M.Sc. (Applied Physics)

Semester-I

S. No.	Subject Code	Subject	L	T	P	Credits		Th.	CW	SW	Pr	Total
						T	P					
1.	PH97105	Classical and Statistical Mechanics	4	-	-	4	-	70	30	-	-	100
2.	PH97106	Communication and Digital Electronics	4	-	-	4	-	70	30	-	-	100
3.	PH97107	Electrodynamics and Relativity	4	-	-	4	-	70	30	-	-	100
4.	PH97108	Mathematical Methods and Numerical Analysis	4	-	-	4	-	70	30	-	-	100
5.	PH97173	Analog and Digital Electronics Lab	-	-	8	-	4	-	-	40	60	100
6.	PH97174	Applied Physics Lab and Workshop Practice	-	-	8	-	4	-	-	40	60	100
7.	PH97198	Comprehensive Viva	-	-	-	-	4	-	-	-	100	100
		Total	**16**	**-**	**16**	**16**	**12**	**280**	**120**	**80**	**220**	**700**

Semester-II

S. No.	Subject Code	Subject	L	T	P	Credits		Th.	CW	SW	Pr	Total
						T	P					
1.	PH97205	Atomic and Molecular Physics	4	-	-	4	-	70	30	-	-	100
2.	PH97206	Computer Programming	4	-	-	4	-	70	30	-	-	100
3.	PH97207	Quantum Mechanics	4	-	-	4	-	70	30	-	-	100
4.	PH97208	Solid State Physics	4	-	-	4	-	70	30	-	-	100
5.	PH97273	Computer Programme Lab and Engg. Drawing	-	-	8	-	4	-	-	40	60	100
6.	PH97274	Basic Laser and Fiber Optics Lab	-	-	8	-	4	-	-	40	60	100
7.	PH97298	Comprehensive Viva	-	-	-	-	4	-	-	-	100	100
		Total	**16**	**-**	**16**	**16**	**12**	**280**	**120**	**80**	**220**	**700**

Semester-III

S. No.	Subject Code	Subject	L	T	P	Credits		Th.	CW	SW	Pr.	Total
						T	P					
1.	PH97305	Nuclear and Particle Physics	-	-	-	4	-	70	30	-	-	100
2.	PH97306	Fiber and Integrated Optics	-	-	-	4	-	70	30	-	-	100
3.	PH97307	Nano Science and Nano Technology	-	-	-	4	-	70	30	-	-	100
4.	PH97308	Lasers and Applications	-	-	-	4	-	70	30	-	-	100
5.	PH97389	Advanced Lasers and Fiber Optics Lab	-	-	8		4	-	-	40	-	100
6.	PH97390	Optical Communication and Nanomaterials Lab	-	-	8	-	4	-	-	40	60	100
7.	PH97398	Quiz/Assignment/Seminar-III	-	-	-	-	2	-	-	50	60	50
8.	PH97399	Comprehensive Viva	-	-	-	-	4	-	-	-	50	50
		Total	**0**	**0**	**16**	**16**	**14**	**280**	**120**	**130**	**170**	**700**

Semester-IV

S. No.	Subject Code	Subject	L	T	P	Credits		Theory Marks	
						T	P		
								CW/SW	END
1.	PH97499	Dissertation	-	-	-	-	26	120	180
			48	**-**	**78**	**48**	**64**	**810**	**1590**
		Grand Total of All Semesters	**126**			**112**		**2400**	

PH97105: CLASSICAL & STATISTICAL MECHANICS											
Subject Code	**Classes**			**Maximum Marks**					**Credits**		
	L	T	P	CW	End	SW	End	Total	T	P	Tot
PH 97105	4	-	-	30	70	-	-	100	4	-	4

Course Objective (CO): The objective of this course is to

1. provide knowledge of fundamental and applied concepts of classical and statistical physics.
2. demonstrate theoretical laws of classical and statistical physics for predicting the motions of bodies.
3. explain of the fundamental concepts in the dynamics of system of particles, motion of rigid body, Lagrangian and Hamiltonian dynamics.
4. cultivate the understanding of macroscopic and microscopic states, the contacts of statistics and thermodynamics, classical ideal gas, Gibbs distribution and partition function.

Expected Course Outcome (ECO): By the end of the course the students will be able to

1. understand the constraints, D'Alembert, Lagrange's and Hamiltonian principle.
2. independently solve the fundamental and advanced problem of scattering in a central force field.
3. establish the equation of motions of particles by using various canonical transformation.
4. solve the problems attributed to the thermodynamic quantities and their statistical distribution.

COURSE CONTENTS

Unit-1 **Lagrangian and Hamiltonian Dynamics:** Mechanics of systems of particles, Constraints, D'Alembert's principle, Lagrange's equations, Conservation theorems and symmetry properties, Velocity dependent potentials, Lagrange's equation from Hamilton's variational principle, Hamilton's equations of motion, Hamilton's equations from D'Alembert's principle, Principle of least action and its various forms.

