Master of Science

In

Physics

Course Structure & Syllabus

Department of Physics

National Institute of Technology Hamirpur

Hamirpur (HP) – 177005, India

Course Structure of M. Sc. in Physics

SEMESTER-I

Sr. No	Course No.	Course Name	Teaching Schedule			Hours /week	Credit
			L	T	P		
1	PH-611	Classical Mechanics	4	0	0	4	4
2	PH-612	Quantum Mechanics - I	4	0	0	4	4
3	PH-613	Mathematical Physics	4	0	0	4	4
4	PH-614	Electrodynamics	4	0	0	4	4
5	PH-615	Atomic and Molecular spectroscopy	4	0	0	4	4
6	PH-616	Electricity and Optics Lab	0	0	4	4	2
7	PH-617	Spectroscopy Lab	0	0	4	4	2
8	PH-618	Computer Programming Lab	0	0	2	2	1
		Total =	**20**	**0**	**10**	**30**	**25**

SEMESTER-II

Sr. No	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	PH-621	Quantum Mechanics – II	4	0	0	4	4
2	PH-622	Electronics	4	0	0	4	4
3	PH-623	Thermodynamical and Statistical Physics	4	0	0	4	4
4	PH-624	Solid State Physics	4	0	0	4	4
5	PH-7MN	Programme Elective -I	4	0	0	4	4
6	PH-625	Solid State Physics Lab	0	0	2	2	1
7	PH-626	Computational Physics Lab	0	0	4	4	2
8	PH-627	Measurement and Instrumentation Lab	0	0	4	4	2
		Total =	**20**	**0**	**10**	**30**	**25**

Programme Elective –I: : List of Programme Electives is given in the Annexure.

SEMESTER-III

Sr. No	Course No.	Course Name	Teaching Schedule			Hours /week	Credit
			L	T	P		
1	PH-631	High Energy Physics	4	0	0	4	4
2	PH-632	Nuclear Physics	4	0	0	4	4
3	PH-7MN	Programme Elective-II	4	0	0	4	4
4	XY-8MN	Open Elective-I	4	0	0	4	4
5	PH-633	Numerical Analysis Lab	0	0	4	4	2
6	PH-634	Electronics Lab	0	0	4	4	2
7	PH-635	Fabrication and Assembly Lab	0	0	2	2	1
		Total =	**16**	**0**	**10**	**26**	**21**

Programme Elective –II: List of Programme Electives is given in Annexure.
Open Elective – I: List of Programme Electives is given in Annexure.

SEMESTER-IV

Sr. No	Course No.	Course Name	Teaching Schedule			Hours/ week	Credit
			L	T	P		
1	PH-7MN	Programme Elective - III	4	0	0	4	4
2	PH-7MN	Programme Elective - IV	4	0	0	4	4
3	XY-8MN	Open Elective-II	4	0	0	4	4
4	PH-851	Seminar	-	-	-	-	1
5	PH-699	M.Sc. Project Work	0	0	0	-	6
		Total =	**12**	**0**	**0**	**12**	**19**

Programme Elective –III & IV: List of Programme Electives is given in Annexure.
Open Elective – II: List of Programme Electives is given in Annexure.

Total Credit of the Programme = 25 + 25 + 21 + 19 = 90

Annexure

List of Programme Electives and Open Electives

Programme Elective-I

Code No.	**Subject Name**	L-T-P	Credits
PH-701	Experimental Techniques in Physics	4-0-0	4
PH-702	Nuclear Detectors and Accelerator Physics	4-0-0	4
PH-703	Thin Film Technology	4-0-0	4

Programme Elective-II

PH-706	Optical Fiber Communication	4-0-0	4
PH-707	Polymer & Liquid Crystals	4-0-0	4
PH-708	Opto Electronics	4-0-0	4

Programme Elective-III

PH-711	Physics of Nano-systems	4-0-0	4
PH-712	Nano-structured Materials	4-0-0	4
PH-713	Plasma Physics	4-0-0	4
PH-714	Solar and Astrophysics	4-0-0	4

Programme Elective-IV

PH-716	Quantum Computing	4-0-0	4
PH-717	Quantum Field Theory	4-0-0	4
PH-718	Quantum Optics	4-0-0	4
PH-719	Atmospheric and Space Physics	4-0-0	4

Open Elective Courses

Code No.	**Subject Name**	**L-T-P**	**Credits**
PH-881	Nuclear Science and Applications	4-0-0	4
PH-882	Nano Technology	4-0-0	4
PH-883	Properties of Matter	4-0-0	4

Course Name: **Classical Mechanics**
Course Code: **PH-611**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the limitations of Newtonian Mechanics and alternate formalism of Lagrange and Hamilton.
- To introduce the fundamental concepts of Lagrangian, and Hamiltonian Formalism, Planetary motion and motion in a central force field.
- To enable the students to understand the advantages of using Hamilton's principle, Lagrangian formalism and canonical transformations.

Course Content

Lagrangian Mechanics: Newton's laws of motion, mechanics of a system of particles, constrain, D'Alembert's principle and Lagrange equations of motion. Velocity dependent potentials and dissipation function. Some applications of Lagrangian formulation, Hamilton's principle, derivation of Lagrange equations from the Hamilton's principle. Conservation theorems and symmetry properties.
Central Force Problem : Two body central force problem, reduction to equivalent one body problem, the equation of motion and first integrals, the equivalent one dimensional problem and classification of orbits. The differential equation for the orbit and integrable power-law potential. The Kepler problem. Scattering in a central force. Rigid Body Dynamics**:** The independent coordinates of a rigid body, orthogonal transformations, the Euler's angles. Euler's theorem on the motion of rigid body, finite and infinitesimal rotations, rate of angular momentum and kinetic energy about a point for a rigid body, the inertia tensor and moment of inertia, the eigenvalues of moment of the inertia tensor and the principal axes transformation. Euler's equations of motion, torque free motion of a rigid body. Canonical Transformations: Legendre transformation and Hamilton's equations of motion, cyclic coordinates and conservation theorems, derivation of Hamilton's equations from a variational principle, the principle of least action. The equation of canonical transformations, examples of canonical transformations, Poisson brackets. Equations of motion, infinitesimal canonical transformation and conservation theorems in the Poisson bracket formulation. Hamilton-Jacobi Theory: The Hamilton-Jacobi equation for Hamilton's Function, The harmonic Oscillator Problem as an example of the Hamilton-Jacobi method.

Course Outcomes

CO1: Identify the role of virtual work, Lagrange's and Hamilton's approach to the mechanics.
CO2: Describe problems like planetary motion, motion of a rigid body, motion in a central force field.
CO3: Apply principles to solve problems involving constraints, central force field and rigid body.
CO4: Assess the results usefulness of the non Newtonian formalism of doing mechanics.

Books and References

1. Classical Mechanics by Goldstein H, Narosa Publishing House, New Delhi.
2. Mechanics by Landau L D and Lifshitz E M, Pergamon Press, Oxford.
3. Classical Mechanics by Aruldhas G, PHI Learning Pvt. Ltd., Delhi.
4. Classical Mechanics by Rana N C and Joag P S, Tata McGraw-Hill Publishing Co. New Delhi.
5. Classical Mechanics by Shankara Rao, Prentice Hall of India, New Delhi.

Course Name: **Quantum Mechanics-I**
Course Code: **PH-612**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To study the basic principles of quantum mechanics.
- Explain the operator formulation of quantum mechanics.
- An understanding of concepts of angular momentum.
- Learn how to solve the Schrödinger's equation for spinless particles moving in three-dimensional potential.

Course Content

Mathematical Tools of Quantum Mechanics: Vector spaces, Schwarz's inequality, Orthonormal basis, Schmidt orthonormalisation method, Operators, Projection operator, Hermitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors, Dirac's bra and ket notation, commutators, Simultaneous eigenvectors, uncertainty relation. Postulates of Quantum Mechanics: The Basic Postulates of Quantum Mechanics, The State of a System, Observables and Operators, Measurement in Quantum, Time Evolution of the System's State, One-dimensional Problems: Introduction, Properties of One-Dimensional Motion, Free Particle: Continuous States, The Potential Step, The Potential Barrier and Well. Angular Momentum: Orbital angular momentum, General Formalism of Angular Momentum, Spin Angular Momentum, Eigen functions of Orbital Angular Momentum, coupling of angular momenta, Clebsch-Gordon Coefficients.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Study quantum mechanics using mathematical machinery.

CO2: Extract quantitative information about microphysical systems.

CO3: Apply it to study physical systems by solving the Schroedinger's equation.

CO4: Describe the dynamics of systems that move under the influence of spherically symmetric potential.

Books and References

1. Quantum Mechanics Concepts and Applications by Nouredine Zettili, John Wiley and Sons, Ltd. Publication.
2. Principles of Quantum Mechanics by R. Shankar, Plenum-New York.
3. Quantum Mechanics: Theory and Applications by Ghatak A and Lokanathan S, Kluwer Academic Publishers.
4. Introduction to Quantum Mechanics by Griffiths, D. J., Pearson India Education service Pvt. Ltd.

Course Name: **Mathematical Physics**
Course Code: **PH-613**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To introduce students to methods of mathematical Physics and develop required mathematical skills.
- To solve problems in quantum mechanics, electrodynamics and other fields of theoretical Physics.

