fundamental equation in generalized coordinates, generalized potentials , velocity dependent potentials

Module-II

The dynamical problem, Lagrange's multiplier rule, Derivation of Lagrange's equations from the fundamental equation, Derivation from Hamilton's principle , Hamilton's principle from fundamental equation, Special forms of Lagrange's equations: existence of potential , Holonomic systems, Rayleigh's dissipation function, principle of least action, Hamiltonian formulation : Legendre transformations, Hamilton's equations, Hamilton's equation from Hamilton's principle, Integral invariants of Poincare, Liouville's theorem on phase volume, Poisson brackets , Dynamical systems : Hamiltonian systems, Dissipative systems , Types of stationary equilibrium /fixed points,Attractors,Llinear stability analysis . Phase space dynamics: simple pendulum, Nonlinear oscillator with friction, Phase Portraits- limit cycles, Poincare section studies of phase space dynamics, Cyclic coordinates and conservation theorems

Module-III

Canonical transformations, Free canonical transformations, Hamilton Jacobi theory: Hamilton's principal function, Jacobi's complete integral, Time independent Hamilton Jacobi equation, Method of separation of variables, Canonical character of a transformation, Lagrangian brackets, Symplectic nature of the Jacobian matrix of a canonical transformation, Invariance of Poisson brackets under canonical transformation, Completely integrable systems. Action angle variables,Invarianttori,Canonical transformation to action angle variables,Periodic and quasiperiodic motion , Examples :simple harmonic oscillator and central forces. Liouville's integrability theorem, Nonintegrable conservative Hamiltonian systems, KAM theory, Homoclinic and heteroclinic tangle, Chaos, Lyapunov number

Module-IV

Rigid body motion: Orthogonal transformations, Euler angles, Coriolis force,Angular momentum and kinetic energy, Inertia tensor, Euler equations, Theory of small oscillations and normal coordinates

Text books and References:

1. H. Goldstein, Poole,Classical Mechanics, Narosa (1985)
2. N.L. Rana and P.S. Joag, Classical Mechanics TMH (1991)
3. Louis N. Hand, Janet D. Finch, Analytical_Mechanics, Cambridge University Press

4. Reinhardt M. Rosenberg, Analytical_Dynamics of Discreet Systems
5. F. Gantmacher, Lectures in Analytical Mechanics, MIR Publishers

Course Outcome: The course is expected to provide the idea of the most fundamental physical principles. Further, it helps to understand the challenging topics like chaotic dynamics, rigid body motion, concept of transformations, chaos at advanced level.

MPH-1102 Mathematical Physics -I [4 0 0 4]

Course Objectives: Mathematical Physics deals with mathematical concepts, techniques and essential tools for the studies of advance Physics.

Module I

Ordinary Differential Equations: First order ODE's – Separable ODE's – Orthogonal trajectories –Second order linear ODE's – Differential operators – Higher order linear ODE's – Homogeneous andinhomogeneous differential equations.

Module II

Series solution of ODE's – Method of power series solution - Frobenius method –Special functions - Bessel, Hermite, Legendre polynomials, Generating functions and orthonormality.

Module III

Partial Differential Equations: Introduction to partial differential equations – Gradient, divergence, and curl in curvilinear co-ordinate systems - Solutions of partial Differential Equation (Complete solution, particular solution, general solution, singular solution)-Laplace transforms – Inverse transforms – Linearity and Shifting theorems – Laplace transform of derivative of a function – Laplace transform of integral of a function – Unitstep function – *t*-shifting– Short impulses –Diracdelta function – Convolution Theorem - Integral equations – Application to solve differential equations.

Module IV

Complex Analysis -Functions of complex variable – Zeros and singular points -Taylor'sseries and Laurent's series expansion– Cauchy's residue theorem –evaluation of residues – evaluation of definite integrals.

Textbooks and References:

1. G. Arfken, Mathematical Methods for Physicists, 5th Edition,Academic Press(2000).
2. Erwin Kreyszig,Advanced Engineering Mathematics.9th Edition. John Wiley (2005).
3. R.K. Jain, S.R.K. Iyengar,Advanced Engineering Mathematics.3rd EditionNaros, (2007)
4. K. F. Riley, M. P. Hobson and S. J. Bence, Mathematical Methods for physics and engineering, Cambridge Univ. Press, (1998)
5. M. P. Boas, Mathematical Methods in the Physical Sciences (3rd Edition) Wiley. (2005)
6. M. C. Potter, and J. Goldberg, Mathematical Methods.Prentice Hall (1988)
7. I. S. Sokolnikoff, and R. M. Redheffer, Mathematics of Physics and Modern Engineering. McGraw Hill.
8. M. R. Spiegel, Theory and Problems of Complex Variable. Schaum'sSeries, McGraw Hill.

Course Outcome: Thecourse is helpful to apply the various mathematical concepts, techniques and essential tools for the studies of quantumphysics.

MPH – 1103 **Quantum Mechanics – I** **[4 0 0 4]**

Course Objectives: Quantum mechanics helps to understand some important phenomena like, Black body radiation, photoelectric effect, Compton's effect etc. which are beyond the scope of classical mechanics. Most importantly, it speaks about the quanta of energy which is discrete in nature.

Module-I

Hilbert space and wavefunctions: Linear vector space, Hilbert space, dimension and basis of a vector space, scalar products, Orthonormal bases: Schmidt normalisation procedure.Square integrable functions:wavefunctions, Dirac notations: Bra and Ket vectors. Operators: General defintions, hermitian operators, projection operators,commutator algebra, uncertainty relation between two operators, inverse and Unitary operators, eigenvalues and eigenvectors of an operator. Matrix representation of Kets, Bras and operators.Matrix representation of the eigenvalue problem, position and momentum representations, connection between position and momentum representations, parity operator, Dirac Delta function

Module-II

Postulates of quantum mechanics: state of a system, Observables and operators, Measurement in quantum mechanics, expectation values, measurement and uncertainty relations, Time-Independent Potentials. Schrödinger Equation and Wave Packets. The Conservation of Probability. Time Evolution of Expectation Values. Harmonic oscillator problem using Schrodinger time independent equation, Matrix theory of 3D isotropic harmonic oscillator

Module-III

Schrodinger Equation for Central Potential: Hydrogen atom, power series solution for the radial part, energy quantization, Laguerre polynomials. Introduction to angular momentum operators and spherical harmonics, Quantization of simple systems: 3D isotropic harmonic oscillator, The Spherical Square Well Potential

Module-IV

Angular momentum operators: L_x, L_y, L_z and L^2 and their commutation relations. Raising and lowering operators (L_+ and L_-). L_x, L_y, L_z and L^2 in spherical polar coordinates. Eigen values and Eigen functions of L_z, L^2 . Matrix representation of L_+, L_- and L^2. Spin 1/2 particles, Pauli spin matrices and their properties. Eigen value problem of J_z and J^2, Angular momentum matrices. Addition of angular momenta and C.G. co-efficients

Textbooks and References

1. S. Gasiorowicz, Quantum Physics, John Wiley (Asia) (2000).
2. P. W. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill (1978).
3. N. Zettili, Quantum Mechanics - Concepts and Applications 2nd edition, 2009.
4. F. Schwabl, Quantum Mechanics, Narosa (1998).
5. L. 1. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).
6. Satyaprakash, Advanced Quantum Mechanics, Kedar Nath Ram Nath (2010).
7. B. H. Bransden and C. J. Joachain, Introduction to Quantum Mechanics, Longman (1993)
8. J. J. Sakurai, Modern Quantum Mechanics, 2nd edition (2005).