Unit-2 **Two-Body Central Force Problem and Coupled Oscillations:** Reduction to equivalent one body problem, Equation of motion under central force (Kepler's law and stability of orbit), virial theorem, scattering in a central force field, normal modes and coupled oscillators, general theory of small oscillation, longitudinal oscillation of two coupled oscillators, many coupled oscillators.

Unit-3 **Canonical Transformation:** Generating functions, Application of canonical transformation, Integral invariance of Poincare, Lagrange and Poissons brackets, Equations of motions in Poisson Brackets, Canonical invariants of Lagrange and Poissons brackets, Jacobi's Identity, Phase space and Lioville Theorem.

Unit-4 **Thermodynamic Quantities:** Macroscopic motion, relations between the derivative of thermodynamic quantities, Nerst theorem and quantum justification, the dependence of thermodynamic quantities on number of particles, thermodynamic potential, equilibrium of a body in an external field.

Unit-5 **Statistical Distribution:** Gibbs distribution, the Maxwellian distribution, free energy in Gibbs distribution, partition function, the Boltzmann distribution, the Bose Einstein distribution, Fermi Dirac distribution, the Fermi and Bose gases of elementary particles, degenerate electron gas, degenerate Bose gas, black body radiation.

Reference

1. H. Goldstein, C. Poole, J. Safko, Classical Mechanics, 3rd Ed. (Pearson Edu. South Asia), 2008.
2. N. C. Rana and P. S. Joag, Classical Mechanics, (Tata McGraw Hill Pub., New Delhi) 1991.
3. L. D. Landau and E. M. Lifshitz, Statistical Physics, 3rd Ed. (Pergemon Press, New York) 1995.
4. R. K. Patharia and P. D. Beale, Statistical Mechanics, 3rd Ed. (Elsevier Ltd., USA) 2011.

PH 97106: ELECTRONICS AND COMMUNICATION ENGINEERING										
Subject Code	**Classes**			**Maximum Marks**				**Credits**		
	L	T	P	CW	End	SW	End	T	P	Tot
PH 97106	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**4**	**-**	**4**

Course Objective (CO): The objective of this course is to

1. introduce the concepts of modulation, demodulation with knowledge of operational amplifier.
2. demonstrate the use of operational amplifier in digital devices along with its applications.
3. explain the laws and theorems of digital electronics and their applications.
4. develop the understanding of flip-flops, multibreathers, timers and registers.

Expected Course Outcome (ECO): By the end of the course the students will be able to

1. understand the significant working of operational amplifier in digital electronics.
2. answer the fundamental and advanced problem of modulation and demodulation techniques.
3. establish laws and theorems of Boolean algebra and develop the logics for exclusive digital operations.
4. solve the problems attributed to the flip-flops, triggers, registers, and counters.

COURSE CONTENTS

Unit-1 **Operational Amplifier:** Differential amplifier, operational amplifier and its parameters, open loop applications and closed loop applications. Differential amplifiers with one, two and three OP-Amp. Frequency response.

Unit-2 **General Linear Application of OPAMP:** DC & AC amplifiers, Peaking amplifier, summing & averaging amplifier, instrumentation amplifier, integrator, differentiator, oscillators, Weinbridge, square wave, triangular wave, comparator, zero crossing detector, Schmitt trigger.

Unit-3 **Analog Modulation & Demodulation:** AM, FM, PM, Methods of AM generation, balanced modulator, SSB generation, Power content in AM wave, transmission efficiency, Frequency modulation (FM): frequency deviation, relationship between FM & PM, FM generation & detection, Transmission bandwidth, Super heterodyne receiver.

Unit-4 **Digital Electronics:** Laws and theorems of Boolean algebra, DeMorgans theorem, elements of transistor for switching devices, Logic gates, Positive and negative logic; OR, AND, NOT, NAND gates, Exclusive OR operation, DTL, RTL & TTL circuits, Half & Full adders, substrator, multiplexers and demultiplexer.

Unit-5 **Flip-Flops**: D, RS, JK flip flop, astable and monostable multivibrator, IC555 timer. Different types of counters and registers, ring counter, up & down counter, decade counters, serial, and parallel registers.

References

1. R.A. Gayakwad, Op-amps and linear integrated circuits, (Prentice-Hall, New Delhi) 2000.
2. R.P. Singh and S.D. Sapre, Communication Systems: Analog and Digital, 2nd Ed. (Tata McGraw Hill, New Delhi) 2009.
3. M. Masis Mano, Digital Design, 4th Ed. (Prentice-Hall, New Delhi) 2006.
4. Malvino, Leach, Saha, Digital Principles & Applications, 5th Ed. (Tata-McGraw Hill, New Delhi) 1994.
5. B.P. Lalhi, Modern Digital & Analog Communication Systems, 4th Ed. (Oxford Univ. Press, UK) 2009.

