# COURSES OF STUDIES FOR THE
# 5-Year integrated M. Sc. (Physics)
# (w.e.f. from 2016-17)

**DEPARTMENT OF PHYSICS**

**VEER SURENDRA SAI UNIVERSITY OF ECHNOLOGY**

**BURLA, SAMBALPUR -768018**

## Course Structure of 5-Year Integrated M.Sc (Physics)

**First Semester**

| Sl. No. | Course Code | Name of the Course | L-T-P | Credits |
|---|---|---|---|---|
| 1 | CH-111 | Chemistry-I (General ) | 3-1-0 | 4 |
| 2 | PH-111 | Physics-I | 3-1-0 | 4 |
| 3 | MAT-111 | Mathematics-I | 3-1-0 | 4 |
| 4 | BIO-111 | Biology-I | 3-1-0 | 4 |
| 5 | HS-111 | English-I | 3-1-0 | 4 |
| 6 | CH-112 | Chemistry Lab-I | 0-0-3 | 2 |
| 7 | PH-112 | Physics Lab-I | 0-0-3 | 2 |
| 8 | HS-112 | Language Lab-I | 0-0-3 | 2 |
| 9 | MAT-112 | Mathematics Lab-I | 0-0-3 | 2 |
| | | **Total Credits** | | 28 |
| | | **Second Semester** | | |
| 1 | CH-121 | Chemistry-II (Basic Inorganic –I) | 3-1-0 | 4 |
| 2 | PH-121 | Physics-II | 3-1-0 | 4 |
| 3 | MAT-121 | Mathematics-II | 3-1-0 | 4 |
| 4 | BIO-121 | Biology-II | 3-1-0 | 4 |
| 5 | CS-121 | Computer Science | 3-1-0 | 4 |
| 6 | CH-122 | Chemistry Lab- II | 0-0-3 | 2 |
| 7 | PH-122 | Physics Lab-II | 0-0-3 | 2 |
| 8 | CS-122 | Computing Lab-I | 0-0-3 | 2 |
| 9 | HS-122 | Language Lab-II | 0-0-3 | 2 |
| | | **Total Credits** | | 28 |
| **Third Semester** | | | | |
| 1 | CH-211 | Chemistry-III (Basic Physical -I) | 3-1-0 | 4 |
| 2 | CH-212 | Environmental Science | 3-1-0 | 4 |
| 3 | HS-211 | Organizational Behavior | 3-1-0 | 4 |
| 4 | PH-211 | Physics-III | 3-1-0 | 4 |
| 5 | MAT-211 | Mathematics-III | 3-1-0 | 4 |
| 6 | CH-213 | Organic Chem. Lab-I | 0-0-3 | 2 |
| 7 | CH-214 | Environmental Science Lab | 0-0-3 | 2 |
| 8 | PH-212 | Physics Lab-III | 0-0-3 | 2 |
| 9 | CS-211 | Computing Lab-II | 0-0-3 | 2 |
| | | **Total Credits** | | 28 |

**Fourth Semester**

| Sl. No. | Course Code | Name of the Course | L-T-P | Credits |
|---|---|---|---|---|
| 1 | CH-221 | Chemistry-IV (Basic Organic –I) | 3-1-0 | 4 |
| 2 | CH-222 | Basic Inorganic Chemistry-II | 3-1-0 | 4 |
| 3 | HS-223 | Economics & Costing | 3-1-0 | 4 |
| 4 | PH-221 | Physics-IV | 3-1-0 | 4 |
| 5 | MAT-221 | Mathematics-IV | 3-1-0 | 4 |
| 6 | CH-223 | Physical Chem Lab-I | 0-0-3 | 2 |
| 7 | CH-224 | Instrumentation Lab | 0-0-3 | 2 |
| 8 | PH-222 | Physics Lab-IV | 0-0-3 | 2 |
| 9 | MAT-222 | Mathematics Lab-II | 0-0-3 | 2 |
| **Total Credits** | | | | 28 |

**Fifth Semester**

| | | | | |
|---|---|---|---|---|
| 1 | PH-311 | Introduction to Mathematical Physics | 3-1-0 | 4 |
| 2 | PH-312 | Basic Solid State Physics | 3-1-0 | 4 |

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|---|---|---|---|---|
| 3 | PH-313 | Nanomaterials and Applications | 3-1-0 | 4 |
| 4 | PH-314 | Mechanics-II | 3-1-0 | 4 |
| 5 | PH-315 | Fundamentals of Electronics | 3-1-0 | 4 |
| 7 | PH-316 | Physics Lab-V | 0-0-3 | 2 |
| 8 | PH-317 | Physics Lab-VI | 0-0-3 | 2 |
| **Total Credits** | | | | 24 |
| | | **Sixth Semester** | | |
| 1 | PH-321 | Thermal Physics | 3-1-0 | 4 |
| 2 | PH-322 | Photonics and Power Devices | 3-1-0 | 4 |
| 3 | PH-323 | Physics of Materials | 3-1-0 | 4 |
| 4 | PH-324 | Physics Modern Science | 3-1-0 | 4 |
| 5 | PH-325 | Digital Systems and Applications | 3-1-0 | 4 |
| 6 | PH-326 | Physics Lab-VII | 0-0-3 | 2 |
| 7 | PH-327 | Physics Lab-VIII | 0-0-3 | 2 |
| **Total Credits** | | | | 24 |
| | | **Seventh Semester** | | |
| 1 | PH-411 | Classical Mechanics | 4-0-0 | 4 |
| 2 | PH-412 | Mathematical Physics-I | 4-0-0 | 4 |
| 3 | PH-413 | Quantum Mechanics-I | 4-0-0 | 4 |
| 4 | PH-414 | Condensed Matter Physics-I | 4-0-0 | 4 |
| 5 | PH-415 | Fortran Programming | 4-0-0 | 4 |
| 6 | PH-416 | Physics Lab-IX (General Physics) | 0-0-3 | 2 |
| 7 | PH-417 | Programming Lab-I | 0-0-3 | 2 |
| **Total Credits** | | | | 24 |