Course Outcome: The basics and need for quantum mechanics will be established. Idea of using mathematical techniques to deal physical phenomena using quantum principles will be developed.

MPH-1104 Condensed Matter Physics -I [4 0 0 4]

Course Objectives: The course aims to provide understanding of the entity of a material along with their properties and behaviour. This also gives idea about tailoring the properties of the material for different device applications.

Module-I

Crystal physics: Symmetry operations; Bravais lattices; Point and space groups; Miller indicesand reciprocal lattice; Structure determination; diffraction: X-ray, electron and neutron; Crystalbinding; Defects in crystals; Point and line defects.

Module-II

Lattice vibration and thermal properties: Einstein and Debye models; continuous solid; linearlattice; acoustic and optical modes; dispersion relation; attenuation; density of states; phononsand quantization; Brillouin zones; thermal conductivity of metals and insulators.

Module -III

Electronic properties: Free electron theory of metals; electrons in a periodic potential; Blochequation; Kronig-Penny model; band theory; metal, semiconductor and insulators; bandgap;intrinsic and extrinsic semiconductors, Hall Effect, p-n junction.

Module-IV

Magnetism: Introduction, Origin of permanent magnetic dipoles, Diamagnetism and Larmor precession, Pauli paramagnetism, Static paramagnetic susceptibility, Nuclear paramagnetism, Exchange interaction, Heisenberg Hamiltonian and resume of the results; spin waves; Weiss theory of ferromagnetism.

Superconductivity: Basic phenomenology, Type I and Type IIsuperconductors; Meissner effect; Critical currents, Isotope Effect, Penetration Depth, London equations; coherence length,BCS pairing mechanism, High Tc superconductors, Josephson's Effect, Super conductors in A.C. fields, Applications of super conductors.

Text books and References:

1. C. Kittel, Introduction to Solid State Physics, John Wiley (1996).
2. A. J. Dekker, Solid State Physics, Macmillan (1986).
3. N. W. Ashcroft and N. D. Mermin, SolidState Physics, HBC Publ., (1976).
4. H. P. Myers, Introduction to Solid State Physics, Viva books (1998).
5. M.A. Omar, Elementary Solid State Physics, Addison-Wesley (1975).
6. H. Ibach and H. Luth, Solid State Physics, Springer, Berlin.
7. S. Flugge, Kristallphysik I, Springer-Verlag Berlin (1955).

Course Outcome: The first two modules of the course provide the understanding of the entity of a material along with their properties and behaviour. The rest modules give idea about prediction and analysis of properties of the material for different device applications.

MPH-1107 Fortran Programming [4 0 0 4]

Course Objectives: The course introduces students to Fortran language where they learn how to write and execute Fortran codes. The learning outcome of this course enables the students to effectively use the skills in the subsequent Computational Physics and new model designing.

Module-I

Introduction to personal computers and operating systems (Windows & Linux),.Computer Operating Systems, Unix,The "man" command,Unix file system and useful Unix commands: ls,mkdir, cd, pwd, Shells, shell scripts, graphics package: gnuplot

Module-II

Fundamentals of Fortran, Fortran 90 Programming Language: The Fortran character set ,Structure of a Fortran statement, Structure of a Fortran Program, constants and variables, assignment statements, Intrinsic functions, List directed output and input statements, initialisation of variables, the implicit None statement, Editing and compiling a simple program,Debugging programs, Control structures and Program design: introduction to top down design techniques: Psuedocode and Flowcharts, Control constructs Branches and Loops, Further debugging techniques, Arrays: Declaration and use, Input and output of Arrays, Multidimensional Arrays, Masked Array assignments: the WHERE construct, The FORALL construct, Allocatable Arrays

Module-III

Data types: REAL, INTEGER, CHARACTER, COMPLEX, Derived data types, Procedures and Structured Programming: Subroutines, The SAVE attribute and Statement, Automatic ARRAYS, Sharing data using Modules, Module Procedures, Passing Procedures as Arguments to other Procedures, Internal Procedures , Scope and Scoping units, Recursive Procedures, Keyword Arguments and Optional arguments, Procedure interface and Interface Blocks, Advanced Options of the USE statements

Module-IV

Pointers and Dynamic data structures: Pointers and Targets, Using Pointers in assignment statements, Using Pointers with Arrays, Dynamic memory allocation with Pointers, Using Pointers in Procedures

Text books and References

1. Fortran 95/2003 for Scientists & Engineers: Stephen Chapman : McGraw –Hill.
2. Unix for Fortran Programmers: Mike Loukides: O'Reilly Media
3. GDB Pocket Reference: Arnold Robbins: O’Reilly Media
4. Phillip K Jamert, Gnuplot in Action

Course Outcome: The knowledge of writing and execution of Fortran codes will be provided. The learning outcome of this course enables the students to effectively use the skills in the subsequent Computational Physics and new model designing.

MPH-1191 Phy. Lab-1 General Physics [0-0-3-2]

1. Two Probe Method for Resistivity Measurement
2. Measurement of differential wavelength of the Na doublet using Fabry-Perot interferometer
3. To determine the coefficient of viscosity of a liquid by rotating viscometer
4. Dielectric constant of solid (wax) by Lecher Wire
5. Verification of Richardson's $T^{3/2}$ low
6. Measurement of attenuation and phase shift of A.C. in L.C.R. net work
7. RF characteristics of coil
8. Determination of Planck's constant by Photoelectric method
9. Estimation of energy band gap of semi conductors using diodes
10. Numerical aperture of an Optical fiber

MPH-1192: Computer Programming Lab I [0 0 3 2]

A. Exercises for acquaintance (Using Fortran 90)

1. To find the largest or smallest of a given set of numbers.
2. Division of two complex numbers (treating a complex number as an ordered pair of reals).
3. To generate and print first hundred prime numbers.
4. To generate and print an odd ordered magic square.
5. Transpose of a square matrix using only one array.
6. Matrix multiplication.
7. Raising a real number to a large integer power.
8. Fibonacci search.
9. Merging of files.

B. Numerical Analysis :

1. Lagrange Interpolation.
2. Regulafalsi.
3. Fixed point method
4. To locate the extrema of a function.
5. Evaluation of Bessel Functions.
6. Newton-Raphson Method.
7. Method of successive approximations.
8. Secant method.

C. Numerical Integration and solution of ODE's :

1. Simpson's rule.
2. Gaussian Quadrature.
3. Euler methods,verlet method and Runge Kutta schemes.

MPH- 1201 **Statistical Mechanics** **[40 0 4]**

Course Objectives: The course aims to bridge between macroscopic thermodynamics and microscopic statistical mechanics by using mathematical methods and fundamental physics for individual particles.

Module-I:
Review of Thermodynamics: Laws of thermodynamics, entropy, potentials.
Statistical Thermodynamics: Macroscopic and microscopic states, connection between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox.

Module-II:
Ensemble Theory: Phase space, Liouville's theorem, Micro Canonical Ensemble, examples, Canonical Ensemble: Equilibrium, partition function, Energy fluctuation, Equipartition and Virial theorem, Harmonic Oscillators, Statistics of Paramagnetism, Grand Canonical Ensemble: Equilibrium, partition function, partition function, Density and Energy fluctuation, Correspondence with other ensembles.