PH 97107: ELECTRODYNAMICS AND RELATIVITY										
Subject Code	**Classes**			**Maximum Marks**				**Credits**		
	L	T	P	CW	End	SW	End	T	P	Tot
PH 97107	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**4**	**-**	**4**

Course Objective (CO): The objective of this course is to

1. introduce the concept of time varying fields and apply this concept to derive Maxwell's equations.
2. demonstrate Maxwell's equation and describe the EM wave propagation in different media.
3. explain the reflection and refraction of EM wave from the boundaries of the media and its dispersion in dielectric conductors and plasma.
4. develop the basic understanding of special theory of relativity and tensor notation for covariance formulation of classical theories.

Expected Course Outcome (ECO): By the end of the course the students will be able to

5. understand the significance Maxwell's equation and its application.
6. answer the basic and advanced problem of EM waves in dielectric and plasma.
7. establish laws reflection, refraction, and dispersion of electromagnetic waves propagation.
8. solve the problems attributed to special and general theory of relativity and cosmology.

COURSE CONTENTS

Unit-1 **Maxwell's Equations:** Electrostatic and magnetostatic energy density, maxwell's displacement current, maxwell equations, vector and scalar potentials, gauge transformations, Lorentz gauge, coulomb gauge, equations of macroscopic electromagnetism, Poynting's theorem and conservation of energy and momentum for a system of charged particles.

Unit-2 **Propagation of Electromagnetic Waves:** Plane waves in dielectric conductors and plasma. Magnetohydrodynamic equations, Pinch effect and magnetohydrodynamic waves.

Unit-3 **Reflection, Refraction and Dispersion of Electromagnetic Waves:** Linear and circular polarization, Stokes parameters, reflection and refraction of electromagnetic waves at a plane interface between dielectrics, polarization by reflection and total internal reflection, frequency dispersion characteristics of dielectrics, conductors and plasmas, illustration of the spreading of a pulse as it propagates in a dispersive medium, causality in the connection between D and E.

Unit-4 **Introduction of Tensors:** Definition of general tensor, Algebra of general tensor, Special (Cartesian) tensors in four dimensions, Symmetric and skew-symmetric tensors, Kronecker delta, fundamental tensor, Contravariant and covariant tensors. Christoffel's symbols.

Unit-5 **Relativity:** Galilean transformation, frame of reference, Michelson and Morely experiment, Lotentz transformation, proper time interval, properties of Lorentz Fitzgerald contraction and time dilation, simultaneity, relative velocity, Minkowski's four-dimensional continuum, Lorentz covariance and new conservational laws, Energy mass relationship, Concepts of relativistic electrodynamics, basics of general theory of relativity and cosmology.

References

1. J. D. Jackson, Classical Electrodynamics, 3rd Ed. (John Wiley & Sons., New York) 1998.
2. D. J. Griffiths, Introduction of Electromagnetic, 3rd Ed. 1999, (Prentice-Hall, New Jersey) 1999.
3. E. C. Jordan and K.G. Balman, Electromagnetic Waves and Radiation Systems, 2nd Ed. (Prentice-Hall, New Jersey) 2009.
4. J. D. Kraus and K.R. Carver, Electromagnetics, 2nd Ed. (McGraw Hill Ltd., New Delhi) 1973.
5. A. Einstein, The Meaning of Relativity, (Princeton Univ. Press, Gutenberg) 1923.

PH 97108: MATHEMATICAL METHODS & NUMERICAL ANALYSIS										
Subject Code	**Classes**			**Maximum Marks**				**Credits**		
	L	T	P	CW	End	SW	End	T	P	Tot
PH 97108	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**4**	**-**	**4**

Course Objective (CO): The objective of this course is to

1. learn the fundamentals of Fourier series, Fourier and Laplace transforms, their inverse transforms.
2. gain insight of curvilinear coordinates, vector algebra and their typical applications in physics.
3. introduced special functions and their recurrence relations for applicability in different areas of physics.
4. have a grasp of the basic elements of complex analysis and learn about the type of matrices and tensors.

Expected Course Outcome (ECO): By the end of the course the students will able

1. expand functions in Fourier components and solve differential equations using Laplace transform.
2. solve the problems of curvilinear coordinates, special functions, complex analysis, matrices, and tensors.
3. establish theorems complex variables and perform elementary conformal mapping.
4. apply functions of matrices in solving linear differential equation.

COURSE CONTENTS

Unit-1 Integral Transforms: Fourier series, Fourier integral theorem, Fourier transform, Parseval's identity related problems, Laplace transform, convolution theorem, transform of derivates: application to ordinary differential equation.

Unit-2 Vector calculus: Introduction to vectors, gradient, divergence, and surface integral, Gauss's theorem, curl of a vector field and Stokes's theorem, orthogonal curvilinear co-ordinates, cylindrical and spherical polar co-ordinates, applications to hydrodynamics, heat flow in solids and electromagnetic theory.

Unit-3 Special Functions: Legendre, Bessel, Hermite and Legaure differential equations and their properties. Recursion relations, orthogonal properties, generating functions.