**Eighth Semester**

| Sl. No. | Course Code | Name of the Course | L-T-P | Credits |
|---|---|---|---|---|
| 1 | PH-421 | Statistical Mechanics | 4-0-0 | 4 |
| 2 | PH-422 | Electrodynamics-I | 4-0-0 | 4 |
| 3 | PH-423 | Quantum Mechanics-II | 4-0-0 | 4 |
| 4 | PH-424 | Computational Techniques in Physics | 4-0-0 | 4 |
| 5 | PH-425 | Basic Electronics | 4-0-0 | 4 |
| 6 | PH-426 | Physics Lab-X (Laser and Photonics) | 0-0-3 | 2 |
| 7 | PH-427 | Programming Lab-II | 0-0-3 | 2 |
| **Total Credits** | | | | 24 |
| | | **Ninth Semester** | | |
| 1 | PH-511 | Electrodynamics-II | 4-0-0 | 4 |
| 2 | PH-512 | Mathematical Physics-II | 4-0-0 | 4 |
| 3 | PH-513 | Atomic and Molecular Physics | 4-0-0 | 4 |
| 4 | PH-514 | Condensed matter Physics II | 4-0-0 | 4 |
| 5 | PH-515 | Nuclear & Particle Physics | 4-0-0 | 4 |
| 6 | PH-516 | Physics Lab-XI (Modern Physics) | 0-0-3 | 2 |
| 7 | PH-517 | Seminar & Technical Writing-I | 0-0-3 | 2 |
| **Total Credits** | | | | 24 |

| | | **Tenth Semester** | | |
|---|---|---|---|---|
| 1 | PH-521 | Experimental Techniques in Physics | 4-0-0 | 4 |
| 2 | PH-522 | Elective-I | 4-0-0 | 4 |
| 4 | PH-523 | Elective-II | 4-0-0 | 4 |
| 5 | PH-524 | Physics Lab-XII (Advanced Materials) | 0-0-3 | 2 |
| 6 | PH-525 | Seminar & Technical Writing-II | 0-0-3 | 2 |
| 7 | PH-526 | Project | 0-0-6 | 6 |
| 8 | PH-527 | 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 | 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 | Spectroscopy | 4-0-0 | 4 |
| 9 | Nano Technology | 4-0-0 | 4 |
| 10 | Quantum Field Theory | 4-0-0 | 4 |
| 11 | Theory of Non-Linear Dynamics | 4-0-0 | 4 |

**PH-111 Physics-I (MECHANICS- I) [3-1-0-4]**

**Course Objectives:** The course provides the exposure to introductory rotational dynamcis, central force motion, various properties of matter, and special theory of relativity.

**Module -I**

**Rotational dynamics**: Centre of mass and Laboratory frames, Rigid body, Equation of motion of a rigid body, Angular momentum, Moment of Inertia, Radius of gyration, Kinetic energy in rotational motion and in rolling motion, Parallel axis theorem and Perpendicular axis theorem, Moment of inertia of an annular disc, cylinder and solid sphere.

Non-inertial frames and fictitious forces, Uniformly rotating frame, Centrifugal force, Coriolis force and its applications

**Module-II**

**Central Force Motion and Gravitation**: Central force, Motion of Center of mass (COM), Reduction of two body problem to one body problem, Reduced mass: Examples, Equation of motion under central force, Conservation laws: Conservation of linear momentum, angular momentum and energy for a system of particles.

Newton's law of Gravitation, Acceleration due to gravity(g), Determination of Time period of a Bar pendulum, Inertial and gravitational mass, Gravitational potential energy, Gravitational potential and field due to a: spherical shell and solid sphere, Kepler's laws of Planetary motion, Satellite in circular orbit and applications, Basic idea of global positioning system (GPS).

**Module-III**

**Properties of matter:** Elasticity, Hooke's law, Elastic constants $(Y, B, \eta, \sigma)$ and relation between them, Torsional couple per unit angular twist, bending of beams, bending moment, Depression occurring at the free ends of a light and heavy cantilever. Surface tension, Molecular theory of surface tension, Surface energy, Pressure difference across liquid and curved surfaces, Viscosity: Coefficient of viscosity, Laminar and turbulent flow, Critical velocity, Poiseuille's equation for Flow of a Liquid through a Capillary Tube, Stoke's theorem

**Module-IV**

**Special Theory of Relativity**: Michelson-Morley Experiment and its outcome, Postulates of special theory of relativity, Galilean transformations, Lorentz transformations, Simultaneity and order of events, Length contraction and Time dilation, Relativistic addition of velocities, Variation of mass with velocity, Mass – Energy equivalence relation, Transformation of energy and momentum

**Reference Books:**


1. Physics: R. Resnick, D. Halliday and J. Walker 8/e. 2008, Wiley.
2. Properties of Matter: D.S. Mathur
3. Mechanics: J. C. Slater and N. H. Frank (McGraw Hill)
4. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley


**Course Outcome:** This course is helpful to understand the advanced mechanics concepts involved in higher semesters.

**PH-112 PHYSICS LAB-I 2 Credits [0-0-3]**

1. Determination of 'g' by bar pendulum.
2. Verification of laws of transverse vibration of a string by using Sonometer
3. Determination of surface tension of water by capillary rise method.
4. Thermal conductivity of a bad conductor by Lee's method
5. Determination of Youngs Modulus of wire by Searle’s method.
6. Determination of Rigidity modulus of wire by static method

# PH-121 Physics-II (3 1 0 4)

## (ELECTRICITY, MAGNETISM AND ELECTRONICS)

**Course Objectives:** The purpose of this course is to improve understanding of the enormous variety of electromagnetic phenomena in terms of a few relatively simple laws, and to exploit the laws of electromagnetism from our everyday experience by specific examples of how electromagnetic phenomena manifest themselves.