Module-III:
Formulation of Quantum Statistics: Quantum mechanical ensemble theory, Density Matrix, Statistics of various ensembles, examples: Free particle in a box, Harmonic Oscillator, Theory of Simple Gases: Ideal gas in different quantum mechanical ensembles.

Module-IV:
Ideal Bose Gas: Thermodynamics, Bose-Einstein Condensation, Blackbody Radiation, Phonons, **Ideal Fermi Gas: T**hermodynamics, Pauli paramagnetism, Landau diamagnetism, Electron gas in metals, Ultracold Fermi Gases, Statistical equilibrium of white dwarfs.

Reference books:

1. R.K. Pathria- Statistical Mechanics, Butterworth-Heinemann (1996)
2. F.Reif- Statistical and Thermal Physics, McGraw Hill (1985).
3. W.Greiner,L. Neise and H. Stocker-Thermodynamics and Statistical Mechanics, Springer.
4. K. Huang- Statistical Mechanics, John Wiley Asia (2000).
5. L.D. Landau and E.M. Lifshitz- Statistical Physics-I, Pergamon (1980).

Course Outcome: The bridge between macroscopic thermodynamics and microscopic statistical mechanics using mathematical methods and fundamental physics for individual particles helps us to understand the physical phenomena.

MPH-1202 Electrodynamics - I [4 0 0 4]

Course Objectives: Electrodynamics helps to have knowledge of the theory of Electromagnetic wave generation and its propagation in vacuum and different media in modern communication system.

Module-I

Electrostatics Boundary value problems

Electric Field and Potential, Electrostatic potential energy, Multipole expansion of potentials, Boundary Conditions, Poisson equation and its solution, Laplace's equation and its solution in rectangular coordinates(Method of variable separation), Cylindrical and Spherical coordinate system, Uniqueness theorem, Method of images.

Module-II

Electrostatics of Dielectrics: Polarization, Bound Charges, Electric Displacement Vectors, Boundary conditions for D and E, Susceptibility, Permeability, Dielectric Constant,Energy and Force on dielectrics

Module-III

Magnetostatics and magnetic properties of matter: The vector potential, scalar potential, Gauge transformations,Coulomb gauge and Lorentz gauge, boundary conditions, boundary value problems, Maxwell's displacement current,Maxwell equations in matter, Energy and momentum in electromagnetic waves, Poynting vector and Poynting theorem.

Module-IV

Electromagnetic Waves: Wave equation, Propagation of plane electromagnetic waves in non-conducting medium, conducting medium and in uniform plasma, Reflection and Transmission at normal and oblique incidence.

Text books and References:

1. Tai L.Chow, Introduction to Electromagnetic theory, Jones& Bartlett student edition
2. J. D. Jackson, Classical Electrodynamics, John Wiley (Asia)
3. J. R. Reitz and F. J. Millford, Foundation of Electromagnetic Theory, Narosa
4. W. Greiner, Classical Electrodynamics, Springer
5. L. D. Landau and E. M. Lifshitz, Electrodynamics of Continuous Media, Butterworth

Course Outcome: The knowledge of the theory of Electromagnetic wave generation and its propagation in vacuum and different media helps to establish modern communication system, and Quantum Electrodynamics.

MPH-1203 Quantum Mechanics-II [40 0 4]

Course Objectives: This course helps to comprehend some basic theories, its applications, and the treatment for complex atoms. The scattering theory is introduced to understand the advanced problems in physics.

Module-I

Time independent Perturbation Theory: Non-degenerate and Degenerate Cases,Applications: Zeeman and Stark effects. Time Dependent Perturbation Theory, Probability of state, Sinusoidal Perturbation, Fermi's Golden rule, Einstein's transition probabilities, Various pictures of quantum mechanics.

Variation method, Variational integral and its properties, Application to state of the Helium atom, WKB approximation, turning points, connection formulae, Applications of WKB. Bohr-Somerfield quantization condition.

Module-II

The spinning electron, The Helium atom, The Configurations 1s2s, 1s2p, The consideration of electron spin - Pauli exclusion principle, The accurate treatment of normal helium atom, Excited states of helium atom.

Module-III

Slater's treatment of complex atoms: Exchange degeneracy, spatial degeneracy, Factorization and solution of secular equation, The Method of Self-consistent Field (SCF), Relation of the SCF method to the variation principle.

Module-IV

Scattering Theory: Born Approximation, scattering cross section, Green's function, Scattering from square well, Screened coulomb potential, Yukawa potential, Partial Wave analysis, Born-OppenHeimer Approximation, Hydrogen molecule ion problem, Valance-Bond method, Molecular Orbital method.

Text books and References:

1. S. Gasiorowicz, Quantum Physics, John Wiley (Asia) (2000).
2. P. Atkins, Molecular Quantum Mechanics, Oxford University Press (2005).
3. P. W. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata Mc-Graw Hill (1995).
4. F. Schwabl, Quantum Mechanics, Narosa (1998).
5. Satyaprakash, Advanced Quantum Mechanics, Kedar Nath Ram Nath (2010).
6. L. I. Schiff, Quantum Mechanics, Mcgraw-Hill(1968).
7. B. H. Bransden and C. J. Joachain, Introduction to Quantum Mechanics, Longman (1993)
8. L. Pauling, and E. B. Wilson, Quantum Mechanics: With Applications to Chemistry, Mc-Graw Hill, New York (1935).
9. N. Zettili,Quantum Mechanics - Concepts and Applications 2ndedition, 2009.

Course Outcome: The treatment of manyphysical problems with advanced theories, and approximation techniques is expected to provide solution for various problems in sciences.

MPH-1209 **Basic Electronics** **[40 0 4]**

Course Objectives: This course provides the basic, power, and digital electronic concepts which are essential to understand the basic electronic devices.

Module-I

Network and Network theorems:

Mesh and node circuit analysis, Reduction of complicated network, Conversion between T and Π-section, Bridged T- network, Lattice network, Superposition theorem, Reciprocity theorem, Thevenin's theorem, Norton's theorem, Maximum power-transfer theorem.

Module-II

Power Electronics:JFET, MOSFET, UJT (Principle, construction, operation with characteristics and application) Oscillators: Klystron oscillator (principle, description, and operation) Multivibrator, Astable, Monostable, Bistable (Principle, Description and Operation), Wave Shaping Circuits.

Module-III

Integrated Circuits and Operational Amplifier: Fabrication of monolithic IC,Integration of circuit components, IC555, limitations of IC,Operational amplifier: Differential amplifier (Circuit configuration and properties, ideal operational amplifier input and output impedances) Application of OP-AMP: Inverting amplifier, Non-inverting amplifier, adder, substractor, integrator, differentiator, logarithmic amplifier, comparator (Principle, basic circuit operation and theory)

Module-IV

Digital Electronics:A/Dconverterand D/Aconverter,Computer Memory: Memory cell, memory organization, Read Only Memory (ROM), Random Access Memory (RAM) and characteristics of memories, Erasable Programmable Read Only Memory (EPROM),Microprocessor (block diagram, basic components, architecture, μP-68000(Software model, organisation)

Text books and References

1. A. Mottershead, Electronic Devices and Circuits, Prentice Hall of India (1993).
2. J. Millman and C. C. Halkias, Integrated Electronics, Tata McGraw Hill (1995).
3. R. Gaekwad, Op-Amps and Linear Integrated Circuits, Prentice Hall of India (1995).
4. A. P.Malvino and D. P. Leach, Digital Principles and Applications, Tata McGraw Hill (1991).
5. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085,Penram India

Course Outcome: The knowledge of this course is expected to provide the operation of various basic electronic devices, and to understand/ fabricate the electronic circuits.