Course Content

Differential Equations: Second order differential equation, Frobenius method, Wronskian and a second solution, The Sturm Lioville problem, Laplace equation, Possion equation, Boundary value problem. Partial differential equation: Hyperbolic equations, One-dimensional wave equation, Higher dimensions, method of Riemann, Initial-boundary value problems, Oscillation of a string, Oscillation of a membrane, Inhomogeneous wave equation.Laplace transforms: Definitions, Conditions of existence, functions of exponential orders, Laplace transform of elementary functions, Basic theorems of Laplace transforms, Laplace transform of special functions, Inverse Laplace transforms, its properties and related theorems, convolution theorem, use of Laplace transforms in the solution of deferential equation with constant and variable coefficients and simultaneous differential equations. Fourier Series & Transformation: Fourier decomposition, Fourier series, and convolution theorem. Fourier transformations and its application to wave theory. Special Functions: Gamma function, the exponential integral and related functions, Bessel functions of the first and second kind, Legendre polynomials, associated Legendre polynomials and spherical harmonics, Generating functions for Bessel, Legendre and associated Legendre functions.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify system properties based on impulse response and Fourier analysis.

CO2: Solve first order ordinary differential equation.

CO3: Solve higher order linear ordinary differential equation with constant coefficients.

CO4: Solve linear differential equations using Laplace transforms.

CO5: Apply basic science and mathematics to analyze complex engineering problems.

Books and References

1. Mathematical Methods for Physicists by George Arfken, Academic Press, San Diego, U.S.A.
2. Mathematical Methods for Physicists and Engineers by Harvil and Pipes L.A,Tata McGraw-Hill Publishing Company, New Delhi.
3. Mathematical Physics by Rajput B.S. Pragati Prakashan, Meerut.
4. Laplace Transforms by Speigal M.R., Schaum Series Tata McGraw-Hill Publishing Company, New Delhi.
5. Advanced Engineering Mathematics by Kreyszig E., John Wiley & Sons, New York.
6. Matrices and Tensors in Physics by Joshi A.W., New Age International Publishers, New Delhi.

Course Name: **Electrodynamics**
Course Code: **PH-614**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the Electric field, Magnetic field, and Electromagnetic theory.
- To introduce the fundamental concepts relevant to energy transfer, reflection, refraction of electromagnetic waves across the interface.

Course Content

Electrostatics: Work and Energy in electrostatics, Poisson and Laplace equations, Earnshaw’s theorem, Boundary conditions and Uniqueness theorem, Multipole expansion, Method of electrostatic images. Magnetostatics: Magnetic scalar and vector potentials, magnetic field vector and Boundary conditions, Maxwell’s modification of Ampere’s law. Time Varying Fields: Continuity equation, Maxwell’s equations, wave equation in free space. Poynting theorem and Poynting vector, Electromagnetic scalar and vector potential, Gauge transformations; Lorentz invariance of Maxwell’s equations. Electromagnetic Waves: Plane waves in non-conducting and conducting media, skin depth, polarization- linear and circular polarization, Reflection and refraction of electromagnetic waves across a dielectric interface at a plane surface between dielectrics. Total internal reflection, Polarization by reflection, Reflection from the surface of a metal. Electromagnetic Radiation: Radiation from moving charges and dipoles, Retarded Potentials, Lienard-Wiechert Potentials, Transmission lines and waveguides. Dispersion relation in plasma.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Gain understanding of Maxwell’s equations & electromagnetic boundary conditions.

CO2: Understanding the phenomenon of reflection, refraction and polarization.

CO3: Distinguish between a good metal and a good dielectric.

CO4: Grasp idea of electromagnetic wave propagation through space and wave guides.

Books and References

1. Classical Electrodynamics by Jackson J.D., John Wiley & Sons Pvt. Ltd., New York.
2. Introduction to Electrodynamics by Griffiths D.J., Pearson Education Pvt. Ltd., New Delhi.
3. Classical Electromagnetic Radiation by Marian J.B and Heald M.A., Academic Press, New Delhi.
4. Classical Electrodynamics by Puri S.P. Tata McGraw-Hill Publishing Company, New Delhi.
5. Electromagnetic Waves and Radiating Systems by Jordon E.C. and Balmain K.G., Prentice Hall of India, New Delhi.

Course Name: **Atomic and Molecular Spectroscopy** Course Code: **PH-615** Course Type: **Core**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the fundamentals of atomic and molecular Physics of the systems.
- To introduce about how to describe the structure of atoms and molecules on the basis of quantum mechanics.
- To introduce about the Physics of spectra of alkali elements, two-electron systems, various coupling schemes, diatomic molecules, their electronic states, vibrations and rotations, their spectra and a brief discussion of polyatomic molecules.
- To introduce about the behavior of atoms in external electric and magnetic fields.
- To introduce about the fundamentals of Raman spectroscopy and its application for the structure determination of molecules.

Course Content

Quantum States of One Electron Atom: Atomic orbitals -Hydrogen spectrum – The Pauli Exclusion Principal – Ritz combination principle, Spectra of alkali elements, Spin – orbit interaction; Larmor's theorem and the fine structure in alkali spectra – Equivalent and non-equivalent electrons-penetrating and non-penetrating orbits, quantum defect and screening parameter, selection rules and intensity rules, breadth of the spectrum-Doppler effect, Natural breadth, external effects. Two Electron Systems: General characteristics of the energy levels of alkaline earth elements; selection rules and intensity rules, Interaction energy in LS or Russell-Saunder's coupling and JJ-coupling, LS-coupling, Hyper fine structure (qualitative) Normal and Anomalous Zeeman effect, Paschen Back effect, Stark effect, Lande's g-factor in LS coupling. Molecular Structure: Types of molecules - Diatomic linear symmetric top, asymmetric top and spherical top molecules, Types of molecular energy states and molecular spectra, Born Oppenheimer approximation-Rotational Spectra, Spectra of diatomic molecules as a rigid rotator-Energy levels and spectra, diatomic molecules as a non rigid rotor. Vibrational Spectra: Vibrational energy of a diatomic molecule as a simple harmonic oscillator – Energy levels and spectrum, Vibrating molecule as an-harmonic oscillator– Morse potential energy curve - Molecules as vibrating rotator – Vibration spectrum of diatomic molecule – PQR branches IR spectrometer (qualitative). Raman Spectroscopy: Raman effect - Quantum theory, Pure rotational spectra of diatomic molecules – Vibration rotation Raman spectrum of diatomic molecules – Experimental set up for Raman spectroscopy – Application of IR and Raman spectroscopy in the structure determination of simple molecules, Franck Condon principle.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the atomic spectra of one and two valance electron atoms.
CO2: Explain the change in behavior of atoms in external applied electric and magnetic field.
CO3: Explain rotational, vibrational, electronic and Raman spectra of molecules.
CO4: Apply these concepts to understand the structure of molecules.

Books and References

1. Introduction to Atomic Spectra by H.E. White, Tata Mcgraw Hill.
2. Fundamentals of molecular spectroscopy by C.B. Banwell & E. M. McCash, Tata Mcgraw Hill.
3. Spectroscopy Vol. I, II & III by Walker & Straughen, Springer.
4. Introduction to Molecular spectroscopy by G.M. Barrow, Tata Mcgraw Hill.

Course Name: **Electricity and Optics Lab**
Course Code: **PH-616**

Contact Hours/Week: **4P** Course Credits: **02**

Course Objectives

- To make students aware of instrument handling.
- To make students learn experimental skills.
- Make students capable to work in groups.

List of Experiments

1. To find the wavelength of light by Newton's ring method.
2. To find the wavelength of light using the Diffraction grating.
3. To find the refractive index of the material of the prism using a spectrometer.
4. Variation of the magnetic field along the axis of a current carrying coil and hence find the radius of the coil.
5. To estimate the resistivity of semiconductor crystal by four probe method.
6. Conversion of galvanometer to Voltmeter & Ammeter.
7. To verify the inverse square law of magnetism.
8. Realization of hysteresis loop of magnetic material.
9. To study the interference pattern using Michelson interferometer and estimate wavelength of light.
10. To study the polarization of light and find a Brewster's angle.
11. To study the interference phenomenon using a Fresnel Biprism setup.
12. To study the optical fiber parameter.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: To realize the behavior of light.

CO2: To study magnetic phenomenon in solids.

CO3: Study of optical fiber parameter.

CO4: Design apparatus for electrical study.

CO5: Understand various physical phenomenon.

Course Name: **Spectroscopy Lab** Course Code: **PH-617**
Contact Hours/ Week: **4P**   Course Credits: **02**
Course Objectives • To make students aware of instrument handling. • To make students learn experimental skills. • Make students capable to work in groups.
List of Experiments 1. NMR spectroscopy of selected materials. 2. To measure Landau's g-factor using electron spin resonance. 3. Optical absorption spectra of materials, estimation of (direct / indirect) band-gap. 4. To verify the existence of discrete atomic energy levels and determine the minimum excitation energy of argon using Frank Hertz apparatus. 5. To determine electronic charge to mass ratio by Millikan's oil drop method. 6. To find ionization potential of mercury. 7. Raman spectrometer: Stokes and anti-Stokes lines. 8. Rydberg constant: Hydrogen spectrum – different series. 9. To study the Zeeman effect. 10. To determine the dielectric constant of solid. 11. New experiments will be incorporated time to time.
Course Outcomes Upon successful completion of the course, the students will be able to CO1: To study the spectroscopic behavior of materials. CO2: Understand nature of atomic energy levels. CO3: To study dielectric properties. CO4: Understand various physical phenomena.