### Module -I

Scalar and vector triple products: Differentiation of a vector with respect to a scalar, Gradient, Divergence & Curl operators, Gauss divergence theorem, Stoke's theorem, Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry, Energy of a point charge Distribution, Energy density, Dielectrics, Field inside a dielectric, Dielectric constant, Capacitor (parallel plate, spherical, cylindrical) filled with dielectric, Displacement vector **D**, Relations between **E**, **P** and **D**. Gauss' Law in dielectrics.

### Module – ll

Magnetic force between current elements and definition of Magnetic Field **B**, Lorentz's force law, Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid, The scalar and Vector Potential, Torque on a current loop in a uniform Magnetic Field, Ballistic Galvanometer, Differential form of electromagnetic induction, Maxwell's equations & physical significance, Wave equation, Electromagnetic Waves, wave properties, Speed, Growth & decay of currents in RC& LR circuits.

### Module -III

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction

(1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell

### Module -IV

n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains $\alpha$ and $\beta$ Relations between $\alpha$ and $\beta$. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions

**ICs** (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers

### References:


1. Introduction to Electrodynamics: D. J. Griffith
2. Electricity& Magnetism: Chattopadhaya& Rakhit
3. Fundamentals of Electronics: Chattopadhaya Rakshit and Saha
4. Principles of Electronics: V.K.Mehta

5. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
6. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994

**Course Outcome:** On completion of the course, the students will:

1. Acquire familiarity with differential operates like divergence, gradient, curl.
2. Learn how to develop and employ circuit models for elementary electronic components, e.g., resistors, sources, inductors, capacitors, diodes and transistors
3. Learn how the primitives of Boolean algebra are used to describe the processing of binary signals and to use electronic components.
4. Learn how to calculate frequency response curves and to interpret the salient features in terms of poles and zeros of the system function;
5. Gain an intuitive understanding of the role of power flow and energy storage in electronic circuits

## PH-122 PHYSICS LAB II (0 0 3 2)

1. Determination of ballistic constant of a Ballisitic Galvanometer
2. Study of LCR Circuit
3. Carry-Foster Bridge
4. Frequency of AC mains using Sonometer
5. Digital gates kit

# Physics-III Waves and Optics

**Course Objectives:** The course aims to provide the knowledge of mathematical description for the concepts in waves and optics, and to learn some applications of them.

**Module – I**

Simple harmonic oscillator, damped harmonic oscillator, Power loss, Q-Factor, Under damped, Over damped motion, Critical damping, Forced vibration. Resonance, Sharpness of resonance. Mathematical description of travelling waves, Wave equation. Transverse waves in a stretched string longitudinal waves in a gaseous medium, Composition of simple harmonic Waves. Lissajous figures [Superposition of two orthogonal S.H.M (i) of equal frequencies (ii) in the frequency ratio 2:1]

**Module -II**

Interference: Conditions of interference, interference by division of wavefront, Biprism and determination of λ, Interference by a thin film with two (i) parallel and (ii) non-parallel refracting surfaces, Newton's ring and determination of λ of monochromatic light, Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer

**Module -III**

Diffraction of light, types of diffraction, Fraunhoffer diffraction: Single slit. Circular aperture, Double slit. Multiple slits. Diffraction grating. Resolving Power of a telescope Resolving power of grating, Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Comparison of zone plate with a convex lens, Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

**Module -IV**

Elementary Idea about polarized and unpolarised light, polarization by reflection and refraction, Malu's law. Brewster's law, Double refraction, ordinary and extraordinary rays, construction and uses of Nicol prism, Half wave and quarter wave plates, Mathematical analysis of linearly, circularly and elliptically polarized light, Construction and application of Polarimeter.

**References:**


1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill
2. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill
3. Optics: Zenkins and White
4. Optics: A. Ghatak
5. Principle of Optics: B. K Mathur
6. Geometrical and Physical optics: P.K.Chakraborty


**Course Outcome:** The usage and knowledge of various optical devices, and some ability for the analysis of different waves will be provided.

# PHYSICS LAB III

1. Michelson’s interferometer
2. Familiarization with Schuster’s focusing method
3. Dispersive power of the prism
4. Newton’s ring
5. Diffraction grating
6. Resolving power of diffraction grating
7. Brewster’s law verification

# Physics-IV MODERN PHYSICS

**Course Objectives:** The course broadly contains the introductory part of atomic physics, nuclear physics and quantum mechanics. The design of the course aims to educate the student with fundamentals of basic modern physics.