Unit-4 Complex variables: Analytic function, Cauchy-Riemann equations, Cauchy's integral theorem and Cauchy's integral formula. Taylor's and Laurents series, Singularities, poles, Residues and residue theorem, Elementary conformal mapping.

Unit-5 Matrices and Tensor Analysis: Definitions and types of matrices, solution of linear algebraic equations, characteristic equation and diagonal form, Cayley-Hamilton theorem, functions of matrices, application in solving linear differential equation, Cartesian tensor in three space, Curves in three space and Frenet Formula, General Tensor analysis.

References:

1. M.L. Boas, Mathematical Methods in the Physical Sciences, 3rd Ed.,2006 (Wiley,Inc)
2. B. L. Gupta, Mathematical Physics, 3rd Ed., 2004 (Vikash Publishing House Pvt. Ltd., New Delhi) 2004.
3. Arfken, Weber and Harris, Mathematical methods for Physicists, 7th edition (Academic Press, Elsevier) 2012.
4. Satya Prakash, Mathematical Physics (Sultan Chand & Sons., New Delhi) 2007.

PH 97205: ATOMIC AND MOLECULAR PHYSICS										
Subject Code	**Classes**			**Maximum Marks**				**Credits**		
	L	T	P	CW	End	SW	End	T	P	Tot
PH 97205	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**4**	**-**	**4**

Course Objective (CO): The objective of this course is to

1. apply quantum mechanics for structural understanding of atoms and molecules.
2. demonstrate vibrational, rotational, and electronic states spectra of atoms and molecules.
3. explain the nuclear spin for the understanding of hyperfine spectra of atoms and molecules.
4. develop the understanding of X-ray and Raman spectra.

Expected Course Outcome (ECO): By the end of the course the students will be able to

1. understand the electronic structure of atoms and molecules
2. explain how the atoms and molecules interact with electromagnetic waves.
3. establish the principles of magnetic resonance, Raman, and X-ray spectra.
4. solve the problems attributed to the vibrational, rotational, and electronic states transition of atoms.

COURSE CONTENTS

Unit-1 **Introduction to Electron Spin:** Stern Gerlac's experiment, vector atom model: spin-orbit interaction), Spectroscopic terms: L-S and J-J coupling schemes.

Unit-2 **Fine Spectra of Atom:** Hydrogen and He atom fine spectra, Fine spectra of alkali and alkaline earth elements, Zeeman and Paschene back effect, Stark effect.

Unit-3 **Hyperfine and X-ray Spectra:** Hyperfine spectra of atoms, nuclear magnetic resonance, X-ray spectra, Moseley's law, Spin and relativity doublet.

Unit-4 **Molecular Spectra:** Molecular spectra of diatomic molecules, rotation, vibrational and electronic bands, isotopic and spin effect of the nucleus, intensity of rotational, vibrational, and electronic bands.

Unit-5 **Raman Spectra:** Nature of Raman Spectra and its Experimental arrangement, Classical and quantum theory of Raman effect, Stokes and antistokes lines, Molecular structure, IR and Raman spectra, Application of Raman spectra.

References

1. M.C. Gupta, Atomic & Molecular Spectroscopy, (New Age International (P) Ltd. New Delhi) 2001.
2. Rajkumar, Atomic and Molecular Spectra: Laser, 5th Ed. (Kedarnath Ramnath Pub. Ltd., New Delhi) 2012.
3. S. L. Gupta, V. Kumar, R. C. Sharma, Elements of spectroscopy, 2nd Ed. (Pragati Prakashan, New Delhi) 1973.
4. J. B. Rajan, Atomic Physics, (S. Chand & Co., New Delhi) 1960.
5. P. F. Bernath, Spectra of Atoms of Molecules, 2nd Ed. (OXFORD Univ. Press, New York) 2005.

PH 97206: COMPUTER PROGRAMMING										
Subject Code	**Classes**			**Maximum Marks**				**Credits**		
	L	T	P	CW	End	SW	End	T	P	Tot
PH 97206	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**4**	**-**	**4**

Course Objective (CO): The objective of this course is to

1. develop the concepts of computer basics & programming with particular attention to Engineering examples.
2. skill the students for programming in C^{++}, MatLAB, MathCAD, LabVIEW and COMSOL Multiphysics.
3. explain the working of i/p, o/p devices and recognize the basic terminology used in computer programming.
4. develop the understanding of various 1D, 2D models and wave propagation under boundary conditions.

Expected Course Outcome (ECO): By the end of the course the students will be able to

1. write, compile and debug programs and use different data types for writing the programs.
2. design programs connecting decision structures, loops, and functions, pointers, address.
3. Use different data structures and create basic data files and developing applications for real world problems.
4. solve the problems attributed to scattering and impedance boundary conditions of wave propagations.

COURSE CONTENTS

Unit-1 **Programming in C^{++}**: Constants, variable and data types, operators, expressions, decision making, branching and looping, functions, declaration of functions, passing values of functions, arrays, initialization, arrays to functions printers, pointers as a addresses.