Course Name: **Computer Programming Lab**
Course Code:**PH-618**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To make students aware of working with computer.
- To make student learn computer programming.
- To make students capable to solve problems using computer programing.

List of Experiments

1. To familiarize with computer and aware with programming software MATLAB etc..
2. To familiarize with basic commands.
3. To learn defining variables and assign values using input commands.
4. To learn loop commands for repeated calculations.
5. To learn programs related to functions
6. To learn the commands to break the operation inside loop.
7. To learn plotting of graphs.
8. To learn printing of the calculated data on screen in different formats.
9. To perform matrix operations.
10. To read data from input file and assign values to the variables.
11. To learn saving calculated data in output files for later use.
12. To learn plotting 3-D graphs.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Learn programming language.

CO2: Solve problems using computers.

CO3: Design solution to any physical problem.

CO4: Analyse physical problems from obtained output.

Course Name: **Quantum Mechanics-II** Course Code: **PH-621** Course Type: **Core**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the approximation methods that deal with stationary states corresponding to time-independent Hamiltonians.
- To study the structure of molecules and atomic systems and to know how electromagnetic radiation interacts with these systems.
- To enable the students to extract the structure of matter from the scattering of particles.

Course Content

Approximate Methods: WKB approximation, WKB expansion, connecting formulas, variational principle and its application to Helium atom and hydrogen molecule. Time-Independent Perturbation Theory: Fine structure of Hydrogen atom, Zeeman Effect, Time-Dependent Perturbation Theory, Two level system, emission and absorption of radiation. Scattering Theory: Scattering amplitude, differential and total cross-section, Scattering Amplitude of Spinless Particles, the Born approximations scattering by a central potential, method of partial waves, optical theorem. Dirac Equation: Free Particle Dirac Equation, Electromagnetic interaction of Dirac Particle, More on relativistic quantum mechanics. Quantum Computation: Quantum bits, Bloch sphere representation of a qubit.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Solve problems using perturbation theory.

CO2: Describe the principles of scattering theory.

CO3: Describe the fundamental of the quantum computing.

CO4: Solve conceptual and mathematical problems associated with the topics covered in Quantum Mechanics.

Books and References

1 Quantum Mechanics by Schiff L.I., McGraw Hill Book.
2 Quantum Mechanics by Merzbacher E, John Wiley & Sons.
3. Quantum Mechanics Concepts and Applications by Nouredine Zettili, John Wiley and Sons, Ltd. Publication.
4. Principles of Quantum Mechanics by R. Shankar, Plenum-New York.
5. Quantum Mechanics: Theory and Applications by Ghatak A and Lokanathan S, Kluwer Academic Publishers.
6. Introduction to Quantum Mechanics by Griffiths, D. J., Pearson India Education Pvt. Ltd..
7. Quantum Computer Science: An Introduction by N. David Mermin, Cambridge University Press.

Course Name: **Electronics**
Course Code: **PH-622**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the basic semiconductor devices, operational amplifier and communication systems.
- To introduce the fundamental concepts relevant to homo, hetro-junctions, electronic circuits, and different modulation techniques used in communication.
- To enable the students to understand the factors that required for the operation as well as control of electronic, optoelectronic devices.

Course Content

Semiconductor Devices: Diodes, Junctions, Transistors, Field effect devices, homo- and hetro-junctions devices, device structure, device characteristics, frequency dependences and applications. Optoelectronic Devices: LEDs, Diodes Lasers, Photodetectors and Solar Cells, Electronic Circuits: Differential amplifier, Operational amplifier OP-AMP as inverting, Non-inverting, Scalar, Summer, Integrator, Differentiator, Schmitt trigger and Logarithmic amplifier, Digital techniques and applications as resistors, counters, comparators and similar circuits. Convertors and Vibrators: A/D and D/A convertors, applications. Transducers. Microprocessors and microcontroller basics. Multivibrators (Bistable, Monostable, Astable), Modulation Techniques: Basic concepts of communication systems, Need for modulation, Information in communication system, Coding, Types of Pulse modulation, Pulse width modulation (PWM), Pulse position Modulation (PPM), Principle of Pulse code modulation (PCM).

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify and Characterize semiconductors, diodes, transistors and operational amplifiers.
CO2: Bias the transistors and FETs for amplifier applications.
CO3: Design op-amp circuits to perform arithmetic operations.
CO4: Design simple analog circuits.
CO5: Understand fundamental principles of communication system.

Books and References

1. Mathematical Methods for Physicists by George Arfken, Academic Press, San Diego, U.S.A
2. Mathematical Methods for Physicists and Engineers by Harvil and Pipes L.A,Tata McGraw-Hill Publishing Company, New Delhi.
3. Mathematical Physics by Rajput B.S. Pragati Prakashan, Meerut.
4. Laplace Transforms by Speigal M.R., Schaum Series Tata McGraw-Hill Publishing Company, New Delhi.
5. Advanced Engineering Mathematics by Kreyszig E., John Wiley & Sons, New York.
6. Matrices and Tensors in Physics by Joshi A.W., New Age International Publishers, New Delhi.

Course Name: **Thermodynamics and Statistical Physics**
Course Code: **PH-623**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the fundamentals of thermodynamics and statistical mechanics.
- To introduce the fundamental concepts relevant to thermodynamic potentials, probability, classical and quantum statistics.
- To enable the students to understand the statistical basis of thermodynamics and its applications to magnetism, black body radiation and phase transition.

Course Content

Thermodynamics: Macroscopic and microscopic coordinates, Extensive and intensive variables,Thermal equilibrium**,**The laws of thermodynamics and their consequences, Thermodynamic potentials and Maxwell's relations, Chemical Potential, TdS and energy equations. Probability and Kinetic theory: The macroscopic and microscopic states, Postulate of equal a priori probability, Probability densities, contact between statistics and thermodynamics, classical ideal gas, Gibbs' paradox, Phase space densities; Liouville's theorem and its consequences, The Boltzmann equation; transport phenomena. Classical Statistical Mechanics: Postulates; Microcanonical, canonical, and grand canonical ensembles, partition functions, fluctuation of energy and density, Equipartition and virial theorems, Ideal gas in canonical and grand canonical ensemble. Quantum Statistical Mechanics: Quantum-mechanical ensemble theory, Introduction to density matrix and its applications, Microcanonical ensemble of ideal Bose, Statistics of the occupation numbers, Statistical mechanics of Bosons, Fermions, Bose-Einstein condensation, Blackbody radiation and Planck's law of radiation, Magnetic behavior of an ideal Fermi gas, Diamagnetism, Paramagnetism. Phase Transition and critical phenomenon: First and second order phase transitions, Ising model, Critical phenomena, Landau theory of phase transitions.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the link between statistics and thermodynamics, classical and quantum statistics and its applications.

CO2: Describe problems like ideal gas, transport phenomenon, critical phenomenon and black body radiation.

CO3: Apply principles to explain Gibbs'paradox, magnetism and phase transitions.

CO4: Assess the results obtained by solving above problems.

Books and References

1. Heat and Thermodynamics by Zemansky M. W. and Dittman R., Mc Graw Hill Co., NewYork.
2. Statistical Mechanics by Patharia R.K, Pergamon, Oxford.
3. Statistical Mechanics by Huang K., Wiley Eastern, New Delhi.
4. Elementary Statistical Physics by Kittel C., Wiley Eastern, New Delhi.
5. Statistical Mechanics by Agarwal B.K. and Eisner M, Wiley Eastern, New Delhi.
6. Introduction to Modern Statistical Mechanics by Chandler D., Oxford University Press, New Delhi.

Course Name: **Solid State Physics**
Course Code: **PH-624**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the solid state of the materials.
- To introduce the fundamental concepts relevant to crystal structure, phonon gas and the electron gas in solids, dielectrics and semiconductors.
- To enable the students to understand the factors that affect thermal, electrical and dielectric behavior of solids.

Course Content

Crystal structure and Defects: Bravais lattice, lattice planes and miller indices, reciprocal lattice, Diffraction conditions, Brillouin zones, Atomic Structure factor; types of crystal binding, cohesive energy of ionic crystals. Point defects: Schottky and Frenkel vacancies, Color centers, *F*-centers. Line defects (dislocation): Edge and Screw dislocation, Burger's vector, Slip, Planar (stacking) faults: Grain boundaries: Low angle grain boundaries. Elastic and Thermal Properties: Introduction, Analysis of Stress- strain relations, Elastic Compliance and Stiffness Constants, Elastic Waves in Cubic Crystals. Phonon heat capacity, Density of states, Debye and Einstein theory of specific heat, Lattice Thermal Conductivity and Umklapp Processes, specific heat of metals. Semiconductors: Direct and Indirect Absorption Processes, Equations of motion, effective mass, intrinsic carrier concentration, impurity conductivity, Cyclotron resonance and Magnetoresistance in semiconductors. Fermi Surfaces and Metals: Zone schemes, Fermi surfaces; Hall Effect, Electron, Hole and Open orbits, Quantization of orbits in a magnetic field, the de Hass-van Alphen Effect, External orbits. Dielectrics: Macroscopic field, The local field, Lorentz field, The Claussius- Mossotti relation, different contributions to polarization: dipolar, electronic and ionic polarizabilities.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of crystallography, different theories of heat and electric conduction, dielectrics, semiconductors.