**Module -I**

**Atomic Physics**: Rutherford Scattering Formula, Rutherford Model of atom and its limitations, Bohr's model of H atom, explanation of atomic spectra, Line spectra of hydrogen atom, Ritz Rydberg combination principle, correction for finite mass of the nucleus, Bohr correspondence principle, limitations of Bohr model, Frank Hertz Expt. Sommerfeld's Modification of Bohr's Theory: Quantization of angular momentum, Zeeman Effect, Raman Effect

**Module -II**

**Nuclear Physics:** Properties of atomic nucleus (mass, charge, spin, magnetic moment), mass defect, binding energy, packingfraction, elementary idea of nuclear force and its properties, liquid drop model: semi-empirical formula for mass and binding energy, Nuclear Shell Model and magic numbers, Nuclear fission and fusion. Radioactive decay law, Half life and average life time of a nucleus, Alpha decay, Beta decay and Gamma ray emission

**Module -III**

**Introduction to Quantum mechanics**: Compton effect, Photoelectric effect, De Broglie hypothesis and wave particle duality, Super position of two waves, group velocity and phase velocity, Wave packet, Experimental confirmation of matter waves (Davision - Germer experiment), Heisenberg's uncertainty principle: Illustration of the Principle through thought Experiments of Gamma ray microscope and electron diffraction through a slit. Estimation of ground state energy of harmonic oscillator and hydrogen atom, non-existence of electron in the nucleus

**Module -IV**

**Application of Quantum mechanics** : The time dependent Schrodinger equation in one and three dimension, Wave function, Normalization, Probability, Operators associated with dynamical variables, Commutator algebra, Commutation relations among position and momentum operators, Hermitian operators, Adjoint of an operator, parity operator, Eigen functions and Eigen values of Hermitian operators, degeneracy, Ehrenfest's theorem, Time independent Schrodinger equation and stationary states, Applications of time independent Schrodinger equation in one dimension : Particle in a potential well (infinite and finite)

**References:**

1. A.Beiser, Conceptof Modem Physics
2. David J. Griffith, Introduction to Quantum Mechanics, Pearson Education (2005)
3. A.K.Ghatak & S.Lokanathan, Quantum Mechanics: Theory & Applications
4. Bransden, Physics of Atoms and Molecules, Pearson India (2003)
5. S. N. Ghoshal, Atomic and nuclear Physics

**Course Outcome:** The course concepts are essential for higher study in Physics and Chemistry, and to apply the basic laws of physics in different areas of Material Science. Further, to convert a physical situation articulated in English to a mathematical formulation, and then analyse it quantitatively.

**Practical IV**

1. Determination of Boltzmann constant using I-V characteristic of PN diode
2. Plank's constant using photoelectric effect
3. Transistor characteristic
4. Photodiode characteristic
5. Zener diode characteristic
6. Verification of Networks theorem

## SEMESTER-V

**PAPER I: INTRODUCTION TO MATHEMATICAL PHYSICS 4 Credits [3-1-0]**

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

### Module I

Orthogonal resolution of vector, Scalar and vector products, Differentiation of vectors, Gradient of a scalar field, Line, surface and volume integrals, Divergence of a vector function, Curl of a vector and its physical significance, Important vector identities, Gauss divergence theorem, Stoke's theorem, Green's theorem, Green's theorem in a plane**,** Orthogonal curvilinear coordinates: expressions for gradient, divergence, curl in Cartesian, spherical and cylindrical coordinates.

### Module II

**Sequences:** Definition, Monotonic sequences, Bounded sequences, Convergent and Divergent Sequences**.**

**Series:** Infinite series, Oscillating and Geometric series, their Convergence, Divergence. Tests of Convergence, Comparison Test, Limit Comparison test, Ratio test, $n^{th}$ root test (Cauchy root test), Alternating series, Absolute and Conditional convergence.

**Power Series:** Power series and its convergence, Radius and interval of convergence, Term by term differentiation, Term by term integration, Product of power series, Taylor and Maclaurin series.

### Module III

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions

**Theory of Errors:** Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error.

### Module IV

Complex numbers, Complex conjugates, Modulus and argument, graphical representation and trigonometric form, Functions of a complex variable, Limit, continuity and differentiability, Analytic function, Necessary and sufficient conditions for analytic function: Cauchy-Riemman differential equations in Cartesian and polar form, Cauchy's integral theorem and formula

### Suggested Books


1. B. D Gupta: Mathematical Physics
2. Satya Prakash: Mathematical Physics
3. M. Dash, P.K. Jena and B. K. Dash: Introduction to Mathematical Physics
4. G. Arfken: Method of Mathematical Physics


**Course Outcome:** The course is helpful to apply the various mathematical concepts, techniques and essential tools for the studies of quantum physics.

**PAPER II: BASIC SOLID STATE PHYSICS** **4 Credits [3-1-0]**

**Course Objectives:** This course deals with crystalline solids and is intended to provide students with basic physical concepts and mathematical tools used to describe solids. The course deals with groups of materials, as in the periodic table, in terms of their structure, electronic, optical, and thermal properties.

