CURRICULUM & SYLLABUS

CHOICE-BASED CREDIT SYSTEM (CBCS)

FOR

MASTER OF SCIENCE (M.Sc.)

(2 Year Postgraduate Degree Program)

IN

PHYSICS

[w. e. f. 2025-26]

FACULTY OF SCIENCE AND HUMANITIES

SRM UNIVERSITY DELHI-NCR, SONEPAT

Plot No.39, Rajiv Gandhi Education City, P.S. Rai, Sonepat Haryana-131029

SRM UNIVERSITY DELHI-NCR, SONEPAT (HARYANA)

VISION

SRM University Haryana aims to emerge as a leading World Class Institution that creates and disseminates knowledge upholding the highest standards of instruction in Engineering & Technology, Science & Humanities, Commerce, Management, Hotel Management & Medicine & Health Science. Along with academic excellence, our curriculum imparts integrity and social sensitivity so that our graduates may best serve the Nation and the World.

MISSION

- To create a diverse community campus that inspires freedom and innovation.
- Strengthen Excellence in educational & skill development processes.
- Continue to build productive international alliances.
- Explore optimal development opportunities available to students and faculty.
- Cultivate an exciting and rigorous research environment.

DEPARTMENT OF PHYSICS

VISION

The Department of Physics at SRM University Delhi-NCR is a young and dynamic Department. However, it is growing rapidly in every aspect. At present, we are offering a four-year B.Sc. (Hons), four-year B.Sc. (Hons) with Research/Academic Project and a two-year M.Sc. in physics. We also offer a Ph.D. program in Physics. Further, we also offer a one semester course on Physics to the first year B.Tech. students of this university. Our department strives to become a center of excellence for higher studies in Physics focused on advanced learning, innovation and knowledge transfer from lab to industry. Our vision is to establish a research-based ecosystem that will put equal stress upon the fundamental branches of physics as well as applied areas, particularly, on topics which have interfaces with other branches of physics. The faculty members as well as the research scholars at the Department are actively engaged in cutting-edge research in different areas of Physics. Our Department envisions to build an academic ambience where 'knowledge is free' of all bounds, innovative and creative ideas are encouraged, and talents are nurtured to realize their full potential.

MISSION

- We aim to offer a balanced blending of comprehensive training in the core areas of physics along with the cutting-edge recent topics of physics.
- We tried to keep a balance between the theoretical courses and experimental courses with an emphasis on problem-solving. This will help the students to develop fundamental concepts, verify them in the lab and thereby discourage the rote-learning.
- Our motto is to prepare a student with the fundamental concepts of physics as well as the skills required to apply them so that they can go on to become a professional physicist in future.
- Overall, we intend to equip a student with the right aptitude and skills so that they can go on to become a professional Physicist in future.
- Additionally, we also intends to inculcate skills like logical thinking, quantitative argumentation, and capability of analyzing a large amount of information (or data) in the students so that even those, who are not going to build a career as a professional physicist, will benefit both professionally and also as a human being.

SCIENCE GRADUATE EMPLOYMENT ATTRIBUTES

- **Able to Apply their Knowledge and Skills in the Disciplinary Area**
- **Analytical & critical thinking and problem-solving skills.**
- **Scientific Temperament Towards Research & Innovation for the Betterment of Society**
- **Efficient Communication & Presentation Skills**
- **Dependability, reliability, responsibility, and independent leadership abilities**

M. Sc. PHYSICS PROGRAM EDUCATIONAL OBJECTIVES

The primary objective of the Master program in Physics is imparting students with an in-depth knowledge and understanding of the subject. While the core courses such as Mathematical Physics, Classical Mechanics, Quantum Mechanics, Statistical Mechanics, and Electrodynamics aims to prepare the students with deep understanding of the fundamental laws of Physics, the elective courses such as Solid-State Physics, Plasma Physics, Electronics, Nuclear and Particle Physics, and Atomic and Molecular Physics should make them familiar with manifestation of these fundamental laws in specific systems or conditions.

Through dissertations and tutorials, it aims to inculcate creative thinking and problem-solving capabilities in the students. The elective and open elective courses are designed in a manner that it will equip the students with a broader knowledge of advanced topics of Physics. The core and elective labs are designed to develop an appreciation for the fundamental concepts and working of devices used in everyday life employing scientific methods/tools of physics. Computational physics course is aimed to equip the students to use computers as a tool for scientific investigations/understanding. The dissertation(s) in both theory and experimental stream are expected to give a flavor of how research leads to new findings. In addition, the M.Sc. course is to lay a solid foundation for a doctorate in Physics/allied subjects later.

M. Sc. PHYSICS PROGRAM LEARNING OUTCOMES

- Understanding the basic concepts of core courses such as classical mechanics, quantum mechanics, statistical mechanics, and electrodynamics to appreciate the underlying principles governing the natural phenomena through logical and mathematical reasoning.
- Understanding the basic concepts of certain advanced fields such as nuclear physics, atomic and molecular physics, solid state physics, plasma physics, and astrophysics, general theory of relativity, nonlinear dynamics, and complex system.
- Learning how to carry out experiments in basic as well as advanced areas of physics.
- Gaining hands-on experience to work in applied fields.
- Developing an attitude and capability for critical thinking and reasoning that can be applied to diverse fields.

M.Sc. Physics Programme Structure

S. No.	Course Type	No. of Courses	Credits	%
1	Core Courses	14	14×4 $+ 2 \times 2 = 52$	57.8
2	Generic (GE)	2	$2 \times 4 = 8$	8.9
3	Discipline Specific Elective (DSE)	6	$6 \times 4 = 24$	26.7
4	Project	1	06	6.7
	Total	23	90	100

M.Sc. Physics Programme structure component-wise distribution

S. No.	Course Type	No. of Courses	Component	Course division	Credits	Total Credit	%
1	Core Courses	14	Theory	10	10 × 4 = 40	52	57.8%
			Practical	4	2 × 2 + 2 × 4 = 4		
2	Generic Elective (GE)	2	Theory	2	2 × 4 = 8	8	8.9%
3	Discipline Specific Elective (DSE)	6	Theory	4	4 × 4 = 16	24	26.7%
			Practical	2	2 × 4 = 8		
4	Project	1	--	1	1 × 6 = 6	6	6.7%
	Total	23	Theory	64/90 = 71%		90	100%

SUMMARY OF CREDITS

Category	I Sem	II Sem	III Sem	IV Sem	Total	%
CORE	20	18	10	04	52	57.8
GENERIC ELECTIVE	04	04	-	-	08	8.9
DISCIPLINE SPECIFIC ELECTIVE	-	-	12	12	24	26.7
PROECT	-	-	-	06	06	6.7
TOTAL	24	22	22	22	90	100

COURSE REVISION DETAILS

FOLLOWING DISCIPLINE SPECIFIC COURSES ARE INTRODUCED.

1. Quantum Computation I (25PHMS315)
2. Quantum Computation I Lab (25PHMS355)
3. Classical and Quantum Informatics (25PHMS316)
4. Quantum Computation II (25PHMS414)
5. Quantum Machine learning (25PHMS415)
6. Quantum Computation Lab II (25PHBS454)
7. Classical field theory (25PHMS314)
8. Quantum field theory (25PHMS413)
9. Astrophysics Lab (25PHMS455)

MAJOR CHANGES ARE THERE IN THE FOLLOWING GENERIC ELECTIVE COURSES

1. MATLAB (25OEPH201)

SEMESTER-I

Code	Category	Course	L	T	P	C
THEORY						
25PHMS 101	Core Course	Mathematical Physics	3	1	0	4
25PHMS 102		Classical Mechanics	3	1	0	4
25PHMS 103		Quantum Mechanics I	3	1	0	4
25PHMS 104		Electrodynamics	3	1	0	4
24OEPH101	Generic Elective I	Clean and Renewable energy Physics	3	1	0	4
24OEPH102		Biophysics				
PRACTICAL						
25PHMS 151	Core	Physics Lab I (General)	0	0	8	4
Total			15	5	8	24

SEMESTER-II

Code	Category	Course	L	T	P	C
THEORY						
25PHMS 201	Core Course	Solid State Physics	3	1	0	4
25PHMS 202		Quantum Mechanics II	3	1	0	4
25PHMS 203		Electronics	3	1	0	4
24OEPH201	Generic Elective II	MATLAB	3	1	0	4
24OEPH202		Programming in C				
PRACTICAL						
25PHMS 251	Core	Physics Lab II (General)	0	0	8	4
25PHMS 252	Core	Computational Physics Lab I	0	0	4	2
Total			12	4	12	22

SEMESTER-III

Code	Category	Course	L	T	P	C
THEORY						
25PHMS 301	Core Course	Atomic & Molecular Physics	3	1	0	4
25PHMS 302		Statistical Mechanics	3	1	0	4
25PHMS 303	Discipline Specific Elective 1	Advanced Solid State Physics I	3	1	0	4
25PHMS 304		Nanomaterials				
25PHMS 305		Soft Matter Physics				
25PHMS 306		Laser Physics & Applications				
25PHMS 307		Nanophotonics				
25PHMS 308		Nonlinear Spectroscopy				
25PHMS 309	Discipline specific Elective II	Analog Communication	3	1	0	4
25PHMS 310		Digital Communication				
25PHMS 311		Optoelectronics				
25PHMS 312		Nuclear Physics I				
25PHMS 313		Astrophysics I				
25PHMS 314		Classical Field Theory				
25PHMS 315		Quantum Computation I				
23PHMS 316		Classical and Quantum Informatics				
PRACTICAL						
25PHMS 351	Core Lab	Computational Physics Lab II	0	0	4	2
25PHMS352	Discipline specific Lab	Advanced Solid State Physics Lab I	0	0	8	4
25PHMS353		Laser &Spectroscopy Lab1				
25PHMS354		Electronics Lab I				
25PHMS355		Quantum Computation Lab I				
		Total	12	4	12	22

Note: The student will opt any one option which will be continued in IV Semester as well.