CO2: Describe problems like basic crystals, dependence of heat capacity and thermal conductivity with temperature, Fermi surfaces in description of electric and magnetic properties of solids, conduction in semiconductors.

CO3: Apply principles to determine crystal structure, thermal behavior of solids, dielectric, magnetic and electric behavior of solids.

CO4: Assess the results obtained by solving above problems

Books and References

1. Introduction to Solid State Physics by Kittle C, John Wiley & Son.
2. Solid State Physics by Dekkar A J, Macmillan India Ltd., New Delhi.
3. Introduction to Solids by Azaroff L V, Tata McGraw-Hill, New Delhi.
4. Solid State Physics by Ashcroft N W and Mermin N D, Thomson Asia Pte. Ltd.
5. Solid State Physics by Singh, R.J., Pearson, Press.

Course Name: **Solid State Physics Lab** Course Code: **PH-625**
Contact Hours/Week: **4P** Course Credits: **02**
Course Objectives • To make students aware of instrument handling. • To make students learn experimental skills. • Make students capable to work in groups.
List of Experiments 1. Curie temperature of a ferrite: Inductance technique. 2. Magnetic susceptibility measurement using Quincke's Method. 3. Electrical conductivity by two and four probe method of semi conducting crystals. 4. Band gap studies of LEDs using Newton's ring method. 5. Hall effect: estimation of carrier concentration, Hall voltage and carrier mobility. 6. X-ray diffraction: estimation of crystallographic parameters. 7. More experiments to be incorporated.
Course Outcomes Upon successful completion of the course, the students will be able to CO1: To realize the behavior of magnetic materials CO2: To study magnetic phenomena in solid. CO3: Study of solid properties. CO4: Understand various physical phenomenon.

Course Name: Computational Physics Lab
Course Code: PH-626

Contact Hours/Week: 4P	**Course Credits: 02**

Course Objectives

- To make students aware of computational techniques.
- To make students learn to solve physical problems.
- Make students capable to work in groups to solve common problems.

List of Experiments

1. Motion of particle in a central force field and plot the output for visualization.
2. The Motion of a projectile using simulation and plot the output for visualization.
3. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
4. The Plotting trajectory of a projectile projected making an angle with the horizontal.
5. To solve Schrodinger's equation to find energy states of particle confined in a box.
6. To solve Laplaces equations in the depletion layer of p-n junction.
7. To find the energies of an harmonic oscillator.
8. Other related problems will be performed.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Solve physical problems.

CO2: Visualize particle motion in the potential field.

CO3: Realize semiconductor device behavior.

Course Name: Measurement and Instrumentation Lab
Course Code: PH-627

Contact Hours/Week: 2P **Course Credits: 01**

Course Objectives

- To make students aware of instrument handling.
- To make students learn experimental.
- Make students capable to work in groups.

List of Experiments

1. To study the thermal expansion phenomenon using a dilatometer.
2. To measure I-V characteristics of a p-n junction diode and extract its parameters.
3. To measure C-V characteristics of a p-n junction diode and extract its parameters.
4. To calibrate a thermocouple for temperature measurement.
5. To use the gauges to measure low pressure/ vacuum level.
6. New experiments will be incorporated time to time

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Realize theoretical concepts using experiments.

CO2: Enhance experimental skills.

CO3: Study various properties of solids.

CO4: Understand various physical phenomenon.

Course Name: **High Energy Physics**
Course Code: **PH-631**
Course Type: **Core**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the developments in the area of high energy Physics.
- To introduce the fundamental concepts relevant to interactions and fields in particle Physics, invariance principles and conservation laws
- To enable the students to understand concepts of QCD and quark model, flavor symmetry, weak decay processes.

Course Content

Introduction and Overview: Historical development, Relativistic Kinematics, Four Vector (Position, Time, energy momentum) Fixed target and colliding beam accelerators (brief idea), Particle classification: Bosons, Fermions, Particles and Antiparticles, Quarks and Leptons; Basic ideas about the interactions and fields in Particle Physics, Types of interactions: Electromagnetic, Weak, Strong and Gravitational, Natural System of Units in High Energy Physics. Invariance Principles and Conservation laws: Conservation of electric charge, Baryon number, Lepton number, Continuous symmetry transformations: translation and rotation; Parity, Pion parity, Charge conjugation, Strangeness and Isospin, Two Nucleon System, Pion-Nucleon System, G-parity, Time reversal invariance, Associated production of particles and Gell-Mann Nishijima scheme, $K0-K0$ doublet, CP violation in K- decay, CPT theorem. Electromagnetic Interactions: Form factors of nucleons. Parton model and Deep inelastic scattering structure functions, Cross Section and Decay Rates. QCD and Quark model: Asymptotic freedom, confinement hypothesis. Classification of hadrons by flavor symmetry: SU(2) and SU(3) multiplets of Mesons and Baryons. The Baryon Octet and Decuplet, Pseudoscalar mesons and Vector mesons. Weak interactions and Gauge invariance: Classification of weak processes, Fermi theory of β-decay, Parity non conservation in β-decay, two component theory of neutrino and determination of helicity, V-A interaction, Strangeness changing and non-changing decays, Cabibbo's theory, Gauge Principle, Local and Global gauge transformations, Abelian and non-Abelian gauge fields, brief idea about standard model.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different mechanisms in the field of high energy Physics.

CO2: Describe problems with different types of particle interactions and fields involved.

CO3: Apply the concepts and principles/laws to describe the particle decay mechanism.

Books and References

1. Introduction to High Energy Physics by D.H. Perkins, Cambridge University Press.
2. Introduction to Particle Physics by M.P. Khanna, PHI Learning.
3. Introduction to Elementary Particles by D. Griffiths, Wiley-VCH Verlag, GmbH & Co KGaA, Weinheim.
4. Particle Physics by Martin and Shaw, Wiley.

Course Name: **Nuclear Physics** Course Code: **PH-632** Course Type: **Core**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about the Nuclear Physics.
- To introduce the fundamental concepts of Nuclear theory involving nuclear models.
- To enable the students to understand the Nuclear forces and different nuclear models used to investigate nuclei and nuclear properties.

Course Content

Nuclear Properties: Introduction, constituents of nucleus and their intrinsic properties, angular momentum, magnetic moment and electric quadrupole moment of nucleus, wave mechanical properties of nucleus, nuclear forces. Nuclear Interactions; Two nucleon system**,** deuteron problem, binding energy, nuclear potential well, p-p and p-n scattering experiments at low energy, meson theory of nuclear force, e.g. Bartlett, Heisenberg, Majorana forces and potentials, exchange forces and tensor forces, effective range theory-spin dependence of nuclear force, Charge independence and charge symmetry of nuclear forces-Isospin formalism, Yukawa interaction. Nuclear Models: Liquid drop model, Bohr-Wheeler theory of fission, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Applications of Shell model like Angular momenta and parities of nuclear ground states, Quantitative discussion and estimates of transition rates, magnetic moments and Schmidt lines, Collective model-nuclear vibration spectra and rotational spectra, Nuclear Decay: Beta decay, Fermi theory of beta decay, shape of the beta spectrum, Total decay rate, Angular momentum and parity selection rules, Comparative half-lives, Allowed and forbidden transitions, selection rules, parity violation, Two component of neutrino decay, Detection and properties of neutrino, Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules, Internal conversion, Nuclear isomerism. Nuclear Reaction: Conservation laws, energetics of nuclear reaction, Direct and compound nuclear reaction mechanism, Compound nuclear-scattering matrix, Reciprocity theorem, Breit Wigner one level formula, Resonance scattering.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of nuclear properties, different models of nuclear forces.

CO2: Describe problems related nuclear modeling and nuclear reactions.

CO3: Apply principles to determine the basic properties of various nuclear systems and different nuclear reaction mechanisms.

CO4: Assess the results obtained by solving problem related to basic nuclear properties and nuclear reaction mechanism.

Books and References

1. Nuclear Structure by Bohr A. and Mottelson B.R., Benjamin Readings.
2. Introductory Nuclear Physics by Krane K. S., Wiley Estern, New York.
3. Nuclear Physics by Roy R.R. & Nigam B.P., New Age International, New Delhi.
4. Nuclear Physics by Irving Kaplan, Addison Wesley, New Delhi.
5. Theory of Nuclear Structure by Pal M. K., East West Press Pvt. Ltd., New Delhi.
6. Nuclear Physics: Experimental and Theory by Hans H.S., New Age International, New Delhi,

Course Name: Numerical Analysis Lab
Course Code: PH-633

Contact Hours/Week: 2P **Course Credits: 01**

Course Objectives

- To make students aware of computational techniques.
- To make students learn to solve physical problems.
- Make students capable to work in groups to solve common problems.

List of Experiments

1. To read data from input file and assign values to variables.
2. To plot graph between two quantities using given equation.
3. To find sum of first n (even, odd or square of) integers.
4. To find the roots of an equation by Iteration/ Bisection/ Regula Falsi/ Newton Raphson's etc. methods.
5. To perform various matrix operations using the program.
6. To perform numerical differentiation.
7. To interpolate/extrapolate given data.
8. To perform numerical integration by different methods.
9. To perform least square curve fitting into linear equation and polynomials.
10. Other relevant problems may be solved.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Solve physical problems using numerical methods.

CO2: Solve equations for root finding.

CO3: Plot data in given equations/ polynomials.