MPH-1204 Computational Techniques in Physics [4 0 0 4]

Course Objectives: Computational Physics deals with the application of numerical analysis methods for solving physical problems, thereby enhances the problem-solving abilities of the students.

Module- I

Errors: Its sources, propagation and analysis, computer representation of numbers. Basic Numerical

Algorithms: Derivatives, quadrature, interpolation, root-finding, special functions, the FFT algorithm, Linear Algebra: Matrices, BLAS algorithms, solving linear algebraic equations.

Module- II

Nonlinear Equations: Minimization and maximization of functions, multi-dimensional root finding, nonlinear models of data

Module- III

Ordinary Differential Equations: propagation of errors: Local and Global Errors, Initial value and boundary value problems, the Kepler and 3-body problems, chaotic dynamics in nonlinear systems, quantum eigenfunctions and eigenvalues

Module- IV

Partial Differential Equations: Elliptic, parabolic and hyperbolic equations, Poisson's equation in electrostatics, wave motion, spectral methods, quantum wavepacket motion, Probabilistic Methods: Random numbers, Integration using importance sampling, Random walks, Metropolis algorithm, Monte Carlo simulation: simple examples.

Text book and References:

1.Numerical Analysis: Timothy Sauer: Pearson Education (2006)
2. S. S. M. Wong, Computational Methods in Physics, World Scientific (1992).
3. W. H. Press, S. A. Teukolsky, W. T. Verlling and B. P. Flannery, Numerical Recipes in C
4. C,Cambridge J.M. Thijssen, Computational Physics, Cambridge University Press (1999).
5. Tao Pang, An Introduction to computational physics, Cambridge University Press (1997).
6. Rubin H. Landau, Computational Physics: Problem solving with computers, John Wiley (1997).

Course Outcome: The knowledge along with the application of numerical analysis methods for solving physical problems, thereby enhances the problem-solving abilities of the students.

M.Sc. Lab-II MPH-1291 Electronics & Photonics Lab [0-0-3 2]

1. Op-Amp Arithmetic Operations
2. Op-Amp Square, Ramp Generator and Wien Bridge Oscillator
3. Op-Amp Precision Full Wave Rectifier
4. Combinational Logic Circuit Design
5. UJT Characteristics
6. Characteristics of electronic devices FET; SCR; Varistor
7. Verification of Thevenin's theorem
8. MOSFET Characteristics
9. Hartley –Colpitt Oscillator
10. Measurement of wavelength of He-Ne LASER (Grating)
11. Study of multivibrator – Astable
12. Study of multivibrator – Bistable
13. Study of multivibrator – Monostable
14. VSWR' in a microwave transmission line
15. Study of square wave response of R.C. Network

MPH- 1292 Programming Lab-II (0 0 3 2)

Matlab, Maple and Mathematica Fundamentals
Introduction to the packages and the important features with illustrative examples

Matlab Programming: Control Flow Statements: *if, else, else if, switch* Statements-*for, while* Loop Structures-*break*, Statement-Input/Output Commands-Function m Files-Script m Files-Controlling Output,Input and output of data, Matlab Graphics

Mathematica Programming : Mathematica Notebook, simple interactive calculations in Mathematica,
Functions in Mathematica, Symbolic operations in Mathematica, computations in Mathematica, Programming in Mathematica , Mathematica Graphics

Maple : Maple worksheet , simple interactive operations in Maple, Programming in Maple with symbolic calculations , Maple Graphics

Text books and References:

1. Sergey E. Lyshevski,Engineering and Scientific Computations Using Matlab- -JohnWiley& Sons
2. Brian Hunt, Ronald Lipsman, Jonathan Rosenberg,A Guide to Matlab for Beginners & Experienced Users, Cambridge University Press.
3. Douglas B. Meade and S.J. Michael May, Getting started with Maple, John Wiley 2009
4. Paul Wellin, Programming with Mathematica: An Introduction: Cambridge University Press (2013).

MPH-1301 Electrodynamics - II [4 0 0 4]

Course Objectives: This course helps to understand the theory of guided waves, dipole ration, and scattering, the concept of relativistic electrodynamics.

Module-I
Dispersion: Normal and Anomalous Dispersion,Dispersion in non-conductors,Frequency dependence of permittivity, Kramers- Kronig relations, Cauchy's formula.

Module-II
Guided waves: Wave guides, TE waves in rectangular wave guide,Co-axial transmission line. Concept of moving charges, Retarded potentials, LienardWiechert potentials, The Fields of a point charge in uniform and accelerated motion, Power radiated by an accelerated point charge, Radiation reaction and its physical basis.

Module-III
Dipole radiation and Scattering: Radiation from an oscillating electric dipole, Electric dipole radiation, Magnetic dipole radiation, Radiation from an arbitrary source.Radiation from a linear centerfed antenna, scattering of plane electromagnetic waves by a bound charge in the electric dipole approximation, resonance scattering, Rayleigh scattering and Thomson scattering.

Module-IV
Relativistic Electrodynamics: The four current density, covariant four-vector, electromagnetic field tensor, Covariant formof Maxwell's equations, Transformation laws and theirphysical significance, relativistic generalization of Larmor's formula, Relativistic formulationoffield of a uniformly moving point charge.

Text books and References:

1. Tai L.Chow, Introduction to Electromagnetic theory, Jones& Bartlett student edition
2. J. D. Jackson, Classical Electrodynamics, John Wiley (Asia) (1999).
3. R. Resnick, Introduction to Special Relativity John Wiley (Asia) (1999)
4. E. C. Jordan and K. G. Balmain, Electromagnetic Waves and Radiating Systems, Prentice Hall (1995).
5. J. Schwinger *et al*, Classical Electrodynamics, Persesus Books (1998).
6. G. S. Smith, Classical Electromagnetic Radiation, Cambridge (1997).

Course Outcome: The course enables one to solve the problems of radiation theory, and relativistic electrodynamics to establish the possible applications.

MPH- 1302 **Mathematical Physics -II** **[4 0 0 4]**

Course Objectives: Mathematical Physics deals with mathematical concepts, techniques and essential tools for the studies of advance Physics.

Module-I

Linear Algebra

Linear vector spaces — span, Basis sets – Orthogonality and completeness, Schmidt orthogonalisation method, Quotient spaces and direct sums, Dual spaces , Linearoperators–functions of operators, Derivatives of operators, Conjugation of operators -hermitian , unitary operators, Baker-Campbel-Hausdorff formula, Generators,Projection operators, Matrices: Operator representations, Orthogonal, Unitary, Hermitian matrix, Orthonormal basis for representing a hermitian operator by a hermitian matrix, Rotation matrix,Change of basis and similarity transformation, Determinant and trace of a matrix, Important results relating to the determinant and trace (no derivation), Inverse of a matrix (no computations), Infinite dimensional vector spaces, linear vector space of all continuous functions, convergence of infinite sequence , Normed linear space and Cauchy sequence, Banach space and Hilbert space,Parseval and Bessel inequalities (no derivation), Basis for Hilbert spaces, Space of square integrable functions, Reisz-Fischer theorem and Stone-Weirstrass approximation theorem (no derivation) , Families of orthogonal polynomials as basis sets in function space .