SEMESTER-IV

Code	Category	Course	L	T	P	C
Theory						
25PHMS 401	Core Course	Nuclear and Particle Physics	3	1	0	4
25PHMS 402	Discipline Specific Elective 1II	Advanced Solid State Physics II	3	1	0	4
25PHMS 403		Characterization of materials				
25PHMS 404		Nanomagnetism And Spintronics				
25PHMS 405		Fiber Optics Sensors				
25PHMS 406		Applied Optics				
25PHMS 407		Rotational & Vibrational Molecular Spectroscopy				
25PHMS 408	Discipline specific Elective IV	Novel and Smart Materials	3	1	0	4
25PHMS 409		Microprocessor & Interfacing				
25PHMS 410		Semiconductor Physics				
25PHMS 411		Nuclear Physics II				
25PHMS 412		Astrophysics II				
25PHMS 413		Quantum Field Theory				
25PHMS 414		Quantum Computation II				
23PHMS 415		Quantum Machine L:earning				
Practical						
25PHMS 451	Discipline specific Lab	Advanced Solid State Physics Lab II	0	0	8	4
25PHMS 452		Laser & Spectroscopy Lab I1				
25PHMS 453		Electronics Lab II				
25PHMS 454		Quantum Computation Lab II				
25PHMS 455		Astrophysics Lab				
25PHMS 491	Project	Dissertation (Compulsory)	0	0	12	6
Total			12	0	20	22

CORE COURSES (THEORY)

1. Mathematical Physics (25PHMS101)
2. Classical Mechanics (25PHMS102)
3. Quantum Mechanics I (25PHMS103)
4. Electrodynamics (25PHMS104)
5. Solid State Physics(25PHMS201)
6. Quantum Mechanics II (25PHMS202)
7. Electronics (25PHMS203)
8. Atomic & Molecular Physics (25PHMS 301)
9. Statistical Mechanics (25PHMS302)
10. Nuclear and Particle Physics (25PHMS401)

MATHMATICAL PHYSICS	
Course Code: 25PHMS101	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Prerequisite: Basic knowledge about linear algebra and tensors, differential equation and complex variables	

COURSE OBJECTIVES

1. To make the students familiar with basic mathematical concepts of linear algebra and tensors.
2. To study second order homogeneous and inhomogeneous differential equations.
3. To develop an advanced level of understanding of complex variables and their integrals.
4. To make the students familiar with Group Theory.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with various mathematical concepts in linear algebra and tensors.
2. Able to solve second order homogeneous and inhomogeneous differential equations.
3. Well versed with complex variables and evaluate complex integrals using Cauchy Integral theorem in various forms and residue theorem.
4. Familiar with the basics of Group Theory.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENTS

Unit I: LINEAR ALGEBRA & TENSORS ANALYSIS

Vector space: Axiomatic definition, linear independence, bases, dimensionality, inner product; Gram-Schmidt orthogonalization. Matrices: Representation of linear transformations and change of base; Matrix diagonalization; Eigenvalues and eigenvectors; Functions of a matrix; Cayley-Hamilton theorem; Commuting matrices with degenerate eigenvalues; Orthonormality of eigenvectors.

Physical Laws, Spaces of N dimensions, Coordinate transformation, The summation convention, Contravariant and covariant vectors, contravariant, covariant and mixed tensor, The Kronecker delta, Tensor of rank greater than two. The line element and metric tensor, conjugate or reciprocal tensors. Associated tensors. Christoffel's symbols. Transformation laws of Christoffel's symbols.

Unit II: THEORY OF SECOND ORDER DIFFERENTIAL EQUATION

Homogeneous equation: Regular and irregular singular points; Fresenius method; Foch's theorem; Linear independence of solutions, Wronskian, second solution. Sturm-Liouville theory; Hermitian operators; Completeness, Solution of inhomogeneous Differential equation by green's functions.

Unit III: COMPLEX ANALYSIS

Analytic function, Cauchy-Riemann conditions, Cauchy's integral theorem, Cauchy's Integral formula, Taylor's and Laurent's series, singular points, branch point and branch cut, residues, evaluation of residues, Cauchy's residue theorem, Jordan's lemma, evaluation of real definite integrals.

Unit IV: GROUP THEORY

Definitions; Multiplication table; Rearrangement theorem; Isomorphism and homomorphism; Illustrations with point symmetry groups; Group representations: faithful and unfaithful representations, reducible and irreducible representations; Lie groups and Lie algebra, SU(2), SU(3), SO(2), SO(3) algebra.

TEXT BOOKS

1. Mathematical Methods for Physicists, G. Arkin, H.J. Weber, and F. E. Harris, (Elsevier).
2. Mathematical Methods for Physicists, T. L. Chow (Cambridge university press).
3. Matrices and Tensors in Physics, A.W. Joshi (Wiley Eastern).
4. Group Theory, A.W. Joshi (Wiley Eastern).

REFERENCE BOOKS

1. Group Theory and Its Application to Physical Problems, M. Hamermesh (Dover Publications).
2. Mathematical Physics, P.K. Chattopadhyay (Wiley Eastern).
3. Introduction to Mathematical Physics, C. Harper (Prentice Hall of India).
4. Mathematical Methods in the Physical Sciences, M.L. Boas (Wiley).
5. Applied Mathematics for Engineers and Physicists, L Pipes& L.R. Horwell.
6. Complex variables and Applications, J. W. Brown & R. V. Churchill (McGraw-Hill).
7. Schaum's outline of Complex variables, M. R. Spiegel, S. Lipschutz, J. J. Schiller, D. Spellman (McGraw-Hill).
8. Mathematical Methods for Physics, J. Mathews and R. L. Walker, (Addison-Wesley).

CLASSICAL MECHANICS	
Course Code: 25PHMS102	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Prerequisite: Basic knowledge about Newtonian Mechanics.	

COURSE OBJECTIVES

1. To understand the formalism of Classical Mechanics.
2. Developing students understanding of the fundamental dynamical problems from real-world viz., rigid body motion and small oscillations.
3. To introduce the Classical field theory.
4. To study special theory of relativity using tensors.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with knowledge of the advanced techniques of classical mechanics and skills to apply those techniques to real world problem.
2. Fluent with the dynamics of rigid bodies and small oscillations.
3. Get a basic understanding of Classical field theory.
4. Get an understanding of special theory of relativity.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENTS

Unit-I: FORMALISMS OF CLASSICAL MECHANICS

Difficulty in Newtonian mechanics, Constraints of motion, generalized coordinates, D' Alembert's Principle and Lagrange's equation, Velocity dependent forces and the dissipation function, Simple applications including central force problem (equation of motion only). Hamilton principle, Lagrange's equation from Hamilton principle, extension to non-holonomic systems, Legendre Transformation, Hamilton's equations of motion, Hamilton's equations from variation principle, Principle of least action.

Canonical transformation and its examples, Poisson's brackets, Equation of motion, Angular momentum, Poisson's Brackets relations, infinitesimal canonical transformation, Conservation Theorems and symmetry properties. Hamilton-Jacobi equation for Hamilton's principal function, Harmonic Oscillator problem.

Unit II: RIGID BODY MOTION AND SMALL OSCILLATIONS

Independent coordinates; orthogonal transformations and rotations (finite and infinitesimal); Euler's theorem, Euler angles; Inertia tensor and principal axis system; Euler's equations; Heavy symmetrical top with precession and nutation, Free vibrations, Normal coordinates, Euler angles, forced oscillations and effect of dissipative forces. Vibration of Tri-atomic Molecule.

Unit III: INTRODUCTION TO CLASSICAL FIELD THEORY

System with infinite degrees of freedom, Classical fields: Lagrangian and Hamiltonian formulations Equations of motion. Symmetries and invariance principles, Noether's theorem.

Unit IV: SPECIAL THEORY OF RELATIVITY

Lorentz transformations; 4-vectors, Tensors, Transformation properties, Metric tensor, Raising and lowering of indices, Contraction, Symmetric and antisymmetric tensors; 4-dimensional velocity and acceleration; 4-momentum and 4-force; Covariant equations of motion; Relativistic kinematics (decay and elastic scattering); Lagrangian and Hamiltonian of a relativistic particle.