**Module-I**

Crystalline nature of matter, Crystal lattice, Primitive cell, Unit cell, Symmetry operations, Crystal systems, Bravais lattices, Packing fraction, Simple crystal structures (SC, BCC, FCC, HCP), Miller indices, Reciprocal lattice, Weigner-seitz cell, Reciprocal lattice to SC, BCC, FCC lattices

**Module-II**

Types of bondings in crystals (ionic, covalent, metallic, van der Waals, Hydrogen), Characteristics of crystals with different bindings, Cohesive energy, Determination of Madelung constant for ionic crystals

**Module-III**

Dielectrics: General concepts and properties, applications, dielectric constant, permittivity, losses, dielectric breakdown, measurements, dipole moment, types of polarization, polar molecules, Langevin's theory of orientational polarizability, Clausius—Mossotti equation, Ferroelectric behavior

**Module-IV**

Magnetism: Diamagnetic, paramagnetic, ferromagnetic mateirals, Origin of diamagnetism, origin of Paramagnetism (Langevin's theory), origin of ferromagnetism, Quantum theory of paramagnetism, Ferromagnetism: spontaneous magnetization and its temperature dependence, Curie-Weiss law, explanation of hysteresis, domain structure

**Books suggested**


1. S. P. Kulia, Essentials of Solid State Physics
2. C. Kittel, Introduction to Solid State Physics, Wiley Eastern Ltd., New Delhi (1988)
3. R.K. Puri and V. K. Babbar, Solid State Physics
4. M. Ali Omar, Elementary Solid State Physics, Pearson India (1999)


**Course Outcome:** Specific outcomes are: • knowledge on crystal symmetry which leads to substantial mathematical implications when dealing with solids. • Idea of describing basic experimental measurements, to show typical data sets and to compare these with theory

## PAPER III: NANO MATERIALS AND APPLICATIONS 4 Credits [3-1-0]

**Course Objectives:** This course aims to provide a comprehensive overview of nanomaterials in terms of the synthesis, characterization, properties, and applications. It will cover the fundamental scientific principles for the different synthesis techniques, assembly of nanostructured materials and, new physical and chemical properties at the nanoscale. Existing and emerging applications will also be discussed through case studies.

**Module-I**

Systems: Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size effect in nano systems, Quantum confinement. Properties of nanomaterials.

**Module-II**

SYNTHESIS: Top down and bottom up approach, Photolithography, Ball milling, Gas phase condensation, Vacuum deposition, Physical Vapour deposition (PVD), Pulsed Lased deposition, Chemical Vapour deposition

**Module-III**

OPTICAL PROPERTIES: Coulomb interaction in nanostructures, Concept of dielectric constant for nanostructures and charging of nanostructure, Quasi-particles and excitons, Excitons in direct and indirect band gap semiconductor nanocrystals, Quantitative treatment of quasi-particles and excitons, charging effects, Radiative processes: General formalization-absorption, emission and luminescence

**Module-IV**

APPLICATIONS: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots – magnetic data storage.Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

**Suggested Books:**

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology
2. S.K. Kulkarni, Nanotechnology, Principles & Practices
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology
4. Richard Booker, Earl Boysen, Nanotechnology
5. M. Hosokawa, K.Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology

**Course Outcome:** At the end of the course, the student will understand the following:

- Knowledge of general physics and chemistry of nanomaterials
- Analysis of processing techniques for nanomaterials – both chemical and physical approaches
- understand the important applications and properties of nanomaterials

**PAPER IV: MECHANICS II 4 Credits [3-1-0]**

**Course Objectives:** Mechanics give the idea of the most fundamental of all physical sciences and subsequently offers enough methodology to deal the problems at advanced level.

**Module I**

Basic concepts of constraints, generalized coordinates, Principle of virtual work, D'Alembert's principle, Lagrangian formulation: Lagrange's equation of motion, Applications of Lagrange's equation, Examples: Atwood's machine, compound pendulum, bead sliding on a rotating wire, for projectile motion, Hamiltonian formulation: function (H), equations, physical significance, applications

**Module II**

Virial Theorem, Scattering in a central force field: Rutherford scattering, Cannonical Transformations, Brackets: Poisson bracket and properties, invariance of Poisson bracket under canonical transformation, Lagrange bracket and properties, Relation between the Lagrange and Poisson bracket, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, (statement only)

**Module III**

Statistical Mechanics: Thermodynamic Probability, Entropy and probability, Elementary idea on ensemble, Partition function, Phase space, Probability distribution function for a classical system (Maxwell-Boltzmann statistics), Elementary idea about the distribution function in quantum mechanical systems (Fermi-Dirac and Bose-Einstein statistics)

**Module IV**

Blackbody radiation:radiation pressure, Stefan-Boltzmann's law, Kirchoff's law, distribution of energy in the black body spectrum, Wien's displacement law, Wien's law, Rayleigh-Jean's law, Planck's quantum theory of radiation : Deduction of Wein's law, Rayleigh-Jean's law, Kirchoff's law from Planck's law

**Books Suggested:**

1. Satyaprakash, Mathematical physics and Classical mechanics
2. Gupta, kumar, Sharma, Classical Mechanics
3. Gupta, Statistical Mechanics
4. BrijLal and N. Subrahmanyam, Heat, Thermodynamics and Statistical Mechanics:

**Course Outcome:** The course is expected to provide the idea of the most fundamental physical principles. Further, it helps to understand the challenging topics in statistical mechanics at advanced level.

**PAPER V: FUNDAMENTALS OF ELECTRONICS 4 Credits [3-1-0]**

**Course Objectives:** This course provides the knowledge on fundamentals of electronics concepts like semiconductors, transistors, amplifiers, and oscillators.

**Module-I**

**Semiconductors:** Energy bands in solids, Intrinsic and extrinsic semiconductors, Carrier concentration.

**p-n junction diode:** forward and reverse biasing of *p-n* junction diode with their respective *VI* characteristics, avalanche breakdown and dynamic resistance, load line and Q-point, Zener diode, Light emitting diodes (LED), Photoconduction in semiconductors, Photodiode, Solar Cell.

**Module - II**

**Transistors:** Construction (*pnp* and *npn*) of transistors and principles of operation, CE *V-I* input-output characteristics and current gain, CB circuit, current amplification factor, relation between α and β, active region, cut-off region, saturation region, dynamic output resistance, current gain, CB characteristics: input and output characteristics, CC circuit, input and output characteristics.