Unit-2 **MatLAB:** Introduction to basics, Array and matrices, Scripts and functions, additional functions, Graphics, Speed enhancement, styles and tricks, advanced data structures, Scientific computing (root finding, iterative algebra, optimization, data fitting, initial value, boundary value and initial-boundary value problems,

Unit-3 **MathCAD**: Regions, menus and basic operations. Solving linear equations with Mathcad, optimization using equations, blocks, solving ODE and PDE, programming, data exchange and analysis, image processing. Analysis to thin film layers, to boundary value problems is electromagnetism, animation with projectile motions.

Unit-4 **LabVIEW:** Front and diagram panels, icon, connectors, functions, acquisition, saving and loading data, using complex math functions, working with data types (array, cluster, strings, matrix, complex, etc), displaying, processing, printing and publishing results.

Unit-5 **COMSOL Multiphysics:** Introduction to various modules, 1D model, wave propagation, boundary conditions, transient response, meshing, 2D Model, perfectly matched layers (PML), scattering boundary conditions, frequency domain solutions, impedance boundary conditions, 2D axisymmetric model and 3D models, RF module applied to em wave propagation.

References

1. R. W. Pryor, Multiphysics Modelling Using COMSOL: A First Principle Approach, (Jones & Bartlett, Ontario, 2000)
2. R. Bitter, T. Mohiuddin, M. Nawrocki, LabVIEW Advanced Programming Techniques, (CRC Press, New York 2000)
3. Course work DVDs Basic LabVIEW Training Courses, National Instruments.
4. B. R. Hunt, R. L. Lipsman, J. M. Rosenberg, A Guide to Matlab, (Cambridge, 2010).
5. B. Maxfield, Engineering with Mathcad (Butterworth-Heinemann. 2006)

PH 97207: QUANTUM MECHNICS										
Subject Code	**Classes**			**Maximum Marks**				**Credits**		
	L	T	P	CW	End	SW	End	T	P	Tot
PH 97207	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**4**	**-**	**4**

Course Objective (CO): The objective of this course is to

1. apply quantum mechanics for the understanding of spherically symmetric potential.
2. demonstrate spin and angular momentum operator and their commutation relations.
3. explain the approximation and variational principle and the scattering theory.
4. develop the understanding of Dirac's relativistic Hamiltonian and relativistic wave equation.

Expected Course Outcome (ECO): By the end of the course the students will be able to

1. understand the wave function, probability current density and square well potential.
2. explain the identical particles, commutation relation of spin and angular momentum.
3. establish the position and time dependent approximation and vibrational principle.
4. solve the problems attributed to the scattering theory and relativistic wave equation.

COURSE CONTENTS

Unit-1 Introduction to Quantum Mechanics: Schrodinger's wave equation; interpretation of wave function: probability current density; 1D and 3D square well potential; linear harmonic oscillator; Heisenberg and quantum mechanical treatments; spherically symmetric potential in three dimensions; hydrogen atom.

Unit-2 Angular Momentum and Spin of Identical Particles: Angular momentum and spin operator, commutation relations; eigenvalues and eigen functions of the angular momentum; Pauli's spin matrices; Pauli's exclusion principle: indistinguishability of identical particles.

Unit-3 Perturbation Theory: Time independent perturbation; effect of an electric field on the energy levels of an atom (Stark effect); Time dependent perturbations; first-order transitions; constant perturbation; Fermi's golden rule; interaction of an atom with electromagnetic radiation.

Unit-4 WKB Approximation and Scattering Theory: WKB approximations; boundary conditions in the quasi-classical case; Bohr-Sommerfeld's quantization rule; penetration through a potential barrier, α decay, scattering cross sections and coefficients; scattering by spherically symmetric potentials, scattering by a Coulomb field, Born approximations.

Unit-5 Relativistic Wave Equations: Klein-Gordon equation for a free particle and particle under the influence of an electromagnetic potential; Dirac's relativistic Hamiltonian, Dirac's relativistic wave equation, significance of negative energy states; Dirac particle under the influence of an electromagnetic potential.

References

1. D.J. Griffith, Introduction to Quantum Mechanics, 2nd Ed. Prentice Hall, 2004.
2. N. Zettili, Quantum Mechanics: Concepts and Application, 2nd Ed., Wiley Eastern, 2009.
3. A. Ghatak and S. Lokanathan, Quantum Mechanics: Theory and Application, 1st Ed., Springer, 2004.
4. L. D. Landau and E. M. Lifshitz, Quantum mechanics: Non-relativistic Theory, 2nd Ed. Pergamon Press, 1965.
5. L. I. Schiff, Quantum Mechanics, 3rd Rev. Edition, McGraw Hill, 1968.
6. E. Merzbacher, Quantum Mechanics, 3rd Ed., Wiley Eastern, 1997.