TEXT BOOKS

1. Classical Mechanics,H. Goldstein, C.Poole& J. Safko, (Pearson Education Asia, New Delhi).
2. Classical Mechanics,N.C. Rana and P.S. Joag (Tata McGraw-Hill, 1991).
3. Classical Mechanics, A Course of Lectures: A K Raychaudhuri (Oxford University Press).
4. Classical Mechanics. Rana and P.S. Joag (Tata McGraw-Hill, 1991).

REFERENCE BOOKS

1. Classical Mechanics, A Course of Lectures: A K Raychaudhuri (Oxford University Press).
2. Classical Mechanics. Rana and P.S. Joag (Tata McGraw-Hill, 1991).

QUANTUM MECHANICS I	
Course Code: 25PHMS103	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Pre-requisite: Basic knowledge about Quantum Mechanics.	

COURSE OBJECTIVES

1. To develop an advanced level of understanding of Schrödinger equation and its applications.
2. To make the students well verse with operators in quantum mechanics.
3. To make the students gain understanding of angular momentum algebra.
4. To study time independent approximation methods.

COURSE LEARNING OUTCOME

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the understanding of Schrödinger equation and its applications.
2. Fluent with the operator application on wave function and their outcome.
3. Get an understanding of angular momentum algebra.
4. Able to understand the time independent perturbation theory and its applications.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENTS

Unit I: SCHRÖDINGER EQUATIONS AND APPLICATIONS

The Schrödinger equations: Time dependent and time independent forms, Probability current density, expectation values, Ehrenfest's theorem, Gaussian wave packet and its spreading. Exact statement and proof of the uncertainty principle, minimum uncertainty wave packet, eigenvalues and Eigen functions, wave function in coordinate and momentum representations, Degeneracy and orthogonality. One dimensional problem: Harmonic Oscillator, delta potential, Double-delta potential; Aharonov-Bohm effect, Three dimensional problems: 3-D spherical well and Fermi energy, free particle, 3-D harmonic oscillator, and Hydrogen atom.

Unit II: OPERATORS

Operator in quantum mechanics, Hermitian operator and Unitary operator change of basis, Eigenvalues and eigenvectors of operators, Dirac's Bra and Ket algebra, Linear harmonic oscillator, coherent states, Time development of states and operators, Heisenberg, Schrödinger and interactive pictures, annihilation & creation operators, Matrix representation of an operator, Unitary transformations.

Unit III: ANGULAR MOMENTUM

Angular momentum algebra, Commutation relations, Eigenvalues and eigenvectors of L^2 and L_z. Ladder operators and their matrix representations, Spin angular momentum, Eigenvalues and eigenvectors of J^2 and J_z. Representation of general angular momentum operator, Addition of angular momentum, C.G. coefficients, Wigner-Ekrat theorem.

Unit IV: TIME INDEPENDENT APPROXIMATION METHODS

Perturbation theory: Nondegenerate case, Degenerate case, Application to one-electron system - Relativistic mass correction, Spin-orbit coupling (L-S and j-j), Zeeman effect and Stark effect. The Variational Method, Helium atoms, Vander-Waal interactions. Exchange degeneracy; Ritz principle for excited states for Helium atom, WKB Approximation: WKB method for one-dimensional problems, Application to barrier penetration.

TEXTBOOKS

1. Quantum Mechanics, L.I. Schiff(Tata McGraw-Hill).
2. Quantum Mechanics,B.Craseman and J.L. Powell(Narosa Publishing House).
3. Quantum Mechanics, S.Gasiorowicz (Wiley).
4. Modern Quantum Mechanics, J.J. Sakurai (Addison Wesley).
5. Quantum Mechanics, P.M. Mathews & K.Venkatesan(Tata McGraw-Hill).

REFERENCE BOOK

1. Quantum Mechanics,V.K.Thankappan(New Age International Publisher).
2. Quantum Mechanics, Concepts and Applications,N.Zettili (John Wiley & Sons Ltd.).
3. Quantum Mechanics,B.H.Bransden and C.J. Joachain (Pearson Education).

ELECTRODYNAMICS	
Course Code: 25PHMS104	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Prerequisite: Basic knowledge about Electricity and Magnetism	

COURSE OBJECTIVES

1. To review the fundamental laws of electrodynamics.
2. To study EM waves in free space, dielectric and conducting media.
3. To develop an understanding of relativistic electrodynamics.
4. To make the students familiar with radiation and related concepts.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the knowledge about the fundamental laws of electrodynamics.
2. Get an understanding of EM waves in free space, dielectric and conducting media.
3. Gain understanding of relativistic electrodynamics.
4. Able to understand radiation and related concepts.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENTS

Unit I: REVIEW OF MAXWELL'S EQUATION

Maxwell's equations in free space and linear isotropic media, Boundary conditions on the fields at interfaces. Scalar and vector potentials. Gauge transformations. Coulomb and Lorentz gauges, Multipole expansion of (i) scalar potential and energy due to a static charge distribution (ii) vector potential due to a steady current distribution. Electrostatic and Magnetostatic energy. Poynting's theorem. Maxwell's stress tensor. Euler-Lagrange equation for the electromagnetic field. The field momentum. Equation of motion in an electromagnetic field.

Unit II: ELECTROMAGNETIC WAVES

Plane EM wave in free space and dielectric media, Reflection and Transmission at dielectric interface, Normal and Oblique incidence, Fresnel's law, Brewster angle, Polarization by reflection and Total internal reflection, Waves in a conducting media: Absorption and dispersion, Skin depth, Reflection at conducting surface, Wave guides: TE mode, TM mode, cut off wavelength. Coaxial transmission line.

Unit III: RELATIVISTIC ELECTRODYNAMICS

Electromagnetic field tensor, Covariance of Maxwell's equations; Lorentz transformation for the electromagnetic fields; Field invariants; Covariance of Lorentz force equation and conservation laws, Relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field and the equation of motion of a charged particle in an electromagnetic field.

Unit IV: RADIATIONS

Radiation from localized sources and multipole expansion in the radiation zone. Lienard-Wiechert potentials; Fields due to a charge moving with uniform velocity; Fields due to an accelerated charge; Radiation at low velocity; Larmor's formula. its relativistic generalization: Radiation when velocity (relativistic) and acceleration are parallel, Bremsstrahlung; Radiation when velocity and acceleration are perpendicular, Synchrotron radiation; Thomson scattering. Cherenkov radiation (qualitative treatment only). Abraham-Lorentz formula for the radiation reaction force.

TEXTBOOKS

1. Introduction to Electrodynamics, David J. Griffiths, (Prentice Hall India).
2. Classical Electrodynamics, J.D. Jackson, (Wiley Eastern).
3. Classical Electromagnetic Radiation, J.B. Marion and M.A. Heald, (Academic Press).

REFERENCE BOOK

1. Classical Electromagnetic Radiation, J.B. Marion and M.A. Heald, (Academic Press).
2. Classical Electricity & Magnetism: W. K. H. Panofsky and M. Phillips.

SOLID STATE PHYSICS	
Course Code: 25PHMS201	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Prerequisite: Basic knowledge about crystal physics, band theory of solids	

COURSE OBJECTIVES

1. To understand the crystal structure and different structural parameters.
2. To understand crystal bonding, defects and diffusion in solids.
3. To develop an advanced level of understanding of lattice vibrations, phonons and specific heat theories.
4. To make the students familiar with free electron theory and band theory of solids.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the knowledge of crystal structure and various structural parameters
2. Gain understanding of crystal bonding, defects and diffusion in solids.
3. Well versed with concepts of lattice vibrations and phonon modes, and theory of specific heat.
4. Able to understand free electron theory and band theory of solids.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENTS

Unit I: CRYSTAL STRUCTURE

Crystalline solids, Direct lattice, translational vectors, two and three – dimensional Bravais lattices, Miller Indices, Closed packed structures. Interaction of X- Rays with matter, absorption of X-Rays, Elastic scattering from a perfect lattice. Reciprocal lattice, Bragg's Law, Ewald construction, Brillouin zones and applications of reciprocal lattice to diffraction techniques. Experimental method in X-ray Diffraction - Laue method, powder method and rotating crystal method, structure factor, bonding in solids. Geometric factors of SC, BCC, FC, Diamond cubic, wurtzite structure.

Unit II: CRYSTAL BONDING, DEFECTS AND DIFFUSION IN SOLIDS:

Bond classification- types of crystal binding, Covalent, molecular and ionic crystals, London theory of van der walls bond, hydrogen bonding, cohesive and Madelung energy,

Point Defects (Schottky and Frankel) and their thermodynamics, Color Centres F, M, R, V and H, Polarons and Excitons, Edge dislocation and screw dislocation, Mechanism of plastic deformation, Stress and strain fields of screw and edge dislocation, Elastic energy of dislocations, Forces between dislocations, Dislocations in fcc, hcp and bcc lattices.

Unit III: LATTICE VIBRATION, PHONONS AND SPECIFIC HEAT THEORIES

Lattice Modes of Vibration, Elastic Vibrations of continuous media, and Vibrations of 1D monatomic and diatomic linear lattice. Phonon Modes, Lattice vibration Spectrum, phonon momentum, Inelastic scattering by phonons. Models of 3D lattices, quantization of lattice vibrations, Einstein and Debye theories of specific heat, phono density of states, neutron scattering.