**Module - III**

**Amplifiers:** Transistor biasing, Methods a of transistor biasing and stabilization, D.C. load line, Common base and Common emitter biasing, Common base and common emitter amplifiers, Classification of amplifiers, Resistance- Capacitance (RC) coupled amplifier (two stage, concept of band width, no derivation), Feedback in amplifiers, Advantages of negative feedback, Emitter follower.

**Module - IV**.

**Oscillators:** Oscillators, Principle of oscillation, classification of oscillators, Condition for self sustained oscillation: Barkhausen criterion for oscillation, Tuned collector common emitter oscillator, Hartley oscillator, C.R.O. (Principle and Working).

**References:**


1. N.N.Bhargava. D.C. Kulshreshtha and S.C.Gupta, Basic Electronics and Linear Circuits by (TITI CHD).
2. J.P. Agarwal, Amit Agarwal, Solid State Electronics, Pragati Prakashan, Meerut).
3. J.D. Ryder, Electronics Fundamentals and Applications by (Prentice Hall of India).
4. B. L. Thereja, Solid State Electronics


**Course Outcome:** The knowledge of this course helps to understand the electronic applications of various materials, and to it is essential to understand the electronic circuit devices.

**Physics Lab –V** **2 Credits [0-0-3]**

1. Hysteresis (P-E)Loop Tracer
2. Ferromagnetic Curie Temperature Kit
3. Solar Cell Characteristic Kit
4. MOSFET Characteristics
5. Hartley –Colpitt Oscillator
6. LED Laser Diode

**Physics Lab –VI** **2 Credits [0-0-3]**

1. Planck’s Constant by Photoelectric Effect
2. e/m experiment by bar magnet method
3. Fermi energy experiment
4. To show the tunneling effect in tunnel diode using I-V characteristics.
5. To determine the wavelength of laser source using diffraction of single slit.
6. To determine the wavelength of laser source using diffraction of double slits

## SEMESTER-VI

**PAPER I:** **THERMAL PHYSICS** **4 Credits [3-1-0]**

**Course Objectives:** The objective of this course is to develop a working knowledge of the laws and methods of thermodynamics and elementary statistical mechanics and to use this knowledge to explore various applications.

**Module I**

Zeroth law and concept of temperature, First law and internal energy, Reversible and irreversible processes, Isothermal and Adiabatic processes (equation and work done), Second law, Carnot cycle and engine, Derivation of it's efficiency, Kelvin scale of temperature

**Module II**

Concept of entropy, Temperature-entropy diagram, Entropy of reversible and irreversible processes, Entropy of ideal and real gases, Third law of thermodynamics, Thermo dynamical potentials, Maxwell's relations, First latent-heat equation (Clausius-Claperyon equation), Second latent-heat equation, Joule-Kelvin effect

**Module III**

Critical phenomena, Critical constants, Triple point, Law of corresponding states Production of low temperature, Liquefaction of gases, Adiabatic demagnetization, application of low temperature physics – refrigerators and air-cooling machines

**Module IV**

Kinetic theory of gases, Postulates and calculation of pressure, Vanderwaal's equation, Brownian motion, Derivation of Avogadro's number, Mean free path, Transport phenomena in gases : Calculation of specific heat, Thermal conductivity and viscosity

**BOOKS:**

1. P. K. Chakrabarty : Advanced text book on heat
2. Zeemansky and P. K. Chakrabarty : Heat & Thermodynamics
3. Brijlal & Subramanyam: Heat and Thermodynamics
4. K. K. Sharma & B. S. Tayal : Thermal and Statistical Physics
5. J. B. Rajan : Heat and Thermodynamics

**Course Outcome:** Many of these applications will relate to topics in materials science and the physics of condensed matter.

## PAPER-II: PHOTONIC AND POWER DEVICES 4 Credits [3-1-0]

**Course Objectives:** This course covers the principles and fundamentals of photonic, and power devices and their applications. The objective is to provide students with the necessary basic understanding and knowledge in fiber optics, and power devices so that they will understand the theory and operation of electronic devices for applications in discrete and integrated analogue electronic circuits.

**Module –I** (PHOTONIC DEVICES)
Classification of photonic devices, Interaction of radiation and matter, Light Emitting Diodes- Construction, materials and operation, Semiconductor Laser- Condition for amplification, laser cavity, hetero structure and quantum well devices, Charge carrier and photon confinement, line shape function, Threshold current, Laser diode

**Module-II**
Photodetectors: Photoconductor. Photodiodes (p-i-n, avalanche) and Photo transistors, quantum efficiency and responsivity. Photomultiplier tube.
Solar Cell: Construction, working and characteristics
LCD Displays: Types of liquid crystals, Principle of Liquid Crystal Displays, applications, advantages over LED displays

**Module-III**
Introduction to Fiber Optics: Evolution of fiber optic system- Element of an Optical Fiber Transmission link- Ray Optics-Optical Fiber Modes and Configurations -Mode theory of Circular Wave guides- Overview of Modes-Key Modal concepts- Linearly Polarized Modes -Single Mode Fibers-Graded Index fiber structure

**Module-IV** (Power Devices)
Need for semiconductor power devices, Power MOSFET (Qualitative),Introduction to family of thyristors, Silicon Controlled Rectifier (SCR)- structure, I-V characteristics, Turn-On and Turn-Off characteristics, ratings, Gate-triggering circuits, Diac and Triac- Basic structure, working and V-I characteristics, Application of Diac as a triggering device for Triac.
Insulated Gate Bipolar Transistors (IGBT): Basic structure, I-V Characteristics, switching characteristics, device limitations and safe operating area (SOA)

**Suggested Books:**


1. J. Wilson & J.F.B. Hawkes, Optoelectronics: An Introduction
2. S.O. Kasap, Optoelectronics & Photonics, Pearson Education (2009)
3. AK Ghatak& K Thyagarajan, Introduction to fiber optics
4. Power Electronics, P.C. Sen, Tata McGraw Hill


**Course Outcome:** The course is crucial to the learning of state-of-the-art and future photonic, power devices and their applications. This course also serves as an introductory course to other more advance and specialized semiconductor and photonic courses.