Module-III

Operator theory

spectral decomposition theory for finite dimensional vector spaces –Direct sums of subspaces, Dimensions in direct sums, Orthogonal complement of a subspace, Invariant subspace, Matrix representation of an operator in a subspace, Reducible and irreducible matrices, Conditions for invariance of a subspace under an operator, Eigenvalues and eigenvectors, Normal operators , Eigenspace of normal operators, Spectral theorem of normal operators (no derivation), Diagonalizability of a normal operator and the spectral theorem, Simultaneous diagonalization and commutation of operators, Function of operators and spectral theorem , Bounded operators in Hilbert space (important results and their implications), Spectra of linear operators,Compact sets- bounded, Open and closed subsets, Bolzano-Weirstrass property- compactness, Heine Borel theorem(no derivation), Compact operators , Spectral theorem for compact hermitian operators (no derivation)

Module-III

Abstract group theory

Revision of basic concepts, Equivalence classes, Cosets and quotient groups , Representation of groups, Schur's lemmas and Great orthogonality theorem (no derivation) , Applications to find character and character table, Applications in quantum mechanics: Bloch theorem and selection rules. Continuous groups: Lie groups and Lie algebras,Infinitesimal generators: Matrix and operator forms, Irreducible representations of SO(2) and SO(3) groups, Basis functions of irreducible representations, Parameters space for SO(3), Orthogonality relations for SO(3),Density functions,Characters of irreducible representations of SO(3), Unitary groups: SU(2), Relations between SU(2) and SO(3), Infinitesimal generators,Local and global mappings between SU(2) and SO(3), Basis states , Multiparticle systems and direct products, Young's Tableaux.

Module-IV
Tensors
Multilinear algebra, Representation and properties, Tensor products, Algebra of Cartesian tensors, Outer product, Contraction and quotient theorems ,Tensor calculus : Rudiments of topology , Manifolds –differentiable maps , Tangent vector fields on a manifold , Tensor fields over a differentiable manifold, Symmetric and antisymmetric tensors,Transformation of tensor components under a general coordinate transformation: Jacobian mapping of tangent vectors , Metric tensor, Kronecker delta and Levi-Civita symbol, Tensor applications in electrodynamics, Angular momentum theory : addition of angular momentum, Clebsch Gordon coefficients, Wigner-Eckert theorem, Multiparticle states : Bell states and Quantum Entanglement.

Text books and References

1.Charles C Pinter:A Book of Abstract Algebra , Dover Books
2. Sheldon Axler : Linear Algebra Done Right , Springer
3.Sadri Hassani : Mathematical Physics A Modern Introduction to Its Foundations , Springer
4.Anadijiban Das: Tensors: The Mathematics of Relativity Theory and Continuum Mechanics, Springer
5. A.W. Joshi : Elements of Group Theory for Physicists

Course Outcome: Thecourse is helpful to apply the various mathematical concepts, techniques and essential tools for the study of quantumphysics.

MPH-1303 Condensed Matter Physics-II [40 0 4]

Course Objectives: The course aims to provide understanding of the entity of a material along with their properties and behaviour. This also gives idea about tailoring the properties of the material for different device applications.

Module -I

Properties of Metallic Lattices: The structure of metals, Lattice defects and configurational entropy, Number of vacancies and interstitials as a function of temperature, Formation of lattice defects in metals, The interpretation of slip, dislocations: Edge and screw dislocations, The Frank-Read mechanism of dislocation multiplications.

Module -III

Dielectric and Optical Properties of Insulators & Ferroelectric Materials: Description of static dielectric constant, Stattic dielectric constant of gases and solids, Internal field according to Lorentz, Complex dielectric constant and dielectric losses; Dielectric losses and relation time, Classical theory of electronic polarization and optical absorption.

General properties of ferroelectrics, Classification and Properties of representative ferroelectrics, Dipole theory of ferroelectricity and its objections, Ionic displacements and theory of spontaneous polarization, Thermodynamics of ferroelectric transitions, Ferroelectric domains.

Module -III

Conductivity of Metals: Features of the electrical conductivity of metals, A simple model leading to a steady state; drift velocity and relaxation time, The Boltzmann transport equation, The electrical conductivity at low temperatures, The thermal conductivity of insulators, The thermal conductivity of metals, The Hall effect in metals

Module -IV

Nano Materials: Physical and chemical properties of Nano materials, Preparation of nano materials: Gas condensation method, Chemical Vapour Deposition technique, Sol-gel method, Electrodeposition, Sputtering; Quantum well, Quantum wire, and Quantum dots, Applications of nano materials.

Text books and References:

1. Introduction to Solid State Physics : C. Kittel (Wiley, New York).
2. Quantum Theory of Solids : C. Kittel (Wiley, New York).
3. Principles of the Theory of Solids : J. Ziman (CambridgeUniversityPress,Cambridge).
4. Solid State Physics : H. Ibach and H. Luth (Springer, Berlin).
5. A Quantum Approach to Solids : P.L. Taylor (Prentice-Hall, Englewood Cliffs).
6. Intermediate Quantum Theory of Solids : A.O.E. Animalu (East-West Press, New Delhi).
7. Solid State Physics: Ashcroft and Mermin (Reinhert& Winston, Berlin).
8. Introduction to Nanotechnology: C.P.Poole, F.J.Owens (John-Wiley, 2003)

Course Outcome: The first two modules of the course provide the understanding of the entity of a material along with their properties and behaviour. The rest modules give idea about prediction and analysis of properties of the material for different device applications.

MPH-1304 **ATOMIC AND MOLECULAR PHYSICS** **[4 0 0 4]**

Course Objectives: The course deals principally with atomic structure and the interaction between atoms and fields. Further, it deals with the binding of atoms into molecules, molecular degrees of freedom (electronic, vibrational, and rotational), elementary group theory considerations and molecular spectroscopy.

Module-I:
Quantum state of one electron atoms,Atomic orbits, Hydrogen spectrum, Pauli's principle, Spectra of alkali elements, Spin orbit interaction and fine structure in alkali spectra.

Module-II:
Equivalent and non-equivalent electrons, normal and anomalous Zeeman effect- Paschen Back effect-Stark effect, Two electron systems –interaction energy in LS and JJ coupling – Hyperfine structure (qualitative), Line broadening mechanisms (general ideas).

Module-III:
Type of molecules-Diatomic linear symmetric top, asymmetric top and spherical top molecules, Rotational spectra of diatomic molecules as a rigid rotor – Energy levels and spectra of non rigid rotor-intensity of rotational lines –stark modulated microwave spectrometer (qualitative).

Module-IV:
Vibration energy of diatomic molecule –PQR branches, IR spectrometer (qualitative). General idea of IR and Raman spectroscopy, analysis of simple diatomic molecules, Intensities of vibrational lines. Selection rules.

Reference books:

1. Introduction to atomic spectra-H.E.White (T)
2. Fundamentals of molecular spectroscopy-C.B.Benwell (T).
3. Spectroscopy Vol. I II III- Walker &Straughen.
4. Introduction of molecular spectroscopy- G.M.Barrow.
5. Spectra of diatomic molecules –Herzberg
6. Molecular spectroscopy Jeanne L Michele
7. Molecular spectroscopy –J.M.Brown.
8. Spectra of atoms and molecules -P.F.Bernath.
9. Modem spectroscopy –J.M.Holias.