Unit IV: FREE ELECTRON THEORY AND BAND THEORY OF SOLIDS

Classical theory of Free electron, Wiedemann Franz relation, failures of classical free electron theory, Quantum theory of free electrons in a 3D box, Fermi gas, energy levels and density of orbitals, Fermi-Dirac distribution function, electronic specific heat of a metal. Electrons in a periodic lattice: Bloch theorem, Kronig-Penny model, band theory in metals, semiconductor, insulator, effective mass. Tight binding approximations. Fermi surface, Conduction in Semiconductors (both Intrinsic and Extrinsic), quantum Hall effect.

TEXTBOOKS

1 Introduction to Solid State Physics,C. Kittel(Wiley, New York)
2 Quantum Theory of Solids,C. Kittel (Wiley, New York)
3 Principles Of the Theory of Solids,J.Ziman(Cambridge University Press, Cambridge)
4 Introduction to Solids,Azaroff& Elementary Solid-State Physics,Omar

REFERENCE BOOKS

1. Solid State Physics, Aschroft & Mermin (Reinhert & Winston, Berlin)
2. Principles of Condensed Matter Physics,Chaikil&Lubensk.
3. Solid State Physics,S. O. Pillai (New Age International Publisher) & Soild State Physics,M. A. Wohab (Narosa).

QUANTUM MECHANICS – II	
Course Code: 25PHMS202	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Prerequisite: Basic knowledge of quantum well, harmonic oscillator problems.	

COURSE OBJECTIVES

1. To acquire knowledge on time dependent perturbation theory.
2. To develop the understanding of the scattering theory.
3. To discuss the symmetries and identical particles in quantum mechanics.
4. To make students familiar with radiation and relativistic quantum mechanics.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the understanding of the time dependent perturbation theory.
2. Fluent with the understanding of the scattering theory and its application.
3. Well versed with the symmetries and identical particles in quantum mechanics.
4. Get an understanding about radiation and relativistic quantum mechanics.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENTS

Unit I: TIME DEPENDENT PERTURBATION THEORY

Time-dependent perturbation theory, interaction picture, first order perturbation, harmonic perturbation, transition probability, ionization of a hydrogen atom, density of final states, ionization probability, second order perturbation, adiabatic approximation, choice of phases, connection with perturbation theory, discontinuous change in H, sudden approximation, distribution of an oscillator, Constant and harmonic perturbations, Fermi's Golden rule, Sudden and Adiabatic Approximation.

Unit II: SCATTERING THEORY

Basic concept of scattering, scattering cross-section, scattering amplitude, scattering by spherically symmetric potentials, partial wave analysis and phase shifts, Ramsauer-Townsend effect; Relation between sign of phase shift and attractive or repulsive nature of the potential; Scattering by a rigid sphere and square well; Coulomb scattering; Formal theory of scattering: Green's function in scattering theory; Lippman-Schwinger equation; Born approximation, applications to Yukawa potential and other simple potentials. Electron scattering by an atom.

Unit III: SYMMETRY IN QUANTUM MECHANICS AND IDENTICAL PARTICLES

Conservation laws and degeneracy associated with symmetries, Discrete symmetries: CPT symmetry, Continuous symmetries: space and time translations, rotations; Identical particles: indistinguishability of identical particles and its consequences, Symmetric and antisymmetric wave functions, Pauli's exclusion principle, connection with statistical mechanics, collisions of identical particles.

Unit IV: RADIATION AND RELATIVISTIC QUANTUM MECHANICS

Absorption and induced emission: Maxwell equation, plane electromagnetic wave, use of perturbation theory, transition probability, interpretation in terms of absorption and emission, electric dipole transitions, forbidden transitions, classical radiation field, asymptotic form, radiated energy, dipole radiation, angular momentum, dipole case, conservation from classical to quantum, Planck's distribution formula, line breadth, selection rules for a single particle, polarization of emitted radiation, Relativistic quantum mechanics: Klein – Gordon equation, Dirac equation and its plane wave solutions, concept of spin.

TEXTBOOKS

1. Quantum Mechanics, L.I. Schiff (Tata McGraw-Hill)
2. Quantum Physics, S. Gasiorowicz (John Wiley& Sons Ltd.)
3. Quantum Mechanics, B. Craseman and J.D. Powell (Narosa Publishing House)
4. Quantum Mechanics, A. Messiah (Dover Publications)
5. Modern Quantum Mechanics, J.J. Sakurai (Addison Wesley)

REFERENCE BOOK

1 Advanced Quantum Mechanics, J.J. Sakurai (Addison Wesley)
2 Relativistic quantum mechanics, J. D. B.Jorken and S. D. Drell(McGraw-Hill)
3 A Textbook of Quantum Mechanics, P. M. Mathews & K. Venkatesan (Tata McGrawHill)
4 Quantum Mechanics, B. H. Bransden and C. J. Joachain (Pearson Education)

ELECTRONICS	
Course Code: 25PHMS203	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Prerequisite: Basic knowledge about electronics	

COURSE OBJECTIVES

1. To discuss basic semiconductor devices.
2. To illustrate the working and characteristics of Field Effect Transistors.
3. To make students familiar about the principle and working of operational amplifier.
4. To develop the understanding of oscillators and wave generators.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the understanding of the semiconductor devices.
2. Fluent with the understanding of Field effect transistor and its characteristics.
3. Becomes familiar with the working of operation amplifier and its application
4. Able to understand the principles behind oscillators and signal generators.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1	(shaded)			
CO2		(shaded)		
CO3			(shaded)	
CO4				(shaded)

COURSE CONTENTS

Unit I: BASIC SEMICONDUCTOR DEVICES

Drift and diffusion current, Generation and recombination of charges, continuity equation, p-n junction, junction diode characteristic, Capacitance of p-n junctions, Varactors, switching diodes, Clippers & Clampers, photoconductors, photodiode, light emitting diodes.

Unit II: FIELD EFFECT TRANSITORS

Junction Field Effect Transistor (JFET): Basic structure & Operation, pinch off voltage, single ended geometry of JFET, Volt Ampere characteristic, Transfer Characteristics. MOSFET: Enhancement MOSFET, Threshold Voltage, Depletion MOSFET, comparison of p & n Channel FET, SCR.

Unit III: OPERATIONAL AMPLIFIER

Operational Amplifiers: Block diagram, open and close loop configuration, inverting & non-inverting amplifier, Op-amp with negative feedback Voltage series feedback, Effect of feedback on closed loop voltage gain, Input resistance, output resistance, band width, output offset voltage, Measurements of Op-amp parameters. Op-amp Application: d.c. and a.c. amplifier, summing, scaling and Averaging amplifier, Integrator, Differentiator, Electronic analog computation comparator.

Unit IV: OSCILLATOS AND WAVE GENERATORS

Oscillators: Principles, Types, frequency stability, Phase shift oscillator, Wein bridge oscillator, LC tunable oscillator, square wave, Triangular wave and pulse generator, Monostable, Bistable & Astable, Multivibrators, Sample and Hold circuits, Principle of Phase Locking.

TEXTBOOKS

1. Semiconductor Devices - Physics and Technology, S.M. Sze (John Wiley), 2002.
2. Solid State Electronic Devices, Ben Streetman, Sanjay Banerjee (Prentice Hall India) 6th Edition, 2005.
3. Electronic Principles, A.P. Malvino (Tata McGraw, New Delhi), 7th edition, 2009.
4. Integrated Electronics, J. Millman, C. Halkias and C.D. Parikh, Tata McGraw Hill, 2nd edition, 2015
5. Linear and Non-linear Circuits, Chua, Desoer and Kuh (Tata McGraw), 1987.
6. Circuit theory Fundamentals and Applications, Aram Budak (Prentice-Hall) 1987.
7. Integrated Electronics, Millman and Halkias (Tata McGraw Hill) 1991.

REFERENCE BOOKS

1. Electronic Devices and Circuits Theory, Boylested and Nashelsky,(Pearson Education) 10th ed. 2009.
2. OPAMPS and Linear Integrated circuits, Ramakant A Gayakwad (Prentice Hall), 1992.
3. Operational amplifiers and Linear Integrated circuits, R.F. Coughlin, and F.F. Driscoll, (Prentice Hall of India, New Delhi), 2000.
4. Principles and Applications in Electronics: A.P. Malvino, D.P. Leach, (Tata Mcgraw- Hill, N.Delhi,1993).
5. Electronic Fundamentals & Applications: John D. Ryder (Prentice Hall of India, N. Delhi)

ATOMIC AND MOLECULAR PHYSICS	
Course Code: 25PHMS301	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Prerequisite: Basic knowledge about atomic and molecular structure of atom.	