**PAPER-III: PHYSICS OF MATERIALS 4 Credits [3-1-0]**

**Course Objectives:** The course provides the knowledge of various kinds of materials, their properties, and applications.

**Module I:**

**Introduction:** Classification of Materials, Properties of materials, Selection of Materials for device application, Material stability, Metastability and Unstability materials.

**Mechanical Properties of Materials:** Stress–strain behaviour, Elasticity and Plasticity, Resilience, Ductility and brittleness, Strength, Toughness, Hardness, Fracture.

**Module II:**

**Polymeric materials**: Types of polymers, Mechanism of polymerization, Mechanical behaviour of polymers, Fracture in polymers, Rubber types and applications, Thermosetting and thermoplastics, Conducting polymers.

**Ceramics:** Types, structure, properties and application of ceramic materials

**Module III**

**Composite Materials**: Microcomposites & Macrocomposites, fibre reinforced composites, Continuous fibre composites, Short fibre composites, Polymer matrix composites, Metal-matrix composites, Ceramic-matrix composites, Carbon-carbon Composites, Hybrid composites.

**Functionally Graded Materials:** Types, Processing methods, Applications.

**Module IV:**

**Liquid Crystals:** General structure of liquid crystals, Mesophase, Mesomorphism, Polymorphism of liquid crystals, Classification of liquid crystals and phases, Nematic, Smectic, Cholesteric phases, order parameter.

**Other materials:** Corrosion resistant materials, Nano phase materials, Shape memory alloy, SMART materials.

**Textbooks:**


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)
5. A. J. Dekker, Solid State Physics, Macmillan India Ltd. (2003)
6. N. W. Ashcroft, and N. D. Mermin, Solid State Physics, Saunders (1976)
7. S. Chandrasekhar, Liquid Crystals, Cambridge University Press (1994)


**Course Outcome:** The knowledge on physical properties of materials is helpful to understand/ design/ synthesize the new materials with potential applications.

## PAPER IV- PHYSICS OF MODERN SCIENCE **4 Credits [3-1-0]**

**Course Objectives:** This course introduces the physical aspects of modern science laws/ concepts, and introduces new parameters in terms of physics.

**Module I**

**Introduction**: Plasma – The fourth state of matter, Debye shielding, Plasma frequency, Collective behaviour, Quasi- neutrality, Plasma criteria, Concept of temperature, plasma sheath

**Plasma Production**: Break down of gases in DC and RF field, V-I characteristic of discharge, Paschen curve, Glow and Arc discharge

**Plasma Applications:** Controlled thermo-nuclear fusion, Space & Astrophysics, MHD energy conversion, solid sate plasma, Gas lasers, Industrial applications of plasma

**Module II**

X-rays and X-ray Spectra: Production of X-rays, reflection and refraction of X-rays, Continuous X-ray spectrum, Characteristic emission spectrum, Characteristic absorption spectrum, Comparison of Optical and X-ray spectra, Molseley's law and its applications, monochromatization of X-rays, explanation of emission and absorption spectra, fine structure of X-ray levels, the fluorescence yield and Auger effect, detection and determination of relative intensity of X-rays.

**Module III**

Lasers Introduction, Characteristics of lasers, Einstein's coefficients & Relation between them, Lasing action, Population inversion, Different types of Lasers (Ruby Laser,He-Ne Laser), Three and Four level pumping schemes, Applications of LASER(elementary ideas) Fiber optics Introduction, Principle of wave propagation in Optical Fiber, Structure of Optical Fiber, Types of Optical Fibers, Acceptance angle and acceptance cone, Numerical aperture, Applications of optical fibers in communications

**Module IV**

Physics of Vision and Hearing senses: Structure of the eye, Optics of Vision: refraction, refractive errors, visual acuity, monocular & binocular vision, size of image, role of ocular lens, retinal pigments, rods and cones, Photochemistry of vision, visual cycle. Structure of ear, physics of audition (amplitude, frequency, pitch), unit of measurement of sound, intensity, conduction of sound through bone ossicles, impedance matching. Role of inner ear (cochlear mechanism), mechanisms of hearing, detection of localization of sound (direction), loudness of sound (amplitude), discrimination of pitch of sound, Audiometry, deafness, hearing aids.

**Reference Books**:


1. Introduction to Plasma Physics and Controlled Fusion, Francis F. Chen, Plenum Press (1984)
2. Fundamentals of plasma physics, J. A. Bittencourt, Springer-Verlag New York Inc. (2004)
3. The Fourth state of matter- Introduction to plasma science, S. Eliezer and Y. Eliezer, IOP Publishing Ltd. (2001)
4. Elementary plasma physics, L.A. Arzimovich, Blaisdell Publishing Company (1965)

5. Plasmas–The fourth state of Matter D. A. Frank-Kamenetskii, Macmillan Press (1972)

**Course Outcome:** The course provides the knowledge on new parameters based on which new devices with more efficiency can be fabricated.