Course Outcome: The knowledge of atomic structure, the interaction between atoms and fieldshelps the concept of binding of atoms into molecules, molecular degrees of freedom (electronic, vibrational, and rotational), elementary group theory considerations and molecular spectroscopy.

MPH-1305 **Nuclear and Particle Physics** **[4 0 0 4]**

Course Objectives: The course provides the knowledge of basic properties of nuclei and nuclear structure. It offers the capability of elementary problem solving in nuclear and particle physics, and relating theoretical predictions and measurement of results.

Module-I:
Nuclear properties: radius, size, mass, spin, moments, binding energy, excited states.
Nuclear Forces: n-n and p-p interaction, nature of nuclear force.
Nuclear Models: Liquid Drop Model, Shell Model and Collective Models.

Module-II:
Nuclear Decay and Radioactivity: Radioactive Decay, Detection of Nuclear Radiation, alpha, beta and gamma Decays, Radioactive Dating.

Module-III:
Nuclear Reactions: Conservation Laws, Reaction Cross section, Coulomb Scattering, Nuclear Scattering, Scattering cross section, Optical Model, Compound Nucleus, Direct Reactions, Resonance Reactions, Neutron Physics, Fission, Fusion.
Particle Accelerators and Detectors: Electrostatic Accelerators, Cyclotron, Synchrotron, Linear Accelerators, Colliding beam Accelerators, Gas-filled Counters, Scintillation Detectors, Semiconductor Detectors.

Module-IV:
Elementary Particles: forces, quantum numbers, CPT theorem.
Particle Physics: Symmetries and Conservation Laws, Gell-Mann Nishijima relation, Quark Model, Coloured Quarks and Gluons, Quark Dynamics, Standard Model.

Reference books:

1. K.S. Krane- Introductory Nuclear Physics, Johm Wiley (1988).
2. R.R. Roy and B.P. Nigam- Nuclear Physics: Theory and Experiment, New Age (1967).
3. A. Das and T. Ferbel- Introduction to Nuclear and Particle Physics, John Wiley (1994).
4. I.S. Hughes- Elementary Particles, Cambridge (1991).
5. F. Halzen and A.D. Martin- Quarks and Leptons, John Wiley (1984).

Course Outcome: The knowledge of basic properties of nuclei and nuclear structure offers the capability of elementary problem solving in nuclear and particle physics, and relating theoretical predictions and measurement of results.

M.Sc. Lab-III MPH-1391 Modern Physics Lab [0-0-3 2]

1. Determination of Hall coefficient, carrier type; concentration and mobility of a semiconductor
2. Magnetic susceptibility of paramagnetic substance by Quinkes's method
3. Conductivity Measurement by – Four Probe Method
4. Fourier Filtering
5. ESR Spectroscopy
6. Determination of 'e/m' by Mullikan's oil drop experiment
7. Determination of absorption co-efficient of Aluminium using G.M Counter.
8. Characteristics of G.M. counter.
9. Study of surface barrier detector.
10. Frank-Hertz Experiment
11. Polarimeter Experiment

MPH-1401 Experimental Techniques in Physics [4 0 0 4]

Course Objectives: This course provides good understanding of materials characterization by introducing the basic principles and operation of several characterizing tools. It offers the ability to decide a suitable tool for the specific characterization of a material. This also helps in data acquisition and interpretation for the materials under investigation.

Module-I

Sensors: Resistive, capacitative, inductive, electromagnetic, thermoelectric, elastic, piezoelectric,piezoresistive, photosensitive and electrochemical sensors.

Module-II

Low pressure: Rotary, sorption, oil diffusion, turbo molecular, cryo pumps; Mcleod,thermoelectric (thermocouple, thermister and pirani), penning, hot cathode and Bayard Alpertgauges; vacuum components.

Module-III

Low temperature: Gas liquifiers; liquid He cryostat design; closed cycle refrigerator; low temperature measurement.

Module-IV

Analytical Instruments: X-ray diffractometer; Spectrophotometers; FT-IR; DSC; DTA, TGA, Raman spectrometer, scanning electron microscope, transmission electron microscope, atomicforce microscope, interferometers.

Text books References:

1. A. D. Helfrick and W. D. Cooper, Modern electronic instrumentation and measurement techniques, Prentice Hall of India (1996).
2. J. P. Bentley, Principles of measurement systems, Longman (2000).
3. G. K. White, Experimental techniques in low temperature physics, Calrendon (1993).
4. A.Roth, Vacuum technology, Elsevier (1990).
5. D. A. Skoog, F. J. Holler and T. A. Nieman, Principles of Instrumental analysis, Saunders CoI. Pub

Course Outcome: Good understanding of materials characterization offers the ability to decide a suitable tool for the specific characterization of a material. This also helps in data acquisition and interpretation for the materials under investigation.

Elective -I MPH-1402 Laser Physics [4 0 0 4]

Course Objectives: The aim of the course is to acquire a thorough understanding of the theory of modern laser physics, which enables to describe the inherent behaviour and functionality of the many different types of modern lasers and their applications.

Module-I

Laser Fundamentals: Interaction of light with matter, quantum behaviour of light, Basic processes (Stimulated absorption, spontaneous and stimulated emission), Einstein coefficients and relation between them, Population inversion,Pumping, Active medium, metastable state, optical resonator,condition for light amplification, Properties: Directionality, intensity, coherence(temporal and spatial coherence), monochromaticity,Types: Ruby laser, Helium Neon laser, CO_2 Laser, Dye Lasers, Semiconductor lasers.

Module-II

Holography: Introduction, basic principle, condition for good recording of the hologram,characteristics of hologram, mathematical analysis,features of holography,Application of holography – HNDT (Holographic Non-Destructive Testing), Holographic storage – optical disk storage, Laser speckle and speckle meteorology, SNDT (Speckle Non-Destructive Testing).

Module-III

Fibre Optics:Optical fibre principle, Types of optical fibres, Properties, Fiber optical communication, Fiber optic sensors: intensity, phase polarization and frequency dependent techniques.

Module-I V

Application of Lasers : Saturation spectroscopy, excited state spectroscopy ,time domain and its applications, Laser fusion, Isotope separation, Medical applications, photo-chemical applications Lasers in industry Materials processing, drilling, cutting, welding , alloying , glazing.

Text books and References

1. K. Thyagarajan and A.K. Ghatak, Lasers Theory and Applications, Mcmillan (1981).
2. K. Koebner (ed.), Industrial Applications of Lasers, Wiley (1984).
3. J.T. Cuxon and D.E. Parker, Industrial Lasers and their Applications, Prentice Hall (1985).
4. B. Culshaw, Optical Fiber Sensing and Signal Processing, Peter Peregrinus Ltd. (1984).
5. F.C. Appard, Fiber Optics Handbook, McGraw-Hill (1989).
6. O. Svelto, Principles of Laser, Plenum (1998).
7. W. T. Silfvast, Laser and Fundamentals, Cambridge (1996).
8. A. E. Seigman, Lasers, Oxford (1986).
9. A. Yariv, Quantum Electronics, John Wiley (1988).

Course Outcome: The deep understanding of the detailed properties of coherent laser light formulates reasonably complicated problems in laser physics and provide solutions to the same.