PH 97208: SOLID STATE PHYSICS										
Subject Code	**Classes**			**Maximum Marks**				**Credits**		
	L	T	P	CW	End	SW	End	T	P	Tot
PH 97208	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**4**	**-**	**4**

Course Objectives (CO): The objective of this course is to

1. cultivate the basics of energy band formation, principle crystallography and crystal diffraction.
2. gain insight of phonons and their dynamics, and to evaluate their dispersive and thermal properties.
3. calculate thermal and electrical properties in the free-electron model.
4. comprehend the basic concepts of superconductivity and related phenomena and its applications.

Expected Course Outcome (ECO): By the end of the course student will be able to

1. explain the fundamental concepts of matter, methods available to determine their structure and properties.
2. demonstrate electronic and thermodynamic properties of solid-state systems and their applications.
3. solve the problems attributed to high temperature superconductivity.
4. formulate free electron model and calculate energy values of intrinsic and extrinsic semiconductor band.

COURSE CONTENTS

Unit-1 **X-Ray Crystallography**: Basics of crystal structures, symmetry, reciprocal lattice, Bravis lattice, imperfection in crystals, crystal diffraction, de-Broglie hypothesis, X-ray diffraction, Bragg's law, Brillouin zones, XRD, power XRD, rotation XRD, correction to Bragg's law.

Unit-2 **Lattice Vibrations**: Vibrations of one-dimensional monatomic and diatomic lattices, quantization of elastic waves, Normal modes and phonons, phonon momentum, Review of Debye's theory of lattice specific heat, density of states in 1D and 3D.

Unit-3 **Free electron Fermi gas:** Energy levels and density of orbitals in one and three dimensions, effect of temperature on Fermi Dirac distribution, electron transport phenomena and recombination, heat capacity of an electron gas, electrical conductivity and Ohm's law, electron motion in a magnetic field and hall effect thermal conductivity of metals.

Unit-4 **Superconductivity:** Occurrence ad destruction of superconductivity by magnetic fields; Meissner effect energy gap and isotope effect, thermodynamics of superconducting transitions, London equation, coherence length, elementary ideas of BCS theory, flux quantization, type II superconductors, single particle tunneling. DC and AC Josephson effects; elementary idea about high T_c superconductivity.

Unit-5 **Energy bands and semiconductor crystals:** Nearly free electron model, Bloch functions, Kroning-Penney model, wave equation of electron in a periodic potential number of orbitals in a band. Metal, insulator, and semiconductors, Band-gap, Intrinsic and extrinsic semiconductors, Carrier concentration and Fermi levels of intrinsic and extrinsic semi-conductors Bandgap, Direct and indirect gap semiconductors.

References

1. C. Kittel, Introduction to Solid State Physics, 5th Ed. (Wiley Eastern Ltd., New Delhi) 1993.
2. S. O. Pillai, Solid State Physics, (New Age International (P) Ltd., New Delhi) 1997.
3. S. M. Sze, Physics of Semiconductor Devices, (Wiley Eastern Ltd., New Delhi) 1993.
4. R.L. Singhal, Solid State Physics, (Kedarnath Ram Nath Publishers, New Delhi) 2012.
5. S. M. Sze, Physics of Semiconductor Devices, (Wiley Eastern Ltd., New Delhi) 1993.

PH 97305: NUCLEAR AND PARTICLE PHYSICS										
Subject Code	**Classes**			**Maximum Marks**				**Credits**		
	L	T	P	CW	End	SW	End	T	P	Tot
PH 97305	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**4**	**-**	**4**

Course Objectives (CO): The objective of this course is to

1. allow students to develop a strong footing in the fundamentals of nuclear forces.
2. gain insight about the basic properties of nuclei and nuclear structure.
3. develop the capability of elementary problem solving in nuclear and particle physics.
4. comprehend the basic concepts of nuclear physics for relating theoretical predictions and measurement results.

Expected Course Outcome (ECO): By the end of the course student will be able to

1. have deep understanding of two body central force problem.
2. demonstrate various nuclear model and explain theories of X-rays and beta particle emissions
3. solve the problems attributed central force, particle emission, particle accelerators of elementary particles.
4. cultivate the knowledge about the type of interaction of elementary particles and their properties.

COURSE CONTENTS

Unit-1 **Two Body Problem and Nuclear Forces:** The deuteron, ground state and experimental data, excited state of deuteron, spin dependence of nuclear forces, scattering cross section, neutron – proton scattering at low energies, high energy nucleon scattering, exchange forces, meson theory of nuclear forces.

Unit-2 **Nuclear Models:** Introduction, degenerate gas model liquid drop model, X-particle model, shell model, spin orbit coupling model, collective and optical models, theories of X-rays and beta particle emissions, barrier penetration, fine structure of X-rays, Fermi's theory of beta decay, parity violation in beta decay and electron capture, X-ray absorption in matter, internal conversion, electron position pair production.

Unit-3 **Particle Accelerators:** Cyclic accelerators, cyclotron, magnetic focusing and orbit stability, radiation loss of energy, synchrocyclotron, electron and proton synchrotron, betatron, biased betatron (Linac) linear accelerator (Microwave).