Course Name: Electronics Lab
Course Code: PH-634

Contact Hours/Week: 4P **Course Credits: 02**

Course Objectives

- To make students learn performing experiments
- To make students learn to the concepts of digital electronics.
- Make students capable to work in groups to solve common problems

List of Experiments

1. To verify logic gates
2. To study the characteristics of NAND gate and its use as universal gate.
3. To study the characteristics of NOR gate and its use as universal gate
4. To study the phase relationship between waveforms using Lissajous figures.
5. To study different waveforms using the oscilloscope
6. To study the inverter operation using operational amplifier.
7. To study the differentiator circuit using operational amplifier.
8. To study the Integrator circuit using operational amplifier.
9. To study the half adder and full adder circuits using NAND gate.
10. To design and verify gain and frequency response of inverting amplifier using IC-741.
11. To design and verify gain and frequency response of the non-inverting amplifier using IC-741.
12. To design and verify gain and frequency response of the differentiator circuit using IC-741.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Realize theoretical concepts using experiments.

CO2: Enhance experimental skills.

CO3: Study various properties of solids.

CO4: Understand various physical phenomenon.

Course Name: Fabrication and Assembly Lab
Course Code: PH-635

Contact Hours/Week: 4P	**Course Credits: 02**

Course Objectives

- To make student fabricate optical components.
- To enable students to understand the manufacturing process.
- To enable students to assemble electronic components.

List of Experiments

1. To fabricate prism from bulk glass block.
2. To fabricate lens from bulk glass block.
3. To fabricate rectangular slab from bulk glass block.
4. To get acquainted with soldering of electronic components.
5. To fabricate an electronic circuit, e.g., power supply, wave shaping, waveforms etc.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Fabricate glass components for optical experiments.

CO2: Learn technical skill of handling equipments carefully.

CO3: Assemble electronic circuits.

Course Name: **Experimental Techniques in Physics**
Course Code: **PH-701**
Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** | Course Credits: **04**

Course Objectives

- To impart knowledge about the experimental techniques used in Physics.
- To introduce the fundamental concepts of X-ray diffraction and spectroscopy.
- To enable the students to understand the theory of X-ray diffraction and different spectroscopic techniques.

Course Content

Crystal structure identification and lattice parameter determination, Particle size determination using Bragg's law of X-ray diffraction.Optical Microscopy; Scanning Tunneling Microscopy; Atomic Force Microscopy; Scanning Electron Microscopy; Transmission Electron Microscopy; Low Energy Electron Diffraction; Reflection High Energy Electron Diffraction; Neutron diffraction; Auger Electron Microscopy; Secondary ion mass spectroscopy; Raman Spectroscopy. Photoluminescence Spectroscopy, Electron spectroscopy for chemical analysis, FTIR, UV-VIS-NIR spectrophotometry & Ellipsometry Thermal Characterization. Differential scanning calorimeter; Differential Thermal Analyzer. Deep Level Transient Spectroscopy; Thermally Simulated Current; C-V and Admittance Spectroscopy; Hall effect and Time of Flight methods for charge carriers,

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of X-ray diffraction, neutron diffraction and spectroscopy.

CO2: Describe problems related to the structure of solids, measurement of magnetic properties and other parameters.

CO3: Apply principles to determine crystal structures, microstructure, band gap and specific heat.

CO4: Assess the results obtained by solving problem related crystal structure and energy band determination.

Books and References

1. Instrumentation and Experiment Design in Physics and Engineering by Sayer, M., Mansingh, A., Measurement.
2 Nanotechnology - Molecularly Designed Materials by G.M. Chow & K.E. Gonsalves (American Chemical Society).
3 Nanotechnology Molecular Speculations on Global Abundance by B. C. Crandall (MIT Press).
4 Nanoparticles and Nanostructured Films–Preparation, Characterization and Application by J.H. Fendler (Wiley).

Course Name: **Nuclear Detectors and Accelerator Physics**
Course Code: **PH-702**
Course Type: **Programme Elective-I**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the Detection of Nuclear Radiations and their measurements.
- To introduce the fundamental concepts related to the experimental determination of Nuclear properties
- To enable the students to understand the Physics of Accelerators of Charged Particles and Neutron Physics

Course Content

Detection of Nuclear Radiations and their measurements: Methods for detection of free charge carriers, Ionization chamber, Proportional counter, Geiger-Muller counter, Semiconductor detectors, Scintillation detector, Cheremkov detector, Wilson cloud chamber, Bubble chamber, Nuclear emulsion techniques. Determination of Nuclear Properties: Nuclear mass measurement, Ion optics, Production and detection of positive ions, Dempster's mass spectrometer, Aston's and Bainbridge's mass spectrograph, Double focusing mass spectroscope. Measurement of nuclear spin and magnetic moment: Nuclear spin from Zeeman effect of hyper fine lines, Nuclear spin and statistics from molecular spectra, Atomic beam method of nuclear magnetic moment determination, Accelerators of Charged Particles: Classification and performance characteristics of accelerators, Ion sources, Electrostatics accelerators, Cockroft – Walton generator, Cyclotron, Synchro-cyclotron, Betatron, Electron and proton synchrotron, Linear accelerator. Neutrons and Neutron Physics: Classification and properties of neutron, Sources of neutron, Neutron detectors; Slow neutron detection through nuclear reactions and induced radioactivity, Fast neutron detection.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of detection of various types of Nuclear Radiations.

CO2: Apply principles to understand and experimental determination of nuclear properties

CO3: Assess the results obtained by solving problem related to nuclear radiation physics.

Books and References

1. Nuclear Radiation Physics by Lapp R. E. and Andrews H. L., Prentice Hall, New Delhi.
2. Mass spectroscopy by Mc Dowell C. A., McGraw Hill Book Company, New Delhi.
3. Experimental Nuclear Physics by Segre E., John Wiley and Sons.
4. Particle Accelerators by Livingstone M.S. and Blewett J. P., McGraw Hill Book Co.
5. Nuclear Radiation Detectors by Kapoor S S and Ramamurthy V. S., Wiley Eastern, New Delhi.
6. Principles of Nuclear Reactor Engineering by Glasstone S. Mc Millan Co. London.
7. Nuclear Physics by Ghoshal S. N., S Chand and Co., New Delhi.

Course Name: **Thin Film Technology** Course Code: **PH-703** Course Type: **Programme Elective-I**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about thin films.
- To introduce the fundamental concepts of film deposition.
- To enable the students to understand various methods of film deposition and their advantages and disadvantages.

Course Content

Thermal evaporation techniques of film deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys, Raoult's law; electron beam evaporation, pulsed laser deposition, ion beam evaporation, glow discharge. Sputtering techniques of film deposition, dc and rf sputtering, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Sol-Gel synthesis, drop casting, spin coating and LB techniques. Physical Vapour deposition, Chemical Vapor Deposition - reaction chemistry and thermodynamics of CVD; Thermal CVD, laser & plasma enhanced CVD, Chemical Techniques - Spray Pyrolysis, Electrodeposition, Ion plating, reactive evaporation, ion beam assisted deposition. Nucleation & Growth in thin films, models of nucleation, basic modes of thin film growth, stages of film growth. & mechanisms, amorphous thin films, Epitaxy - homo, hetero and coherent epilayers, lattice misfit and imperfections, epitaxy of compound semiconductors. Properties and technological applications of thin film.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of film deposition.

CO2: Describe problems related to deposition of thin films and their growth.

CO3: Apply principles to determine the effect of different techniques of film deposition and growth.

Books and References

1. The Materials Science of Thin Films by Milton Ohring, Academic Press Sanden.
2. Thin Film Phenomena by Kasturi L. Chopra, Mc Graw Hill (NewYork).
3. Thin – Film Deproperities; Principles and practices by Denald L. Smith, Mc. Grow Hill, Inc.
4. Thin Film Fundamentals by Goswami A., New Age International Publishers. New Delhi.
5. Handbook of Physical Vapor Deposition (PVP) Processions by Renald M. Matten, Norses Publication.
6. Physical Vapor Deposition of Thin Film by John E. Mohan, John Wiley & Sons.

Course Name: **Optical Fiber Communication**
Course Code: **PH-706**
Course Type: **Programme Elective-II**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about Optical fibre Communication.
- To introduce the fundamental concepts of optical fibre communication.
- To enable the students to understand the optical fibre network and optical fibre communication.

Course Content

Fiber Optics: Total internal reflection, step index and graded index fibers, Guided Modes of a step-index fiber, graded index fibers, single-mode fibers. Optical Fibers: Attenuation in optical fibers, Dispersion, Bit rate and bandwidth, splicing and splicing loss, Pulse dispersion, Dispersion compensation, Fiber materials, fiber fabrication methods, fiber characterization, optical amplifiers. Modes in planar optical waveguides: TE and TM modes, Modes in channel waveguides, Some integrated Optical devices: Prism Coupling,optical switching and wavelength filtering etc. Optical fiber sensors; basic principles and applications.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of propagation of signals through waveguide.
CO2: Describe problems related to attenuation and dispersion in optical fibres.
CO3: Apply principles to understand optical fibre communication system.
CO4: Assess the results obtained by solving problems related to the propagation of optical signal.

Books and References

1. Optical Electronics by A.K. Ghatak and K. Thyagarajan, Cambridge University Press.
2. Introduction to Fiber Optics by A.K. and K. Thyagarajan, Cambridge University Press.
3. Optical Fiber Communications by G. Keiser, McGraw-Hill, Inc. New Delhi.
4. Photonics by A. Yariv and P. Yeh, Oxford University Press.