Elective-II MPH-1403 Theory of nonlinear dynamical systems [4 0 0 4]

Course Objectives: The course aims to introducethe students to abstract mathematical concepts that are integral for a proper grasp of the standard techniques used in nonlinear dynamics.

Module I

Linear and nonlinear differential equations,Vector fields, Phase space and differential equations, Stability of steady states, Linearization of nonlinear systems, Oscillating solutions of nonlinear systems, Numerical Simulations and examples,Discrete time systems, Linear and nonlinear maps, Stability of the fixed points of maps, The logisticmap, Iterations of maps, numerical computations

Module II

Saddle-Node bifurcation, Transcritical bifurcation, Pitchfork bifurcation, Hopfbifurcation, Flip bifurcation, Period doubling bifurcation, Simulations

Module III

Deterministic chaos: Definitions and examples,Unpredictability and determinism, Chaos paths, Poincare' sections,Strange attractors, The Lorenz system, Numerical solutions of chaotic systems, logistic map, Lorenz system, Rossler systems.Distributed systems:Definitions and examples, Reaction-diffusion equations, Turing bifurcation, Spatio-temporal chaos

Module IV

Applications:Chaos in classical mechanics and electronics, Ecological systems: Simple and modified Lotka-Volterra equations for predator-prey mechanisms and species competition , Population dynamics and economic systems: application of the logistic equation, Biological and physiological systems: glycolysis, circadian rhythms, models of neurons

Text books and References

1. H. Steven,and Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering
2. A.J Lichtenberg M.A Lieberman Regular and Chaotic Dynamics
3 Shlomo Sternberg: Dynamical Systems: Dover

Course Outcome: On completion of this course, the student is expected to have mastered the basic techniques for analysing linear and nonlinear ordinary differential equations. It also helps to equip the students to successfully analyse nonlinear dynamical systems of various kinds using advanced numerical techniques.

Elective-III **Spectroscopy** **[4 0 0 4]**

Course Objectives: The objectives of this course are to introduce the theory of the various instruments and the signals produced when analysing compound, and to equip the student with enough information to be able to interpret signals from spectroscopic instruments.

Module-I: Microwave 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.

Module-II:Infrared spectroscopy
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 - H2O and N2O molecules - Reflectance spectroscopy.

Module-III:NMR and NQR Techniques
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.

Module-IV: ESR and Mossbauer Spectroscopy
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.

Reference Books:

1. C.N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata McGraw-Hill Publications, New Delhi (1994)
2. G. Aruldas, Molecular Structure and Spectroscopy, PHI, New Delhi (2001)
3. D.N. Satyanarayana, Vibrational Spectroscopy and Applications, New Age International Publications, New Delhi (2004)
4. Raymond Chang, Basic Principles of Spectroscopy, Mc Graw-Hill Kogakusha, Japan(1980)
5. Straughn and Walker, Spectroscopy, Vol I &II Chapman and Hall (1967)
6. Towne and Schawlow, Microwave Spectroscopy, McGraw-Hill (1995)
7. D.A. Lang, Raman Spectroscopy, Mc Graw-Hill International, N.Y.
8. John Ferraro, Introductory Raman Spectroscopy, Academic Press (2008)

Course Outcome: Students can understand the usage of different spectroscopic techniques to determine the molecular structure, energy levels, its application to physical and chemical analysis.

Elective-IV **Physics of Semiconductor Devices** **[4 0 0 4]**

Course Objectives: To introduce to students the theory and applications of semiconductor device physics for electrical, electronics and computer engineering, and to know the characteristics of different semiconductor devices.

Module-I

Semiconductor fundamentals:

Quantum theory of solids, formation of energy bands, mathematical formulation of Kronig-Penney model, K-space diagram, representation of k-space diagram in 2-D and 3-D,Direct and indirect band gap semiconductor, energy bands in solids, classification of solids on the basis of band theory. Importance of silicon crystal structure ,donor and acceptor in energy band model, effective mass of electron and hole, density of states, Fermi –Dirac distribution function for electron and holes, Fermi energy and temperature dependence of Fermi energy

Module-II

Carrier concentrations in thermal equilibrium and Transport phenomena:

Thermal equilibrium, equilibrium distribution of electron and holes, electron concentration in conduction band and hole concentration in valence band, carrier concentration in intrinsic semiconductor, np product, Fermi level position in an intrinsic semiconductor, charge neutrality condition, general theory for n and p, compensated semiconductor, equilibrium distribution of electron and hole in extrinsic semiconductor, degenerate and non degenerate semiconductor, Fermi energy level as a function of concentration and temperature with graphical representation, complete ionization, freeze out condition, partial ionization, carrier drift: electron and hole mobility, drift current density and conductivity, carrier diffusion: diffusion current, total current density, Einstein relationship between diffusion coefficient and mobilities.

Module-III

Fabrication technology and semiconductor devices: Introduction to fabrication technology, Qualitative idea of different fabrication technology like: Oxidation of silicon, Lithography, Etching, doping, dopant diffusion, thin film deposition, interconnect,building blocks of PN junction,Depletion layer model, reverse biased PN junction,C-V characterstic,junctionbreakdown,carrierinjuction under forward bias,current continuity equation,excess carrier in forward biased ,I-V characterstic,Introduction to BJT,collector and base current,currentgain,base width modulation,Ebers-Moll model.

Module-IV

MOSFET and Photonic Devices

MOS capacitor: Flat band condition, surface accumulation, surface deplection, threshold condition and threshold voltage, MOS C-V characteristics, Introduction to MOSFET:CMOS technology, surface mobilities, high mobility FETs,MOSFET V_t,Body effect, steep retrograde doping,Q_{inv} in MOSFET,Radiative transition and optical absorption,Light emitting diodes (Visible,organic,infrared),Phtodetector:Photoconductor,Photodiode(construction,working, theory),Solar cell(solar radiation-n junction solar cell).

Text books and References:

1. C.C.Hu,Modern: Semiconductor Devices for Integrtedcircuits,Pearson(2010)
2. S.M.Sze:Semiconductor Devices “Physics and Technology),WILEY(2009)

3. R.Neamann:Semiconductor Physics and Semiconductor Devices
4. R. A. Smith, Semiconductors, Academic Press (1978).
5. K. Seeger, Semiconductor Physics: An introduction, Springer Verlag (1991).
6. C. Hamaguchi, Basic semiconductor physics, Springer Verlag (2001).

Course Outcome: Thestudents are expected to have theknowledge about the basic materials and properties of semiconductors with application to various circuits and devices.

Elective-V Materials Science and Technology [4 0 0 4]

Course Objectives: The course has been aimed to provide the fundamental science and engineering principles relevant to mateirals, and to understand the relation between structure, characterization, properties, and processing of mateirals.

Module-I
Necessity of Materials Science and Technology:
Introduction to Materials Science, The Relationship of Science and Technology, How is basic science linked to everyday Materials, Criteria for materials selection.
Solidification and Crystalline Imperfections: Solidification of metals, Solidification of single crystal, Metallic solid solution, Crystalline Imperfections.

Module-II
Phase Transformation in Metals:
Introduction, Basic concepts, Kinetics of Solid state, Reactions, Multiphase transformations
Mechanical Properties of Metals:
Stress and strain in metals, Deformations, Failures,
Types of Metal Alloys: Ferrous alloys, Nonferrous Alloys.
Corrosion: Electrochemical corrosion of metals, galvanic cells, corrosion rates, types of corrosion, oxidation of metals, corrosion control.