Unit-4 **Nuclear Reactions:** Conservation laws of nuclear reactions, reaction energies and Q value, threshold energy, binding energy and of value charged particle induced reactions, neutron induced reaction, photodisintegration, reaction cross section, theories of nuclear reactions, compound nucleus, excitation energy, direct reactions, theory of stripping and pick up reactions, partial wave analysis of nuclear reaction cross section, fission, fission fragment distribution, fission neutrons, chain reaction controlled chain reaction, nuclear fusion, controlled fusion, physics of nuclear reactors.

Unit-5 **Elementary Particles:** Production of new particles in high energy reactions, types of interaction and their relative strengths, parameters of elementary particles like quantum number, mass baryon number, strangeness, parity charge conjugation etc., conservation laws and their validity, properties of elementary particles, resonance states of elementary particles, quarks.

References

1. B.L. Cohen, Concepts of Nuclear Physics, (Tata McGraw Hill, New Delhi) 2012.
2. M. L. Pandya & R.P.S. Yadav, Elements of Nuclear Physics, 7th Ed. (Ked. Ram Nath Pub., New Delhi) 2012.
3. R. R. Roy and B. P. Nigam, Nuclear Physics theory and experiment, 1st Ed. (Wiley Eastern, New Delhi) 2000.
4. D.C. Tayal, Nuclear Physics, 4th Ed. (Himalaya Pub. House, Bombay) 1994.
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PH 97306: FIBER OPTICS AND INTIGRATED OPTICS										
Subject Code	**Classes**			**Maximum Marks**				**Credits**		
	L	T	P	CW	End	SW	End	T	P	Tot
PH 97306	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**4**	**-**	**4**

Course Objectives (CO): The objective of this course is to

1. deliver the knowledge about optical waveguide and TE, TM mode propagation.
2. gain insight about the basic properties of optical fiber waveguide and their mode analysis.
3. develop elementary problem-solving capability of EM propagation in waveguide and anisotropic medium.
4. comprehend the basic concepts of integrated optics for directional coupler and coupled wave theory.

Expected Course Outcome (ECO): By the end of the course student will be able to

1. have deep understanding of EM wave propagation in symmetric and asymmetric optical wave guide.
2. demonstrate various fabrication and cabling techniques of optical fiber and its application.
3. solve the problems attributed mode propagation attenuation and dispersion of optically bounded EM wave.
4. deliver the knowledge about the type of optical waveguide and anisotropic crystals.

COURSE CONTENTS

Unit-1 Introduction: The optical fiber, comparison of optical fiber with other inter connectors, concept of an optical waveguide, rays and modes, principle of light guidance in optical wave guides, fiber types, Electromagnetic analysis of simplest optical waveguide; basic wave guide equation, propagating modes of symmetric step index planar waveguide, TE modes of symmetric step index planar waveguide, the relative magnitude of longitudinal component of electric and magnetic field, power associated with a mode, radiation modes, leaky modes.

Unit-2 Optical fiber waveguides: Scalar wave equation and modes of fiber, modal analysis for step index fiber, fractional power in the cone, modal analysis of parabolic index medium. Attenuation in optical fiber, pulse dispersion in optical fiber losses at fiber splices, measurement of refractive index profile and spot size of an optical fiber.

Unit-3 Optical fiber Fabrication, Cabling and Applications: Material consideration, loss and band width limiting mechanisms, mechanical and thermal characteristics, perform fabrication of multicomponent glass fibers, mechanical consideration for optical fiber cabling, fiber cable design, example of cable design. Applications: Fiber optic components and devices, fiber optic sensors.

Unit-4 Integrated Optics: Modes in an asymmetric planar waveguide, strip waveguides, the optical directional coupler and coupled mode theory, some guided wave devices, periodic waveguides, fabrication of optical waveguide.

Unit-5 EM Wave Propagation in Anisotropic Crystals: index ellipsoid index ellipsoid in presence of external electric field. Electrooptic (EO) effect in KDP crystals, EO devices. Acoustooptic (AO) effects. Raman-Nath and Bragg AO effect. AO devices.

References

1. A. Ghatak & K. Thyagarajan, Optical electronics, (Cambridge Univ. Press, Cambridge) 1989.
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3. Robert G. Hunsperger, Integrated Optics: Theory & Technology (Springer, New Delhi) 6th Ed., 2009.
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PH97307: NANO SCIENCE & NANO TECHNOLOGY											
Subject Code	**Classes**			**Maximum Marks**					**Credits**		
	L	T	P	CW	End	SW	End	Total	T	P	Tot
PH 97307	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**100**	**4**	**-**	**4**

Course Objectives (CO): The objective of this course is to

1. provide understanding of fundamental and applied concepts of nano materials.
2. develop a familiarity with the characterization tools used for the analysis of electrical optical and structural properties of nano materials.
3. demonstrate the basic functioning of nano fabrication techniques.
4. cultivate the fundamental understanding of metal semiconductor alloys, micro and nano elector mechanical systems.