Course Name: **Polymer & Liquid Crystals** Course Code: **PH-707** Course Type: **Programme Elective-II**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about Polymers and liquid crystals.
- To introduce the fundamental concepts of polymers and liquid crystals.
- To enable the students to understand different concepts related to polymers and liquid crystals.

Course Content

Polymer, Introduction, monomer, degree of polymerizations, chemistry of polymers, polymer synthesis and polymer structure, polymers classification's, polymer morphology, thermal properties, multicomponent polymeric materials, applications. Liquid Crystals, Classification of liquid crystals: Thermotropic and lyotropic, Nematic, Smectic, cholestric, Ferroelectric liquid crystals (LCs), Blue phase LCs, molecular structure of LCs, structure-property relationship of thermotropic liquid crystals. Molecular and mean field theory, Birefringence phenomena, polarizing microscopy, texture identifications and defects, Electric & Magnetic effects, Optical properties of liquid crystals. Liquid crystal composites:polymer and nano-materials dispersed liquid crystal composites, polymer liquid crystals, molecular dynamics between LCs and Dopants. Liquid crystal applications, present and future displays, manufacturing of LCDs, twisted nematic, super-twisted nematic, LED, IPS based displays and overview of LC in advance field's.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of polymers and liquid crystals.

CO2: Describe problems related to preparation, classification and characterization of polymers and optical crystals.

CO3: Apply principles to determine the basic properties of polymers and liquid crystals.

Books and References

1. Introduction to Liquid crystal Chemistry and Physics by Peter J. Cooling and M. Hird, Taylor and Francis.
2. The Physics of Liquid Crystals by P.G. De. Gennes, Oxford University Press.
3. Liquid Crystals by S. Chandrasekhar, Cambridge University Press.
4. Liquid Crystal fundamental by S. Singh, D. A. Dunmur, World Scientific.
5. Handbook of Polymer Science and Technology by M. H. Ferry, CBS, Vol. 2.
6. Polymer Science by Gowarikar, Johan wiley and Sons.
7. Principles of Polymer Science by Bahadur and Sastry, Narosa Publishing House.

Course Name: **Opto-Electronics** Course Code: **PH-708** Course Type: **Programme Elective-II**	
Contact Hours/Week: **4L**	Course Credits: **04**

Course Objectives

- To impart knowledge about opto electronics.
- To introduce the fundamental concepts of opto electronics including, optical fibre network and fibre communication.
- To enable the students to understand different aspects of opto electronics, including fibre network, light sources and detectors.

Course Content

Dielectric wave guide and optical fibers: Light propagation in homogeneous medium, Snell's law and total internal reflection, Optical fibers, types of optical fibers, Numerical aperture, dispersion in optical fibers, optical bandwidth and bit rate, attenuation, scattering and absorption in optical fibers, Fiber materials and fabrication techniques. Semiconductor Science and Light Sources: Review of energy bands, Fermi level in semiconductors, doping of semiconductors, direct and indirect band gap semiconductors, effective mass, Fermi level, classification of semiconductors into element, binary, ternary and quaternary compounds, conduction mechanisms, amorphous semiconductors. Junction Devices: P-N junction, potential barrier and barrier width, forward and reverse saturation current junction capacitance, contact potential explanation based on band structure, M-S contact and its properties, photodiodes, photovoltaic devices and solar cell materials. Display devices and photo detectors: Luminescence from quantum well, photo luminescence and phosphorescence, phototransistors electro luminescence process, LED's their structures and choice of materials, Plasma displays, photon devices and their characteristics, solar cells. Emission and absorption of radiation, population inversion, pumping, doped laser, gas laser, semiconductor laser, liquid dye laser, laser modes and holography.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of opto electronics.

CO2: Describe problems related optical network, optical communication, light sources and detectors.

CO3: Apply principles to determine parameters of optical fibre, fibre network, optical sources, detectors and display devices.

CO4: Assess the results obtained by solving problems related to different opto electronic devices.

Books and References

1. Physics of Semiconductor Devices by S. M.Sze, Wiley, New York.
2. Semiconductors, Opto-electronic Devices by P. Bhattacharya, PHI.
3. Optoelectronics and Photonics- Principles and Devices by S.O. Kasap, Pearson Education Inc.
4. Semiconductor Physics and Devices by S. S. Islam, Oxford University Press.
5. Optical Electronics by A. K. Ghatak & K Thyagarajan, Cambridge University Press.
6. Optoelectronics by J. Wilson & J.F.B.Hawkes, PHI.

Course Name: **Physics of Nano-Systems**
Course Code: **PH-711**
Course Type: **Programme Elective-III**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the nano-systems.
- To introduce the fundamental concepts of atomic level system.
- To enable the students to understand the Physics at nano scale.

Course Content

Hetrostructures – An overview of quantum mechanical concepts related to lowdimensional systems. Hetrojunctions, Type I and Type II heterostructures, Classification of Quantum confined systems, Electrons and holes in Quantum wells, Electronic wavefunctions, energy subbands and density of electronic states in Quantum wells, Quantum wires, and Quantum dots, Effective mass mismatch in heterostructures, Coupling between Quantum wells, Superlattices, Electron states - Wavefunctions and Density of States for superlattices, Excitons in bulk, in Quantum structures and in heterostructures, The unit cell for quantum well, for quantum wire and for quantum dot. Nanoclusters and Nanoparticles – introduction, Metal nanoclusters- Magic numbers, Geometric structures, Electronic structure, Bulk to nanotransition, Magnetic clusters; Semiconducting nanoparticles; Rare-gas and Molecular clusters. Introduction, Carbon molecules, Carbon clusters, Structure of C60 and its crystal, Small and Large Fullerenes and Other Buckyballs, Carbon nanotubes and their Electronic structure. Properties and Characterization of Nano Materials: Size dependence of properties, Phenomena and Properties at nanoscale, Mechanical/Frictional, Optical, Electrical Transport, Magnetic properties. Electron Microscopy, Scanning Probe Microscopies, near field microscopy, Micro- and near field Raman spectroscopy, Surface-enhanced Raman, Spectroscopy, X-ray photoelectron spectroscopy. Synthesis of nanomaterials: Fabrication techniques: Self-Assembly, Self- Replication, Sol-Gels, Langmuir-Blodgett thin films, Nanolithograph, Bioinspired syntheses, Microfluidic processes, Chemical Vapor Deposition, Pulse laser deposition. Nanoelectronics, Nanosensors, Environmental, Biological, Energy Storage and fuel cells.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of Hetrostructures and Hetrojunctions.

CO2: Describe problems related to Quantum confinement.

CO3: Apply principles to determine the basic properties of Nanoclusters and Nanoparticles.

Books and References

1. Nanomaterials- Synthesis, Properties and Applications by Edelstein A. A. and Cammarata R .C., Institute of Physics Publishing, London.
2. Quantum Wells: Physics and Electronics of two-dimensional systems by Shik A. World Scientific.
3. Nanostructured Carbon for advanced Applications by Benedek et al G., Kluwer Academic Publishers.
4. Quantum Wells, Wires, and Dots: Theoretical and Computational Physics by Harrison, P, John Wiley.
5. Quantum Heterostructures: Microelectronics and Optoelectronics by Mitin, V.V, Kochelap, VA and Stroscio, MA Cambridge University Press.
6. Introduction to Nanotechnology by Poole, Jr. C.P. and Owens, F.J., Wiley India.

Course Name: Nano-Structured Materials
Course Code: PH-712
Course Type: Programme Elective-III

Contact Hours/Week: 4L **Course Credits: 04**

Course Objectives

- To impart knowledge about the nano-structured materials.
- To introduce the fundamental concepts of synthesis and characterization of nano materials.
- To enable the students to understand various properties at nano scale.

Course Content

Introduction to Nanomaterials: Types of Nanomaterials, Emergence and challenges in nanotechnology, Properties of Nanomaterials, role of size in Nanomaterials, nanoparticles, nanowires, nanoclusters, quantum wells, conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state, Properties of Nanomaterials: Stability of Nanomaterials, Mechanical properties, Optical, Electrical and Magnetic properties, nano-diffusion. Fabrication of Nanomaterials: Synthesis routes for nanomaterials: Bottom-up and top-down approaches, Solid, Liquid, Gas phase synthesis, Hybrid Phase synthesis, Synthesis of bulk Nanostructured materials: Approaches and challenges. Characterization techniques of nanomaterials : Characterization of Nanostructures: Structural Characterization X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM). Thermal Characterization of Materials: DTA, TGA, DSC (Principle and Applications). Future Applications: MEMs, Nanomachines, Nanodevices, quantum computers, Opto-electronic devices, quantum electronic devices, Environmental and Biological applications. Nanocomposites: Types of Nanocomposite (i.e. metal oxide, ceramic, glass and polymer based); Core-Shell structured Nanocomposites, Superhard Nanocomposite, Mechanical Properties, Modulus and the Load-Carrying Capability of Nanofillers, Failure Stress and Strain Toughness, Glass Transition and Relaxation Behavior, Abrasion and Wear Resistance, Permeability, Dimensional Stability Contents, Thermal Stability and Flammability, Electrical and Optical Properties, Resistivity, Permittivity, and Breakdown Strength, Refractive Index, Light-Emitting Devices.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts to develop nano materials for different applications..