Module-III
Types and Application of Materials:.
Ceramics- Glasses, Glass-ceramics, Clay products, Refractories, Fireclay, Silica, Basic and special Refractories.
Polymers- Plastics, Elstomers, Fibers, Advanced Polymeric materials, Applications.
Composites- Introduction, Fiber reinforced-plastic composite materials, Concrete, Wood, Sandwich structures, Metal-matrix and Ceramic matrix composites, Natural composites.

Module-I V
Semiconductor Devices- the p-n junction, some applications of p-n junction diodes, Bipolar junction diodes, Compound semiconductors.
Fabrication of Microelectronic devices, Nanoelectronic and Spintronic Devices

Text books and References

1. W.D. Callister, Materials Science and Engineering, 5th Edition John Wiley(2000)
2. V. Raghavan, Materials Science and Engineering, 4th Edition, Prentice Hall India (1991)
3. C. Kittel, Introduction to Solid State Physics, 7th Edition, Wiley Eastern Ltd.(1996)
4. G. Burns, Solid State Physics, Academic Press (1995)

Course Outcome: The course will provide knowledge to understand experimental skills to characterize the various kinds of materials to establish a research professional career.

Elective-VI Advanced Quantum Mechanics [4 0 0 4]

Course Objectives: This course will explore the various types of quantum systems, equations, techniques and quantum fields. Students will learn the world of quantum field theory, and quantum electrodynamics.

Module-I:
Relativistic Quantum Mechanics: Introduction, Klein-Gordon (KG) equation, current and probable density (continuity equation), KG equation in electromagnetic field, Dirac's relativistic equation, covariant and adjoint forms of Dirac equation, Spin-orbit energy, Negative energy states of electron.

Module-II:
Quantization of Fields: Introduction, Relativistic Lagrangian and Hamiltonian of a charged particle in an EM field, Lagrangian and Hamiltonian formulations of field, Quantum equation for the field, Second quantization, Quantization of KG equation, Creation, Annihilation and number operators, Occupation number representation.

Module-III:
Quantum Field theory: Canonical quantisation, Free propogators Quantization of fields, Real and charged scalars Second quantisation of real scalar field, Second quantisation of complex scalar field, Second quantisation of Dirac field, Second quantisation of Electromagnetic fields

Module-IV:
Quantum Electrodynamics: Non linearLagrangians, Fermions in an External Field, Interaction of Electrons with the Radiation Field: Quantum Electrodynamics (QED): The Lagrangian and the Hamiltonian Densities, Equations of Motionof Interacting Dirac and Radiation Fields, The Interaction Representation (Dirac Representation), Perturbation Theory, Wick's Theorem, Feynman Diagrams and Rules of Quantum Electrodynamics

References:

1. J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley (2011)
2. G. Baym, Lectures on Quantum Mechanics, Benjamin/Cummings (1973)
3. F. Schwabl, Quantum Mechanics, Springer (1990)
4. D.J. Griffiths, Introduction to Quantum Mechanics, Pearson (2005)
5. Satyaprakash, Advanced Quantum Mechanics, Kedar Nath Ram Nath (2010).
6. W. Greiner, J.Reinhardt, Quantum Electrodynamics, Springer-Verlag, Berlin(2009).
7. J. D. Bjorken, S. D. Drell, Relativistic Quantum Mechanics, McGraw Hill (1978).

Course Outcome: Thecourseis expected to identify, understand, design, set up, and carry out the various physical phenomena to provide the theoretical predictions.

Elective-VII Crystallography [40 0 4]

Course Objectives: Tounderstand the general principles of crystal and molecular structures and structure-property relationship, and to obtain the basic knowledge of X-ray diffraction analysis and phase transition problems.

Module-I

Symmetry of crystals, crystal projection and point groups, space groups.
Production of X-Ray, X-Ray generator, absorption of X-Rays and principle of filter. Scattering of X-Ray by an electron, an atom and a unit cell, Structure factor calculations.
Diffraction of X-Rays, Laue and Bragg equation, X-Ray powder diffraction, determination of lattice parameters by Debye-Scherrer method, X-Ray diffractometer, X-Ray line profile analysis, broadening of diffraction line, size and strain broadening, Scherrer equation,

Module-II

Chemical analysis by X-ray Diffraction and X-Ray fluorescence, Qualitative Analysis-Hanawalt method, Quantitative Analysis-External Standard method, Direct Comparison method, Internal Standard method, Energy Dispersive X-ray (EDX), Wavelength Dispersive.Particle induced X-ray emission (PIXE) and their applications;Introduction to medical X-ray and X-ray techniques (radiography, radiotherapy, CT scanning etc.)

Module-III

Reciprocal lattice, sphere of reflection, Oscillation and Weisenberg photograph and their interpretation. Introduction to small Angle X-ray Scattering (SAXS) and its applications, Residual stress and its determination by X-ray diffraction, Elementary idea of Neutron and Electron diffraction.

Module-IV

Fourier Series representation of electron density in crystals, projection of electron density in two dimensions, electron density contours. Phase problem and its solutions, trial and error method, Patterson function, Heavy atom method, Isomorphous replacement method, Direct methods, Use of Harker-Kasper inequalities, Refinement- differential synthesis and method of least squares.

Text Books and references:

1. B.D. Cullity-Elements of X-ray diffraction, Addison-Wesley Publishing Company.
2. S.K. Chatterjee-X-ray diffraction-its theory and applications, Prentice Hall, India.
3. B.E. Warren-X-ray diffraction, Addison-Wesley Publishing Company.
4. A.R. Verma and O.N. Srivastava-X-ray Crystallography, New Age InternationalPublisher.
5. H.P. Klug and L.E. Alexander-X-ray Diffraction procedures, John Wiley & Sons.
6. J.A. Nielson and D. McMorrow-Elements of Modern X-ray physics, John Wiley & Sons (2001)
7. G.V. Pavlinsky, Fundamentals of X-ray Physics, Cambridge International Sci. Pub (2008)
8. A. K. Singh, Advanced X-ray Techniques in Research and Industry-, Capital Publishing Company.
9. N. Kasai, M. Kakudo, X-ray diffraction by macromolecules, Springer (2005)

Course Outcome: Thefollowing skills are expected at the end of this course:Ability to describe fundamental crystallographic concepts, ability to extract the relevant information from a crystallographic paper, and ability to find specific tools for solution of a given crystallographic problem.

MPH-1491 **Physics Lab-IV** **[0-0-3 2]**

1. Velocity of ultrasonic waves in a given medium at different temperatures
2. Obtaining B-H curve and hysteresis loss for given sample
3. Curie Temperature of Magnetic Materials
4. Dielectric Constant and Curie Temperature of Ferroelectric Ceramics
5. Study of energy gap of Germanium by four-probe method
6. Find the Young's modulus for the given metal using composite piezoelectric oscillator technique.
7. Modulation of detection
8. Programming using into 8085 microprocessor
9. DSO
10. Hysteresis (P-E)Loop Tracer
11. Ferromagnetic Curie Temperature Kit
12. Solar energy trainer Kit
13. To understand the principle and working of Scanning Electron Microscope & to find out the grain size of a given sample
14. To study the morphology of a sample using SEM and to study elemental analysis by EDX method
15. To determine the thermodynamic constants and glass transition temperature of a given polymer sample using Differential Scanning Calorimeter (DSC)