COURSE OBJECTIVES

1. To develop understanding of the concepts of atomic physics.
2. To study molecular Spectroscopy.
3. To make the students familiar with electronic band spectra.
4. To make students familiar with Laser principle and Laser based Fluorescence Spectroscopy.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Well versed with the concepts of atomic physics.
2. Able to understand the concepts in Molecular Spectroscopy
3. Fluent with the ideas of electronic band spectra
4. Get an understanding Physics of Laser action and its application in Fluorescence Spectroscopy.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1	■			
CO2		■		
CO3			■	
CO4				■

COURSE CONTENTS

Unit I: ATOMIC PHYSICS

One electron atomic systems: Hydrogenic atomic systems, Fine structure and hyperfine structure, Determination of nuclear spin using hyperfine structure, Interaction with electromagnetic fields: Zeeman, Paschen-Back and Stark effect. The ground state of two-electron atoms – perturbation theory and variational methods. LS and J-J couplings schemes, Briet's scheme. Many-electron atoms – Central Field Approximation. The Hartree-Fock equations. The spectra of alkali using quantum defect theory. Selection rules for electric and magnetic multipole radiation. Auger process.

Unit II: MOLECULAR PHYSICS

Microwave spectroscopy: Diatomic molecule as rigid rotator; its energy level and spectra, Intensity of rotational lines, Diatomic molecule as non-rigid rotator. Isotope effect in rotational spectra; Infrared spectroscopy: Diatomic molecules as harmonic and anharmonic oscillator, Diatomic molecule as vibrating rotator, Energy levels and spectrum, thermal distribution of quantum states, Isotope effect in vibration spectra; Raman spectroscopy: Introduction, Pure rotational Raman spectra, Pure Vibrational Raman spectra, Raman rotational vibrational spectra.

Unit III: ELECTRONIC BAND SPECTRA

Salient features of electronic band spectra, Born Oppenheimer approximation, Vibrational coarse structure of electronic bands, progression and sequences, Rotational fine structure of electronic bands, The Fortrat parabola. Intensity of electronic bands: Franck Condon principle (absorption and emission), quantum mechanical treatment of Franck Condon principle.

Unit IV: LASER PHYSICS & FLUORESCENCE SPECTROSCOPY

Laser: Spontaneous and stimulated emission, Einstein A & B coefficient, optical pumping, population inversion, rate equation, modes of resonator and coherence length. Fluorescence and Phosphorescence, Kasha's rule, quantum yield, nonradioactive transition, Jablonski diagram, Time resolved fluorescence and determination of excited state life-time.

TEXT BOOKS

1. Introduction to Atomic spectra, H.E. White
2. Fundamental of Molecular spectroscopy, C.N. Banwell
3. Atomic spectra & Structure, G. Herzberg
4. Physics of Atoms and Molecule, Bransden and Joachain
5. Molecular spectroscopy, J. M. Brown
6. Introduction to Molecular spectroscopy, G. M. Barrow
7. Spectra of Atoms and Molecule, P.F. Bemath

REFERENCE BOOK

1. Laser- Theory and Application, K. Thyagrajan and A. K. Ghatak
2. Principle of Fluorescence spectroscopy, Lacowicz
3. Theory & Interpretation of Fluorescence and Phosphorescence, Ralph

STATISTICAL MECHANICS	
Course Code: 25PHMS302	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Prerequisite: Basic knowledge about thermodynamics	

COURSE OBJECTIVES

1. The correlation between thermodynamic quantities and statistical parameters.
2. Thermodynamic behaviour of different basic systems using different ensembles and applicability of classical statistics for different particle systems.
3. Applicability of quantum statistics for different particle systems.
4. Phase transition and its explanation based on different models.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Know various statistical terms and their relations with thermodynamic quantities.
2. Understand different ensembles and partition function.
3. Well versed with quantum statistics of ideal gases.
4. Understand phase transition and different models.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives(COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENT

UNIT I: STATISTICAL BASIS OF THERMODYNAMICS

Objective of statistical mechanics, Central Limit Theorem, Microstates, Macrostates, Phase space and ensembles, Ensemble average and time average, Ergodic hypothesis, Postulatesof equal a-priori probability, Contact between statistics and thermodynamics: Boltzmann's postulate of entropy, Classical ideal gas, Entropy of Mixing, Gibbs paradox and its solution, Liouville’s theorem.

UNIT II: CLASSICAL STATISTICAL MECHANICS

Theory of Microcanonical, Canonical, and Grand Canonical ensembles. Partition function Contact with thermodynamics, Helmholtz and Gibbs free energies, Applications to classical ideal gas and systems of harmonic oscillators. Equipartition and Virial Theorems. Density and energy fluctuations, Chemical equilibrium and Saha Ionization Equation.

UNIT III: QUANTUM STATISTICS OF IDEAL GASES

Quantum states and phase space, Density matrices, Density matrix in statistical mechanics, Quantum Liouville theorem, Some simple applications (Harmonic oscillators, Free particles in a box). Statistical Mechanics of Ideal Bose and Fermi gases, Bose-Einstein Condensation, Phonon gas, Electron gas in a Metal, White Dwarf Stars, Chandrasekhar Mass Limit.

UNIT IV: RECENT TRENDS IN STATISTICAL MECHANICS

Review of condensation in a van der Waals gas, Critical exponents, Introduction to mean-field theory of phase transitions, One- and two-dimensional Ising model, Explanation of second order phase transition in magnetic materials. Calculation of exponents from Landau theory of phase transition. Rudiments of Real Space Renormalization Group Transformations. Brownian motion, Fokker-Planck Equation, Introduction to non-equilibrium processes, Fluctuation-Dissipation Theorem.

TEXTBOOK

1. Statistical Mechanics, R.K. Patharia and P. D. Beale (Elsevier).
2. Fundamentals of statistical and thermal physics, F. Reif (Waveland Press).
3. Statistical Mechanics, K. Huang (Wiley Eastern, New Delhi).
4. Statistical Mechanics, B.K. Agarwal and M. Eisner (Wiley Eastern).
5. Elementary Statistical Physics, C. Kittel (Wiley).
6. Statistical Mechanics, L.D. Landau, E.M. Lifshitz (Butterworth-Heinemann).

REFERENCE BOOK

1. Equilibrium Statistical Physics, M. Plischke and B. Bergersen (World Scientific).
2. Statistical Mechanics A set of lectures, R. P. Feynman (The Benjamin/Cummings Publishing Co, Inc.)
3. Fundamentals of statistical and thermal physics, F. Reif (Waveland Press).
4. Statistical Mechanics, K. Huang (Wiley Eastern, New Delhi).

NUCLEAR AND PARTICLE PHYSICS	
Course Code: 25PHMS401	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course
Prerequisite: Basic knowledge about thermodynamics	

COURSE OBJECTIVE

1. To Learn the properties, and structure of the nucleus and nuclear models.
2. To solve the deuteron problem and understand nuclear forces.
3. Gain knowledge about the interactions between the nuclei and different types of nuclear reactions.
4. Gain basic knowledge about elementary particles.

COURSE LEARNING OUTCOME

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. able to explain the basic properties, structures of nucleus and nuclear models.
2. able to understand deuteron and its properties and explain nuclear forces.
3. Can explain nuclear decay and nuclear reactions.
4. Basic knowledge of elementary particles

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives(COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENT

UNIT–I: **BASIC PROPERTIES AND STRUCTURE OF NUCLEUS:**

Rutherford scattering, nuclear size, nuclear radius and charge distribution, nuclear form factor, mass and binding energy, angular momentum, parity and symmetry, Magnetic dipole moment and electric quadrupole moment.

NUCLEAR STRUCTURE: Single particle shell model (including Mean filed approach, spin-orbit coupling), Liquid drop model, Bethe-Weizsacker binding energy/mass formula, Physical concepts of the unified model (Collective Model).

UNIT–II : **TWO NUCLEON SYSTEMS & NUCLEAR FORCE**

Two-body bound state: Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron, rms radius, , electromagnetic moment and magnetic dipole moment of deuteron, Central and tensor forces, n-p scattering, Scattering length and its significance, spin dependence of n-p interaction, effective range theory, Scattering from molecular hydrogen, low energy p-p scattering,
NATURE OF NUCLEAR FORCES: charge independence, charge symmetry and isospin invariance of nuclear forces, Meson theory

UNIT-III: NUCLEAR DECAY AND REACTIONS:

Alpha decay, Gamow theory of alpha decay, Beta decay, Fermi theory of beta decay, shape of beta spectru plot and its importance. Gamma decay, Multipole transitions in nuclei, selection rule. Internal conversion a isomerism.
NUCLEAR REACTIONS Concept of direct and compound nuclear reactions, Different types of reactions, Kinematics of reactions, Q- value, Conservation laws, Statistical theory of nuclear reactions and evaporation probability.

UNIT-IV: ELEMENTARY PARTICLES:

Classification of elementary particles, properties of elementary particles, Conservation laws and quantum numbers for elementary particles, Fundamental interactions, C, P, T invariance and CPT theorem, Gell-Mann Nishijima scheme. Properties of quarks and their classification. Elementary ideas of SU(2) and SU(3) symmetry groups,

TEXTBOOKS

1. Concepts of Nuclear Physics, B. L. Cohen (Tata McGraw-Hill).
2. Nuclear Physics, I. Kaplan(Narosa Publishing House).
3. Nuclear Physics,R. R. Roy &B. P. Nigam (New Age International Publisher).
4. Nuclear Physics, S. N. Ghoshal (S. Chand)

REFERENCE BOOKS

1. Nuclear Physics, M. K. Pal (Affiliated East West Press Pvt. Ltd.).
2. Nuclear Physics,J. M. Blatt and V. F. Weisskopf (John Wiley & Sons).