CO2: Describe problems related to synthesis and characterization.

CO3: Apply principles to describe Environmental and Biological applications.

Books and References

1. Nanostructures and Nanomaterials; Synthesis, Properties and Applications by Guozhong Cao Imperial College Press.
2. Introduction to Nanotechnology by Chales P Poole, Frank J Owen, Wiley India.
3. Handbook on Nanotechnology Vol 5 by H S Nalwa, Academic Press.
4. Nano: The Essentials Understanding Nanoscience and Nanotechnology by T Pradeep, McGraw Hill.

Course Name: Plasma Physics
Course Code: PH-713
Course Type: Programme Elective-III

Contact Hours/Week: 4L	**Course Credits: 04**

Course Objectives

- To impart knowledge about the plasma state .
- To understand the fundamental concepts of plasma physics.
- To enable the students to understand various properties of the plasma state.

Course Content

Plasma state, Debye shielding and Plasma frequency, Criteria for plasma state, Plasma production/ Occurrence of plasma, Simple applications of plasma. Single charged particle motions in constant and uniform electromagnetic field, Non-uniform magnetic field, grad – B drift and curvature drift, Magnetic mirror, Adiabatic invariants, Introduction to plasma as fluids, Plasma fluid equations, Adiabatic fluid responses. Waves in plasma, Linearization procedure, Plasma oscillations (Electron waves), Plasma normal modes, Sound wave in a neutral gas, Plasma ion sound waves/acoustic waves, An electromagnetic Plasma waves, Wave properties applications, Upper and lower hybrid waves. Plasma equilibrium stability, Frozen flux theorem, Ponderomotive force, Plasma instabilities and its types.Controlled Fusion, Fusion History, Lawson criteria, Fundamentals of Inertial Magnetic Fusion, Magnetic Confinement method (Magnetic Mirrors), Tokamak.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts to develop plasma applications.

CO2: Describe problems related to plasma physics.

CO3: Apply principles to describe plasma problems.

Books and References

1. Introduction to Plasma Physics and Controlled Fusion by Chen F. F., Plenum Press, New York.
2. Principle of Plasma Physics by Krall N.A. and Trivelpiece A.W., Tata McGraw- Hill Publishing Company, New Delhi.
3. Fundamental of Plasma Physics by Seshadri S R, Addison-Wesley Pub. Co.
4. Plasma Physics by Dendy R, Cambridge University Press, New York.
5. Introduction to Unmagnetized Plasma by Chanchal Uberoi, Prentice Hall of India Pvt. Ltd., New Delhi.

Course Name: **Solar and Astrophysics** Course Code: **PH-714** Course Type: **Programme Elective-III**	
Contact Hours/Week: **4L**	Course Credits: **04**
Course Objectives • To impart knowledge about the Astrophysics . • To understand the fundamental concepts of Solar Physics. • To enable the students to understand the various problems of Solar and Astrophysics Physics.	
Course Content	
Structure of the Sun: Solar interior, solar atmosphere, photosphere, chromosphere, corona; Small & large scale Solar structures, Sun spots and their properties, Prominences, Solar Flare: classifications, phases & flare theory; Solar cycle, Solar magnetic field. Observed and derived properties of solar wind, Solar wind formation: Fluid theory for static as well as expanding isothermal solar atmosphere, Spatial configuration of magnetic field frozen into the solar wind, Termination of solar wind, Heliosphere. Qualitative description of Astro-objects (from planets to large scale structures): length, mass and time scales, Evolution of structures in the universe; Red shift, Expansion of the universe. Simple orbits, Kepler's laws, Flat rotation curve of galaxies and implications for dark matter, Role of gravity in different astrophysical systems; Radiative Process: Radiation theory and Larmor formula, Different radiative processes.Star formation, Stellar evolution, Supernovae, H-T diagram, Compact Stars. Milky way galaxy, Spiral and elliptical galaxies, Active galaxy, Black holes.	
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Identify different concepts to develop solar physics applications.. CO2: Describe problems related to solar and astrophysics.. CO3: Apply principles to describe solar and astrophysics.	
Books and References 1. Astrophysics of the Sun by Harold Zirin, Cambridge University Press, Cambridge. 2. Solar System Astrophysics by J. C. Brandt & P.W. Hadge. 3. Guide to the Sun by Kenneth J. H. Philips, Cambridge University Press. 4. Astrophysical Concepts by M. Harwitt, Springer-Verlag, New York. 5. An Introduction to Modern Astrophysics by W. Carroll & D. A. Ostlie, Pearson. 6. The Physics of Astrophysics Vol I & II by Frank H. Shu, University Science Books.	

Course Name: **Quantum Computing**
Course Code: **PH-716**
Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the quantum-mechanical phenomena such as superposition and entanglement to perform computation.
- To introduce the fundamental concepts, Quantum Computing.
- To enable the students to understand the quantum computing and quantum information in depth.

Course Content

Introduction to Quantum Computation: Quantum bits, Bloch sphere presentation of a qubit, multiple qubits. Background Mathematics and Physics, Hilber space, Probabilities and measurements, entanglement, density operators and correlation, basics of quantum mechanics, Measurements in bases other than computational basis. Quantum Circuits: single qubit gates, multiple qubit gates, design of quantum circuits. Quantum Information and Cryptography: Comparison between classical and quantum information theory. Bell states. Quantum teleportation. Quantum Cryptography, no cloning theorem. Quantum Algorithms: Classical computation on quantum computers. Relationship between quantum and classical complexity classes. Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search. Noise and error correction: Graph states and codes, Quantum error correction, fault-tolerant computation

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the fundamental notations of quantum mechanics.

CO2: Describe the fundamental elements needed to perform quantum computation.

CO3: Apply elementary operations to develop more sophisticated applications of quantum computing.

Books and References

1. Quantum Computation and Quantum Information by Nielsen M. A., Cambridge University Press.
2. Principles of Quantum Computation and Information by Benenti G., Casati G. and Strini G., Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics World Scientific.
3. Principles of Quantum Computation and Information by G. Benenti and G. Casati , World Scientific.

Course Name: **Quantum Field Theory**
Course Code: **PH-717**
Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the quantum field theory.
- To introduce the fundamental concepts involving relativistic effects.
- To enable the students to understand the Electron-Positron and Electron-Photon Scattering etc.

Course Content

Canonical Quantization: Resume of Lagrangian and Hamiltonian formalism of a classical field, Second quantization: Concepts and illustrations with Schrodinger field. Klein Gordan Field: Quantization of a real scalar field and its application to one meson exchange potential, Quantization of a complex scalar field. Dirac Field: The Dirac Equation, Relativistic Covariance. Anti-Commutators, Quantization of the Dirac Field, Electrons and Positrons. Gauge Field: Gauge Invariance and Gauge Fixing. Quantization of the Electromagnetic Field, Propagator, Vacuum Fluctuations. Interacting Theory and Elementary Processes: Feynman diagrams and their applications, Lowest Order Cross-Section for Electron-Electron, Electron-Positron and Electron-Photon Scattering, Wick's Theorem, Scattering matrix and Higher order corrections.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of relativistic and non-relativistic quantum theory.

CO2: Describe problems related to quantization and scattering.

CO3: Apply principles to understand anti matter concept.

Books and References

1. Quantum Field Theory by C. Itzykson and J. B. Zuber, McGraw-Hill Book Co.
2. Quantum Field Theory by L. H. Ryder, Cambridge University Press.
3. The Quantum Theory of Fields Vol I, by S. Weinberg, Cambridge University Press.
4. Introduction to The Theory of Quantum Fields by N. N. Bogoliubov and D. V. Shirkov, Interscience.
5. An Introduction to Quantum Field Theory by M. E. Peskin and D. V. Schroeder, Westview Press.

Course Name: **Quantum Optics**
Course Code: **PH-718**
Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the fundamental concepts of Quantum Optics.
- To introduce the applications of optical coherence.
- To enable the students to understand the classical and quantum theories of optical coherence.

Course Content

Quantization of the radiation field, quantum harmonic oscillator, the zero-point energy, the connection between the positive and negative frequency parts of the electric field operator; states of the quantized radiation field - single mode number states, thermal states, phase states, the minimal uncertainty states, the coherent and squeezed coherent states. Various definitions of a coherent state: the minimal uncertainty states, the states with classical motion, the displacement operator eigenstates, the Glauber-Sudarshan P-function, the Q-function and other quasi-probability distribution functions and their use in the semi-classical description of a radiation field, Nonclassical aspects like squeezing and antibunching and examples of nonclassical states and experimental status. Important experiments in Quantum Optics: Photon counting experiments, Intentsity-intensity correlation - Hanbury-Brown and Twiss experiment. The concept of an analytic signal, elementary description of stochastic processes, correlation functions and coherence functions, Stationary and ergodic processes, Wiener-Khinchin relations, Young's double slit experiment to discuss the conditions on the classical coherence functions and quantum coherence functions for various orders of coherence, higher-order correlations functions**.**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the introductory background in quantum mechanics.

CO2: Describe thermal states, phase state and squeezed coherent states.

CO3: Apply principles to understand the examples of nonclassical states and experimental status.

CO4: Assess the results obtained by solving problem related to quantum optics.

Books and References

1. Optical coherence and quantum optics, by L. Mandel and E. Wolf, Cambridge.
2. Quantum Optics An Introduction by Mark Fox, Oxford University Press.
3. Fundamentals of Quantum Optics and Quantum Information by Peter Lambropoulos, David Petrosyan, Springer-Verlag Berlin Heidelberg.