Expected Course Outcome (ECO): By the end of the course student will be able to

1. have deep understanding of two body central force problem.
2. demonstrate various nuclear model and explain theories of X-rays and beta particle emissions
3. solve the problems attributed central force, particle emission, particle accelerators of elementary particles.
4. cultivate the knowledge about the type of interaction of elementary particles and their properties.

COURSE CONTENTS

Unit-1 Introduction: Photon and phonon, fermi distribution and density of states, doping and alloying, electron waves, effective mass of electron and holes, energy band gap, drift, diffusion and tunneling, boundary conditions, metal-semiconductor contacts, carrier mobility, exitons.

Unit-2 Characterization-Tools: Scanning electron microscopy and energy dispersive x-ray, tunnelling electron microscopy, atomic force microscopy, UV-VIS spectroscopy, ellipsometry, fluorescence spectroscopy, x-ray diffraction, I-V, C-V and Q-V measurements.

Unit-3 Fabrication Techniques: Top-down and bottom-up methods, molecular beam epitaxy, atomic layer deposition, pulsed laser deposition, chemical vapor deposition, spin coating, thermal and magnetron sputtering, UV optical lithography.

Unit-4 Materials Properties: 3D, 2D, 1D and 0D confinement of nanostructure, Optical and electrical properties: Si, Ge, SiO_2, SiN, GaAs, InSb, CdS, CdSe, ZnO, $Al_xGa_{1-x}N$, $Al_xGa_{1-x}As$, $In_xN_{1-x}P$, $Cd_xSe_{1-x}Te$, $S_xZn_{1-x}O$, $Al_xGa_{1-x}In_yAs_{1-y}$, $Al_xGa_{1-x}As_yIn_{1-y}$, $Mg_xZn_{1-x}S_yTe_{1-y}$.

Unit-5 MEMS & NEMS: Sensing and actuation, pressure-, flow-, acceleration-sensors, imaging and display, DMD, laser tuning, wavelength locker, M x N optical switch, microfluidics, mixing microfluids, Applications to RF system.

References

1. S. Lindsay, Introduction to Nanoscience, (Oxford university Press,) 2014.
2. N. Maluf,and K. Williams, An Introduction to Microelectromechanical Systems Engineering, 2nd Ed., (Artech House Boston) 2004.
3. J. H. Davies, The Physics of Low-dimensional semiconductors (Cambridge, Cambridge, 1998).
4. S. K. Kulkarni, Nanotechnology: Principles and Practices (Capitol, Delhi 2007)
5. J. Piprek, Semiconductor optoelectronic Devices, Introduction to physics and simulation, Academic Press, London, 2003.

PH97308: LASER AND APPLICATIONS											
Subject Code	**Classes**			**Maximum Marks**					**Credits**		
	L	T	P	CW	End	SW	End	Total	T	P	Tot
PH 97308	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**100**	**4**	**-**	**4**

Course Objectives (CO): The objective of this course is to

1. provide understanding of Einstein's A&B coefficients, population inversion in three and four level lasers.
2. develop a familiarity with the Q-factor of laser oscillations, Q-switching and mode looking mechanism.
3. demonstrate the basic functioning solid state, gases, and semiconductor lasers.
4. cultivate the elementary understanding of nonlinear optics and versatile applications of lasers.

Expected Course Outcome (ECO): By the end of the course student will be able to

1. have deep understanding of light matter interaction, gain and absorption coefficients.
2. demonstrate working of various lasers like Ruby, He-Ne, excimer, and free electron etc.
3. solve the problems attributed to the stable and unstable resonators, active and passive Q-switching.
4. cultivate the knowledge about the nonlinear optics and laser applications in drilling cutting and sensing.

COURSE CONTENTS

Unit-1 Interaction of Radiation with Matter: Stimulated and spontaneous emission. Einstein's A&B coefficients, line broadening mechanisms, gain and absorption coefficients, principles of laser, population inversion, population inversion in three and four level lasers, laser amplification, conditions for

Unit-2 Laser Beam Output Modifications: Q-factor of laser oscillations, laser linewidth, resonators, stable and unstable resonators, a laser cavity, active and passive Q-switching, mode looking, detection of pulsed laser output.

Unit-3 Various Kinds of Lasers: some representative laser system, Ruby, He-Ne, CO_2, Nd-glass lasers, cu-vapour, N_2 argon, excimer laser, semiconductor, and free electron lasers.

Unit-4 Elementary Concepts of Nonlinear Optics: Operating principles and characteristics, introduction second order optical susceptibility, parametric up and down conversion, second harmonic generation, third order optical susceptibility, nonlinear refraction and absorption, optical phase conjugation.

Unit-5 Applications of Lasers: Material processing, cutting, drilling, welding, communication, holography, lasers in biology and medicine laser spectroscopy, laser Raman spectroscopy, laser remote sensing laser plasma interaction, laser induced fusion.

References

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3. A. Yariv, Quantum Electronics –3rd Ed. (John Wiley & Sons, New York) 1989.
4. A. K. Ghatak and K. Thyagarajan, Optical Electronics, (Cambridge Univ. Press, New Delhi) 1989.
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