CORE PRACTICAL COURSES

1. Physics Lab I (General) (25PHMS151)
2. Physics Lab II (General) (25PHMS251)
3. Computational Physics Lab I (25PHMS252)
4. Computational Physics Lab II (25PHMS351)

PHYSICS LAB – I (General)	
Course Code: 25PHMS151	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course Lab
Prerequisite: Basic knowledge about various parameters involved in experiments.	

COURSE OBJECTIVES

1. To give practical knowledge on various diodes.
2. To learn and appreciate the principals involved in measuring various parameters.
3. To get practical knowledge on the various gains of different types of amplifiers.
4. to build an understanding about various components of an electrical circuit and to develop skill to measure the related physical quantities

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Familiar with experimental knowledge of various diodes, transistors and amplifiers.
2. Get an insight into the Physics involved in the experiments.
3. Equipped with knowledge of various components of electronic circuits.
4. Well versed with the theoretical knowledge behind every experiments

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

COURSE OBJECTIVES (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

Note: Students will be required to perform at least twelve experiments in a semester. List of experiments may be amended.

LIST OF EXPERIMENTS

1. Fresnel's equation.
2. Cauchy equation
3. Sodium D1 and D2 line.
4. Ultrasonic liquid tank
5. Polarimeter
6. Microwave
7. Piezoelectric technique: Young's modulus
8. Dielectric constant: Transition temperature
9. Planck's constant: Photoelectric effect

10. e/m ratio: Thomson method
11. Hall effect: Hall coefficient & carrier concentration
12. Lattice dynamics: Monoatomic lattice vibration & cut-off frequency
13. Lattice dynamics: Diatomic lattice vibration & optical bandgap.
14. Heat capacity: Specific heat of a solid substance.
15. Forbidden energy gap: Four probe method.
16. Fourier analysis of a signal: Square & triangular wave

TEXTBOOKS

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal, New Delhi

REFERENCE BOOKS

1. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India

PHYSICS LAB – II (General)	
Course Code: 25PHMS251	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Core Course Lab
Prerequisite: Basic knowledge about various parameters involved in experiments.	

COURSE OBJECTIVES

1. To give practical knowledge on various diodes.
2. To learn and appreciate the principals involved in measuring various parameters.
3. To get practical knowledge on the various gains of different types of amplifiers.
4. to build an understanding about various components of an electrical circuit and to develop skill to measure the related physical quantities

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Become familiar with experimental knowledge of various diodes, transistors and amplifiers.
2. To get an insight into the Physics involved in the experiments.
3. Equipped with knowledge of various components of electronic circuits.
4. Well versed with the theoretical knowledge behind every experiments

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1	■			
CO2		■		
CO3			■	
CO4				■

Note: Students will be required to perform at least twelve experiments in a semester. List of experiments may be amended.

LIST OF EXPERIMENTS

1. pn jn: Clipping and clamping
2. To study *h*- parameter of Common emitter amplifier.
3. To study Hartley oscillator characteristics at Low frequency
4. Colpit oscillator: High frequency
5. To study JFET and MOSFET characteristics
6. To study J-K flip flop: Counter, and resistor.
7. Frequency & amplitude modulation and demodulation.
8. IC555 timer: multivibrator.
9. Multivibrator with OP AMP.

10. Triangular wave generator with OP AMP.
11. To determine charge to mass ratio of electron by using Magnetron.
12. To study the Magnetostriction effect in a metallic rod.
13. To study the frequency response of an operational amplifier.
14. To study the use of operational amplifier for different mathematical operation.
15. To study the use of operational amplifier for voltage to current conversion.
16. To study the use of operational amplifier for current to voltage conversion.
17. To study the characteristic of SCR and its application as a switching device.

TEXTBOOKS

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Textbook of Practical Physics, Indu Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal, New Delhi

REFERENCE BOOKS

1. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India

COMPUTATIONAL PHYSICS LAB I	
Course Code: 25PHMS252	Continuous Evaluation: -- Marks
Credits: 2	End Semester Practical Examination:-- Marks
L T P : 0 0 4	Course Type: CORE
Prerequisite: NIL	

COURSE OBJECTIVES

1. To discuss the 2D plotting using Gunplot
2. To illustrate the linear and nonlinear fitting.
3. To familiarise students with the data types, arrays and loops.
4. To create competency in basic level programming.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of the course, students would be

1. Able to draw the 2D plotting using Gnuplot
2. Equipped with the knowledge of linear and nonlinear fitting using Gnuplot
3. Fluent in data types, arrays and loops concepts required for programming.
4. Well-versed with basic programming.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum **-----**of experiments)

1. Introduction to plotting graphs with Gnuplot/Origin/Sigmaplot/any other suitable plotting software:
   (a) Plotting 2D graphs: both functions and data files. Changing plot range, plot style: the options- with points (w p), with dots (w d), with lines (w l), with linespoints (w lp), linetype (lt), linewidth (lw). Using the set command for samples, xrange, yrange, xlabel, ylabel, title etc. The *using* and *every*option.

(b) User defined functions [Including the use of ternary operator (? :) for piece-wise defined functions.]
(c) Fitting data files using gnuplot.
(d) Polar and parametric plots [Graphs to be saved by using GUI - The “export” protocol is not needed.]

2. Programming with Fortran/C++
   a) Introduction to Programming: Algorithms, Flowchart, Structured programming, basic idea of Compilers.
   b) Data Types
   c) Array and Function
   d) Do loops
   e) If-Else statement.
3. Basic numerical Problems with computer programming.
   (a) To check if a number is i) prime number, ii) odd number, iii) even number.
   (b) Sum and average of a list of numbers,
   (c) largest of a given list of numbers and its location in the list,
   (d) sorting of numbers in ascending descending order using Bubble sort and Sequential sort, Binary search
   (e) Finding the values of trigonometric functions.

TEXTBOOKS

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co.)
2. Computational: Physics an introduction by RC Verma, PK Ahulawalia and K C Sharma (New Age International Publisher)
3. Introduction to Numerical Analysis by F b Hilderbrand(Tata McGraw Hill, New Delhi)
4. Programming with Fortran 77, Schaum’s outline series by William E. Mayo and Martin Cwiakala(McGrawHill, Inc).

REFERENCE BOOKS

1. Fortran Programming and Numerical methods by R C Desai (Tata McGraw Hill, New Delhi).
2. Computer Applications in Physics Suresh Chandra (Narosa Publishing House).
3. Introductory methods of numerical methods of numerical Analysis by S SSastry(P H of India).
4. Computer oriented Numerical Method by V Rajaraman (Prentice Hall of India).

COMPUTATIONAL PHYSICS LAB II	
Course Code: 23PHBS351	Continuous Evaluation: -- Marks
Credits: 2	End Semester Practical Examination:-- Marks
L T P : 0 0 4	Course Type: CORE
Prerequisite: NIL	

COURSE OBJECTIVES

1. To discuss the extrapolation, intrapolation and curve fitting.
2. To make student familiar with the numerical technique to solve differential and integration problems
3. To illustrate numerical solution of ordinary differential equation.
4. To create competency in basic level programming.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Able to extrapolation, intrapolation and curve fitting
2. Equipped with the knowledge of numerical technique to solve differential and integration problems
3. Fluent in numerical solution of ordinary differential equation.
4. Well versed with basic programming

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

LIST OF EXPERIMENTS

Following numerical Problems with computer programming is to be covered. Examples to be picked directly from physics problems.

(A Student is supposed to complete/perform minimum ------of experiments)

1. To calculate the area of simple geometrical shapes: triangle, rectangle, circle.
2. Error analysis: Round off errors, truncation error, machine error, random error.
3. Curve fitting: Least-square curve fitting, straight line and polynomial fits.
4. Matrix analysis.

5. Interpolation and Extrapolation: Finite difference, forward difference, backward difference, central differences, Lagrange method.
6. Solution of algebraic equation: Bisection method, iteration method, Newton Raphson method.
7. Numerical differentiation: Taylor series method, numerical differentiation using Newton's forward difference formula, Newton's backward difference formula, Strilling formula.
8. Numerical integration: trapezoidal rule, Simpson 1/3 rule, gaussian quadrature, Legendre-gauss quadrature, numerical double integration
9. Numerical solution of ordinary differential equation: Taylor series method, Euler's methods, forth order Runga - Kutta method.
10. Second order differential equation: Initial and boundary value problem.

TEXT BOOKS

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co.)
2. Computational: Physics an introduction by RC Verma, PK Ahulawalia and K C Sharma (New Age International Publisher)
3. Introduction to Numerical Analysis by F b Hilderbrand(Tata McGraw Hill, New Delhi)
4. Programming with Fortran 77, Schaum's outline series by William E. Mayo and Martin Cwiakala(McGrawHill, Inc).

REFERENCE BOOKS

1. Fortran Programming and Numerical methods by R C Desai (Tata McGraw Hill, New Delhi).
2. Computer Applications in Physics Suresh Chandra (Narosa Publishing House).
3. Introductory methods of numerical Analysis by S S Sastry (P H of India).
4. Computer-oriented Numerical Method by V Rajaraman (Prentice Hall of India).

DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES

1. Advanced Solid State Physics I (25PHMS 303)
2. Nanomaterials (25PHMS 304)
3. Soft Matter Physics(25PHMS 305)
4. Laser Physics & Applications (25PHMS 306)
5. Nano Photonics (25PHMS 307)
6. Nonlinear Spectroscopy (25PHMS 308)
7. Analogue Communication (25PHMS 309)
8. Digital Communication (25PHMS 310)
9. Optoelectronics (25PHMS 311)
10. Nuclear Physics I (25PHMS312)
11. Astrophysics I (25PHMS313)
12. Classical Field Theory (25PHMS314)
13. Quantum Computation I (25PHMS315)
14. Classical and Quantum Informatics (25PHMS316)
15. Advanced Solid State Physics II (25PHMS402)
16. Characterization of Materials (25PHMS403)
17. Nanomagnetism and Spintronics (25PHMS404)
18. Fiber Optics Sensors (25PHMS405)
19. Applied Optics (25PHMS406)
20. Rotational & Vibrational Molecular Spectroscopy (25PHMS407)
21. Novel and Smart Materials(25PHMS408)
22. Microprocessor & Interfacing (25PHMS409)
23. Semiconductor Physics (25PHMS410)
24. Nuclear Physics II (25PHMS411)
25. Astrophysics II (25PHMS412)
26. Quantum Field Theory (25PHMS413)

27. Quantum Computation II (25PHMS414)

28. Quantum Machine learning (25PHMS415)

ADVANCED SOLID STATE PHYSICS I	
Course Code: 25PHMS303	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To discuss about transport properties of solids.
2. To illustrate optical properties of the materials.
3. To make students familiar with the magnetic properties and superconductivity of materials.
4. To develop understanding of dielectric and ferroelectric properties of solids.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Fluent with good knowledge of transport properties of solids.
2. Get an understanding of optical properties of materials.
3. Well-versed with the magnetic properties ofsolids and can explain superconductivity.
4. Able to understand the dielectric and ferroelectric properties of solids.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENT

UNIT I: SEMICONDUCTOR PHYSICS

Band theory of solids -Fermi distribution and energy - Density of states - Valence and conduction band density of states - intrinsic carrier concentration - intrinsic Fermi level. Extrinsic semiconductors: n and p type doping - Densities of carriers in extrinsic semiconductors and their temperature dependence - extrinsic semiconductor Fermi energy level.

UNIT II: DIELECTRIC AND FERROELECTRICS

Maxwell equations, Polarization, Macroscopic electric field, Depolarization field, Local electric field at an atom, Lorentz field, field of dipoles inside cavity, Dielectric constant and Polarizability, static dielectric constant of gases and solids; Complex dielectric constant and dielectric losses, relaxation time, Debye equations; Cases of distribution of relaxation time, Cole - Cole distribution parameter, Dielectric modulus; ferroelectric crystals, displace transitions, Antiferroelectricity, ferroelectric domains, piezoelectricity, Pyroelectricity.

UNIT III: MAGNETIC MATERIALS

Langevin Diamagnetism equation, Quantum theory of atomic diamagnetism; Landau diamagnetism (qualitative discussion); Paramagnetism: classical and quantum theory of paramagnetism, Ferromagnetism: Ferromagnetic ordering, Magnon, Curie-Weiss law, temperature dependence of saturated magnetization.

UNIT IV: **SUPERCONDUCTIVITY**

Basic Properties of Superconductors, Types of Superconductors, Phenomenological thermodynamics treatment, two fluid model: Magnetic behavior of superconductors, intermediate state, London's equation and penetration depth, quantized flux. electron-phonon interaction and cooper pair, brief discussion of the BCS theory, its results and experimental verification, p and d wave pairs, DC and AC Josephson effects, Brief introduction to high temperature superconductors.

TEXTBOOKS

1. Solid State Physics, N. W. Ashcroft and N.D. Mermin (Ist Ed., Cengage Learning, 2003)
2. Elementary Excitations in Solids, D. Pines (CRC press, 1999)
3. The Wave Mechanics of Electrons in Metals, S. Raimes (North-Holland, 1970)
4. Lecture Notes on Electron Correlation & Magnetism, P. Fazekas (World Scientific, 1999)
5. Solid State Physics A.J. Dekker:
6. Introduction to Solid State Physics, C. Kittel

REFERENCE BOOKS

1. Introduction to Superconductivity,M. Tinkham (Dover Publications Inc., 2004)
2. Condensed Matter Physics,M. Marder(2nd Ed., John Wiley & Sons, 2010)
3. Principles of Condensed Matter Physics,P.M. Chaikin and T.C. Lubensky (Cambridge UniversityPress, 1995)

NANO MATERIALS	
Course Code: 25PHMS304	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To discuss general concepts of material properties at nano dimensions.
2. To highlight characterization of nanomaterials
3. To develop understanding about the thin film growth and vacuum systems.
4. To make students familiar with thin film deposition and characterization of thin films.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Fluent with good knowledge on the properties of material at nanoscale.
2. Get an understanding of characterization of nanomaterials
3. Able to understand the growth of thin film and vacuum systems.
4. Well-versed with the techniques of thin film deposition and its characterization.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENT

UNIT I: PHYSICS OF NANOMATERIALS

Background to nanoscience and nanotechnology - scientific revolutions - nanosized effects, surface to volume ratio- – atomic structure – molecules & phases – energy at the nanoscale molecular and atomic size -quantum effects. Definition of a nano system - classification of nanocrystals - dimensionality and size dependent phenomena; Quantum dots, Nanowires and Nanotubes, 2D films.

UNIT II: SYNTHESIS OF NANOMATERIALS

Top down and bottom up Approach, **Mechanical methods:** Grinding – high energy ball milling; **Chemical Methods:** Sol-gel technique – co-precipitation method; **Physical Methods:** Principle of different vacuum pumps; (vacuum pumps: rotary pump, diffusion pump, turbo molecular pump, cryogenic-pump, ion pump, Ti-sublimation pump), Measurement of Pressure, Concept of different gauges; Pirani, Penning and pressure control. Vapor deposition: electron beam-thermal evaporation and different types of epitaxial growth techniques - pulsed laser deposition, Magnetron sputtering – Deposition progress and Micro lithography – RF/DC magnetron sputtering.

UNIT III: CHARACTERIZATION OF NANOMATERIALS

X- ray diffraction- Quantitative determination of phases; Structure analysis - crystallite size analysis using Debye-Scherrer's formula, Rutherford backscattering, AFM, TEM, SEM, STM, Surface Profilometer, EDAX. Raman spectroscopy, XPS, XAS and EXAFS. Basic principles and applications of UV-Vis Spectroscopy, Photoluminescence.

UNIT IV: BASICS OF THIN FILMS AND PROPERTIES OF NANOMATERIALS

Thin film growth modes: Vapor condensation & adsorption, surface diffusion, sticking coefficient, formation of thermodynamically stable cluster, theory of nucleation, Growth modes: Island growth, Volmer weber, Layer growth. Epitaxy, Evolution of stresses and strain in thin films.

Importance of the nanoscale materials and their devices, Electronic, magnetic, dielectric, optical and mechanical properties at nanoscale, Applications of nanomaterials in various fields.

TEXTBOOKS

1. The Physics of Low Dimensional Semiconductors, John H. Davies (Cambridge University Press)
2. Nanotechnology- An Introduction, J.J. Ramsden, William Andrew Elsevier
3. Nano-optoelectronics Sensors & Devices, Ning Xi, King w. Chiu Lai, and William AndrewElsevier
4. Quantum Heterostructures- Microelectronics & Optoelectronics,(V.V. Mitin, V.A. Kochetp& M.A. Stroscio, Cambridge University Press
5. Nanostructures & Nanomaterials, Synthesis, Properties & Applications, G. Cao (Imperial CollegePress)

REFERENCE BOOKS

1. Introduction to Nanotechnology, C.P.Poole Jr. & F.J. Owens (John Wiley & Sons)
2. Nanotechnology, M. Wilson, K. Kannangara, G. Smith, M. Simmons & B. Raguse (OverseasPress)
3. Thin Film Phenomenon L. Chopra, McGraw-Hill
4. Methods of Experimental Physics (Vol 14), G. L. Weissler and R.W. Carlson
5. A User's Guide to vacuum Technology, J. F. O'Hanlon, John Wiley, and Sons
6. Evaporation: Nucleation and Growth Kinetics", J.P. Hirth and G. M. Pound, Pergamon Press
7. Nanostructured Materials and Nanotechnology, H. S. Nalwa (Ed.) (Academic Press, 2002)

SOFT MATTER PHYSICS	
Course Code: 25PHMS305	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To impart the knowledge of basic materials in soft matter physics.
2. To illustrate the properties of polymers.
3. To impart the Elastic properties of soft materials and fluid dynamics.
4. To discuss the various interactions involved in soft matter physics

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Fluent with good knowledge about materials viz. liquid crystals, colloids, polymers etc.
2. Able to understand the different statics involved in polymer materials
3. Get an understanding of the elastic properties of soft materials and fluid dynamics.
4. Well-versed with the various interactions involved in soft matter physics

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENT

UNIT I: SOFT MATERIALS

Amorphous materials, Brownian motion, Diffusion, Connection between Diffusion and random walks, Langevin equation. Order parameters in liquids, Long-and short-range order, Liquid crystals, Liquid crystal order parameter, Polymers, Colloids, Quasi-crystals, Granular Materials.