Course Name: **Atmospheric and Space Physics**
Course Code: **PH-719**
Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the fundamental concepts of Quantum Optics.
- To introduce the applications of optical coherence.
- To enable the students to understand the classical and quantum theories of optical coherence.

Course Content

The Neutral atmosphere, atmospheric nomenclature, the Hydrostatic equation, Geopotential height, expansion and contraction, fundamental forces in the atmosphere, apparent forces, atmospheric composition, solar radiation interaction with the neutral atmosphere, climate change, Momentum equation in rotating coordinates, component equation in spherical coordinates, scale analysis of equation of motion, continuity equation, thermodynamics of dry atmosphere, thermal wind, vertical motion, EM Radiation, fundamentals of EM waves, effects of environment, Antennas- basic considerations, types of antennas. Propagation of waves: ground wave, sky wave, and space wave propagation, troposcatter communication and extra terrestrial communication, The Ionosphere, morphology of ionosphere, the D, E and F-regions, chemistry of the ionosphere, ionospheric parameters, E and F region anomalies and irregularities in the ionosphere, Basic concepts, overview of GPS system, augmentation services, GPS system segment, GPS signal characteristics, GPS errors, multi path effects, GPS performance, satellite navigation system and applications, The expanding universe, Cosmological models: Big Bang and Steady State models, Dark matter.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the introductory background in space Physics.

CO2: Describe problems related to Atmospheric and Space Physics.

CO3: Apply principles to understand Atmospheric and Space Physics.

Books and References

1. An Introduction to Dynamic Meteorology by James R Holton, Academic Press Inc.
2. An atmospheric Science by John E. Oliver & John J. Hindore, Climatology, Pearson Education.
3. Electronic Communication systems by George Kennedy & Bernard Davis, Tata McGraw Hill Co.
4. Introduction to Ionospheric Physics by Henry Rishbeth & Owen K. Garriot, Academic press.
5. Understanding GPS principles and applications by Elliot D. Kaplan and Christopher J. Hegarty, Artech House, Boston.

Course Name: **Nuclear Science and Applications**
Course Code: **PH-881**
Course Type: **Open Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the Nuclear Physics.
- To introduce the fundamental concepts Nuclear theory involving nuclear models
- To enable the students to understand the Nuclear forces and different nuclear models used to investigate nuclei and nuclear properties.

Course Content

Introduction to the Nucleus and theories of Nuclear Composition, Non-existence of Electron in Nucleus, Classifications of Nuclei, Properties of Nucleus, Wave Mechanical Properties of Nucleus, Binding Energy & Nuclear Stability, Nuclear Forces & their Properties. Nuclear alpha, beta and gamma decay (Basic Idea). Models of Nuclear Structure : Liquid Drop Model, Semi-Empirical Mass Formula and its Applications, Experimental Evidence of Nuclear Magic Numbers. Detectors of Nuclear Radiation **:** Interaction Between Energetic Particles and Matter, Ionization Chamber, Proportional Counter, Gieger-Muller Counter, Solid-State Detector, Nuclear Emulsions. Radioactivity and Radiation Hazards, Introduction to Radioactivity, Radioactive Series, Successive Transformation and Radioactive Equilibrium, Neutron Sources and types of Neutrons, Mass & Wavelength of Neutrons, Neutron Detection, Nuclear Reactions, Induced Radioactivity, Radio Isotopes, Applications of Radioisotopes, Radioactive Dating, Biological Effects of Nuclear Radiations, Radiation Hazards, Radiation Levels for safety, Radiation Protection Methods, Nuclear Disasters, Nuclear Waste Disposal. Nuclear Reactors: Nuclear Cross section, Theory of Nuclear Fission and Fusion, Source of Stellar Energy, Thermonuclear Reactions, Transuranic Elements, Nuclear Power Reactor Technology, Uranium Enrichment Techniques, Pressurized Water Reactor (PWR), Boiling Water Reactor (BWR), Fast Breeder Reactor, Fusion Reactor Technology, Lawson Criterion, Plasma Confinement Mechanism, Tokamak, Present Nuclear Energy Status.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of nuclear properties, different models of nuclear forces.

CO2: Describe problems related nuclear modeling and nuclear reactions.

CO3: Apply principles to determine the basic properties of various nuclear systems and different nuclear reaction mechanisms.

CO4: Assess the results obtained by solving problem related to basic nuclear properties and nuclear reaction mechanism.

Books and References

1 Nuclear Physics by S. N. Ghoshal, S. Chand & Company Ltd.
2. Nuclear Physics: Principles and Applications by John Lilley, Wiley India Pvt Ltd.
3. Introductory Nuclear Physics by Kenneth S. Krane, Wiley India Pvt Ltd.
4. Modern Physics by R. Murugeshan and Kiruthiga Sivaprasath, S. Chand & Company Ltd.
5. Nuclear Physics by Tayal D C, Himalaya Publishing House.
6. Basic Nuclear Physics by Srivastava B.N., Pragati Prakashan, Meerut.

Course Name: **Nano Technology**
Course Code: **PH-882**
Course Type: **Open Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the nano-systems.
- To introduce the fundamental concepts of atomic level system.
- To enable the students to understand the Physics at nano scale..

Course Content

Introduction:Nanoscience, nanotechnology, nanostructures, under lying physical principles of nanotechnology, Fundamental physicochemical principles - size dependence properties of nanostructured materials, matter quantum confinement, The importance of nanoscale morphology, Societal aspects of nanotechnology: Health, environment, hype and reality. Synthesis Techniques: Top down and bottom up approaches to produce nanomaterials. Overview of self-assembly, Inert gas condensation, arc discharge, RF plasma, plasma arc technique, ion sputtering, laser ablation, laser pyrolysis, ball milling, molecular beam epitaxy, chemical vapour deposition method and electro deposition. Metal/Semiconductor Nanostructures: Size control of metal nanoparticles and their characterization, study of their properties, optical, electronic, magnetic, surface plasmon band and its applications, role in catalysis, nano-particles, stabilization in sol, glass, and other media, change of bandgap, blue shift, composites, Plasmon resonance and its applications. Carbon Nanostructures: Introduction, Carbon nano-structure, carbon nanotubes, graphene, mechanical, optical and electrical properties & applications, functionalization of carbon nanotubes, reactivity of carbon nanotubes, applications. Tools for characterization of nanomaterials: X-ray diffraction, scanning electron microscopy (SEM) and EDAX analysis, transmission electron microscopy (TEM), a brief historical overview of atomic force microscopy (AFM) and scanning tunneling microscopy (STM), UV-Vis, IR and Raman spectroscopy, Photoluminescence (PL) spectroscopy.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of Nanoscience, nanotechnology, nanostructures.

CO2: Describe size dependent properties of nano materials.

CO1: Apply principles to determine the basic properties of Nanoclusters and Nanoparticles using different characterization techniques.

Books and References

1. Nano Materials by Bandyopadhyay A.K. New Age International Publishers, New Delhi
2. Quantum Wells: Physics and Electronics of two-dimensional systems by Shik, A. World Scientific.
3. Introduction to Nanotechnology by Poole, Jr. C.P .and Owens F.J., Wiley India.
4. Nanomaterials- Synthesis, Properties and Applications by Edelstein A. A. and Cammarata R. C., Institute of Physics Publishing, London.
5. Nanostructured Carbon for advanced Applications by Benedek et al G., Kluwer Academic Publishers.
6. Quantum Wells, Wires, and Dots: Theoretical and Computational Physics by Harrison P. John Wiley.
7 Nanotechnology, Innovation and Opportunity by Lynn E. Foster, Pearson Education, New Delhi.

Course Name: **Properties of Matter**
Course Code: **PH-883**
Course Type: **Open Elective**

Contact Hours/Week: **4L** Course Credits: **04**

Course Objectives

- To impart knowledge about the mechanical properties of solids and fluids.
- To introduce the fundamental concepts related to elasticity and fluid dynamics.
- To enable students to understand the ultrasonic generation and propagation through media.

Course Content

Elasticity: Stress, strain, Hook's law, Young's modulus, bulk modulus, modulus of rigidity, Poisson's ratio, ratio between elastic constants, torsion of a cylinder, bending beam and cantilevers, cantilever loaded at one end, cantilever supported at two ends and loaded in the middle. Thermal Properties: Conduction, convection and radiation, thermal conductivity, thermal diffusivity, heat flow problems in different structures and media. Piezoelectric Materials: Piezoelectric effect, Magnetostriction effect, Ultrasonics generation, properties and their applications. Shock waves: Introduction, Types of shock waves, Mach number, Generation of shock waves, various types of shock waves, applications of shock waves. Fluid Mechanics: Equation of continuity, equation of motion, viscosity of liquids, dimensions of viscosity, Poieseuille's equation, Stoke's law, Raynold's number.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different concepts of electricity and fluid mechanics.

CO2: Describe problems related to mechanical and thermal properties.

CO3: Apply principles to understand different mechanism in fluids.

Books and References

1. Modern Engineering Physics by A.S. Vasudeva, S.Chand & Co. New Delhi.
2. Mechanics and Wave Motion by V.K. Singh, D. Singh and D.P. Singh, I.K. International Publishing House Pvt. Ltd, New Delhi.
3. Mechanics by D. S. Mathur, S.Chand & Company (Pvt.) Ltd, New Delhi.