**PAPER V: DIGITAL SYSTEMS AND APPLICATIONS 4 Credits [3-1-0]**

**Course Objectives:** The students will learn how to analyze and design basic digital circuits.

**Module I:**

**Introduction to CRO:** Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of aveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

**Integrated Circuits** (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification ofICs. Examples of Linear and Digital lCs.

**Module II:**

**Digital Circuits:** Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

**Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

**Module III:**

**Data processing circuits**: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

**Arithmetic Circuits:** Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor

**Module IV:**

**Sequential Circuits:** SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops.Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

**Reference Books:**


1. A.P. Malvino, D.P.Leach and Saha, Digital Principles and Applications, 7th Ed, Tata McGraw Hill (2011)
2. Anand Kumar, Fundamentals of Digital Circuits, 2nd Edn, PHI Learning Pvt. Ltd. (2009)
3. Venugopal, Digital Circuits and systems, Tata McGraw Hill (2011)
4. G K Kharate, Digital Electronics, Oxford University Press (2010)
5. R.J.Tocci, N.S.Widmer, Digital Systems: Principles & Applications, PHI Learning (2001)
6. Shimon P. Vingron, Logic circuit design, Springer (2012)
7. SubrataGhoshal, Digital Electronics, Cengage Learning (2012)
8. S.K. Mandal, Digital Electronics, 1st edition, McGraw Hill (2010)


**Course Outcome:** Students will be able to analyze basic combinational logic and synchronous sequential circuits. • Students will be able to build, test, and debug logic circuits. • Students will be able to design basic combinational logic and synchronous sequential circuits.

## Physics Lab VII

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using (1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.
8. To determine J by Caloriemeter.

## Physics Lab VIII

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To design a switch (NOT gate) using a transistor.
3. To verify and design AND, OR, NOT and XOR gates using NAND gates.
4. To design a combinational logic system for a specified Truth Table.
5. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
6. To minimize a given logic circuit.
7. Half Adder, Full Adder and 4-bit binary Adder.
8. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
9. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
10. To build JK Master-slave flip-flop using Flip-Flop ICs
11. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
12. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
13. To design an astable multivibrator of given specifications using 555 Timer.
14. To design a monostable multivibrator of given specifications using 555 Timer.

**MPH-** **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, Invariant tori, 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- 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 and inhomogeneous 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 –Dirac delta 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 Edition Naros, (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's Series, McGraw Hill.


**Course Outcome:** The course is helpful to apply the various mathematical concepts, techniques and essential tools for the studies of quantum physics.

**MPH- 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: wave functions, 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- 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 indices and reciprocal lattice; Structure determination; diffraction: X-ray, electron and neutron; Crystal binding; Defects in crystals; Point and line defects.

**Module-II**

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

**Module -III**

**Electronic properties**: Free electron theory of metals; electrons in a periodic potential; Bloch equation; 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 II superconductors; 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, Solid State 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- 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.

**M.Sc. Lab-1 General Physics 2 Credits [0-0-3]**

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 semiconductors 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-** **Statistical Mechanics** **[4 0 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: T**hermodynamics, 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- 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- Quantum Mechanics-II [4 0 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-Oppen Heimer 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 2$^{nd}$ edition, 2009.


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

## MPH- Basic Electronics [4 0 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/D converter and D / A converter, 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- 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 LabII** **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-** **Computer Programming Lab** **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 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, Lienard Wiechert 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 form of Maxwell's equations, Transformation laws and their physical significance, relativistic generalization of Larmor's formula, Relativistic formulation of field 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-** **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:** The course is helpful to apply the various mathematical concepts, techniques and essential tools for the study of quantum physics.

## MPH- Condensed Matter Physics-II [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**

**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 (Cambridge University Press,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 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 fields helps the concept of binding of atoms into molecules, molecular degrees of freedom (electronic, vibrational, and rotational), elementary group theory considerations and molecular spectroscopy.

**MPH-** **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** **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 Aluminum using G.M Counter.
8. Characteristics of G.M. counter.
9. Study of surface barrier detector.
10. Frank-Hertz Experiment
11. Polarimeter Experiment

## MPH- 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 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 behavior 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 Introduction to the theory of nonlinear dynamical systems
**3 1 0 4**

**Course Objectives:** The course aims to introduce the 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 logistic map, Iterations of maps, numerical computations

**Module II**

Saddle-Node bifurcation, Trans critical bifurcation, Pitchfork bifurcation, Hopf bifurcation, 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 — 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** **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 based on 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 characteristics, junction breakdown, carrier injuction under forward bias, current continuity equation, excess carrier in forward biased, I-V characteristic, Introduction to BJT, collector and base current, current gain, 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:** The students are expected to have the knowledge about the basic materials and properties of semiconductors with application to various circuits and devices.

## Elective    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, 5$^{th}$ Edition John Wiley (2000)
2. V. Raghavan, Materials Science and Engineering, 4$^{th}$ Edition, Prentice Hall India (1991)
3. C. Kittel, Introduction to Solid State Physics, 7$^{th}$ 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** **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 linear Lagrangians, Fermions in an External Field, Interaction of Electrons with the Radiation Field: Quantum Electrodynamics (QED): The Lagrangian and the Hamiltonian Densities, Equations of Motion of 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:** The course is expected to identify, understand, design, set up, and carry out the various physical phenomena to provide the theoretical predictions.

## Elective Crystallography [4 0 0 4]

**Course Objectives:** To understand 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 International Publisher.
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:** The following 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.

**M.Sc Lab-IV** **Advanced Physics Lab** **[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 microprocessors
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)