UNIT II: POLYMERS

Polymer statistics: Single chain statistics; Chain under external action; Flory theory; Polymer solutions: Dilute, Semi-dilute and melts; Osmotic pressure; Scaling laws; Segregation in polymer mixtures; Polymers near the interfaces: Adsorption; Depletion layer; Steric repulsion; Dynamics of a polymer chain: Rouse model; Normal modes; Motion of monomers; Hydrodynamic interactions.

UNIT III: ELASTICITY AND FLUID MECHANICS

Elasticity, Nonlinear elasticity, Rubber elasticity, Larger extensions of rubber, Linear elasticity, Solids of cubic symmetry, Isotropic solids. Newtonian fluids, Euler's equation, Navier-stokes equation, Polymeric solutions, Plasticity, Super-fluid 4He, Two-fluid hydrodynamics, Second sound, Origin of super-fluidity.

UNIT IV: INTERFACIAL INTERACTIONS

Van der Waals interaction; non-retarded interaction; interactions of many molecules; Electrostatic interaction; screening; Colloidal dispersions; Interfacial tension; Laplace pressure; Surface-active agents; interface free energy; thermal fluctuations of interfaces; fluctuations of fluid membranes; persistence length; steric repulsion; micelles; critical micelles concentration; vesicles; micro-emulsions.

TEXTBOOKS

1. Statistical thermodynamics of Surfaces, Interfaces, and Membranes", Samuel A. Safran, CRCPress.
2. Scaling Concepts in Polymer Physics, Pierre-Gilles de Gennes , Cornell University Press
3. The Theory of Polymer Dynamics, M. Doi, S. F. Edwards, Oxford Science Publication.

REFERENCE BOOKS

1. Theory of Polymer Dynamics, W.J. Briels.
2. Condensed Matter Physics, 2nd Edition, Michael P. Marder, Wiley
3. Oxford Master Series in Condensed Matter Physics, Richard A.L. Jones.

LASER PHYSICS & APPLICATIONS	
Course Code: 25PHMS306	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To impart the basic principles and properties of Laser
2. To illustrate the various types of Laser
3. To impart the properties of matter.
4. To discuss various laser applications

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Fluent with good knowledge Principles of Laser operation
2. Get an understanding of the working of different types of laser
3. Get an understanding of Nonlinear processes
4. Well-versed with the Novel applications of Laser

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENT

UNIT I: LASER FUNDAMENTALS

Rate equations, Einstein Coefficients, lasing action, Population Inversion, Principles and characteristics ofLaser-Directionality, Coherence, polarization, width and profile of spectral lines, Intensity- Laser Components, Three & Four level Lasers, Q-Switching, Mode Locking. spectral characteristics of laser emission, single and multi-mode lasers, line broadening mechanisms, thermal broadening, doplar broadening, collision broadening, broadening due to impurities in solids.

UNIT II: DIFFERENT LASERS

Principle and Working of Ruby, Nd-YAG, Helium Neon laser, Argon Laser, Nitrogen laser, Carbon dioxide (CO_2) laser, Dye laser, Excimer laser, Titanium-sapphire laser- Threshold condition for oscillations., Qualitative Description of Longitudinal and TE laser systems. Thresholdcondition for Oscillation in Semiconductor Laser. Bipolar and Unipolar semiconductor laser, energy band engineering, condition for Gain in bipolar semiconductor laser, Homojunction and heterojunction semiconductorlasers, GaAs quantum well, GaAs/AlGaAs hetero structure fabrication for lasing applications, Freeelectron laser.

UNIT III: NON-LINEAR PROCESSES

Propagation of Electromagnetic Waves in Nonlinear medium, Self-Focusing, Phase matching condition, Fiber Lasers,Stimulated Raman Scattering and Raman Lasers, CARS, Saturation and Two photon Absorptions. Phase matching condition, Frequency doubling, Optical mixing. Time resolved laser spectroscopy: Generation and measurement of ultra-short pulses andlifetime measurements with lasers, pump and probe techniques

UNIT IV: NOVEL APPLICATIONS OF LASER

Cooling and Trapping of Atoms, Principles of Doppler and Polarization Gradient Cooling, Qualitative Description ofIon Traps, Optical Traps and Magneto-Optical Traps, Evaporative Cooling and Bose Einstein Condensation. Optical tweezing, Health Monitoring-Endoscopy, Clinical diagnostic. Military applications, Industrial applications. Laser based optical diagnostic techniques-Raman, Laser Induced Fluorescence, Laser Induced Breakdown Spectroscopy (LIBS).

TEXTBOOKS

1. Laser Spectroscopy and Instrumentation, W. Demtroder.
2. Principles of Lasers, O. Svelto.

REFERENCE BOOKS

1. Laser Cooling and Trapping, P.N. Ghosh.
2. Frontiers in Atomic, Molecular and Optical Physics, S.P. Sengupta.

NANOPHOTONICS	
Course Code: 25PHMS307	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To illustrate the photonics operative at a nano scale
2. To discuss the concepts of near field and their application in microscopy.
3. To highlight the plasmonics and elementary concept of photonic crystals.
4. To impart the knowledge on the application of photonic materials in biotechnology.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Fluent with good knowledge of the field of nanophotonics.
2. Get an understanding of near field interaction and their application in microscopy.
3. Able to understand the Plasmonics and photonic crystals.
4. Well-versed with the application of photonic materials in biotechnology.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1	■			
CO2		■		
CO3			■	
CO4				■

COURSE CONTENT

UNIT I: INTRODUCTION

Overview of Nanophotonics, Confinement of Photons and electrons, Bandgap-Tunneling, Localization under periodic potential, Quantum Confinement Effects-Quantum wells/wire/dots, Nanoscopic interactiondynamics, Dielectrics confinement effects, Superlattices.

UNIT II: NEAR-FIELD INTERACTION & MICROSCOPY

Near-Field Optics, Near-Field Microscopy, Example of Near-Field Studies-Single Molecule Spectroscopy & Nonlinear Optical Processes. Nano-scale enhancement of optical interactions-Surface Enhanced RamanScattering Spectroscopy. Time and Space-Resolved studies of Nanoscale Dynamics.

UNIT III: PLASMONICS& PHOTONIC CRYSTALS

Metallic Nanoparticles-Spherical, Nano rods and Nano shells, Local Field Enhancement, Subwavelength AperturePlasmonics, Nanostructure and excited states, Basic concepts of Photonic crystals, Nonlinear Photonic crystals, Photonic crystal sensors, Nanocomposites as photonic media.

UNIT IV: MATERIALS & APPLICATIONS IN BIOTECHNOLOGY

Nanocomposites, Bioderived Materials, Biotemplates, Bacteria as Bio-synthesizers, Near-Field Bioimaging, Optical Diagnostics, Nanoclinics for Targeted Therapy and Gene delivery. Photodynamic Therapy for killing cancer cells, Nanomedicine.

TEXTBOOKS

1. Biophotonics,P. N Prasad
2. Introduction to Nanophotonics, S. V. Gaponenko

REFERENCE BOOKS

1. Principles of Nano-optics, Lukas Novotny
2. Diffractive Optics &Nanophotonics, V. A. Soifer

NONLINEAR SPECTROSCOPY	
Course Code: 25PHMS308	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To introduce different linear and nonlinear phenomenon that takes place in light matter interaction.
2. To make the students able to understand the saturation spectroscopy.
3. To introduce concept of Coherent Raman spectroscopy and Coherent Anti Raman scattering (CARS) spectroscopy.
4. To develop the basic knowledge about non-linear spectroscopy.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Fluent with good knowledge of different physical principles underlying in various spectroscopictechniques.
2. Get an understanding of broadening mechanism in saturation spectroscopy.
3. Well-versed with the concept of Coherent Raman spectroscopy and Coherent Anti Ramanscattering (CARS) spectroscopy.
4. Able to understand the basic ideas of non-linear spectroscopes.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENT

UNIT I: INTRODUCTION

Prologue: Linear Spectroscopy, Brief introduction to tunable laser sources and linear spectroscopy, The Density Matrix for a Two-Level System, the Interactions and the Hamiltonian, Relaxation, the Master Equation and the Vector Model, the Nonlinear Polarization Density and Nonlinear Susceptibility, physical principles underlying various spectroscopic techniques and line broadening phenomena, Inhomogeneous Broadening, Effective Operators for Multiquantum Transitions.

UNIT II: SATURATION SPECTROSCOPY

Burning and Detecting Holes in a Doppler-Broadened Two-Level System, Crossover Resonances and Polarization Spectroscopy, Coupled Doppler-Broadened Transitions, Experimental Methods of SaturationSpectroscopy in Gases, Ramsey Fringes in Saturation Spectroscopy, The Line-Shape Problem in Saturation Spectroscopy, Experimental Results in Saturation Spectroscopy of Gases, Multiphoton and Double-Resonance Saturation Techniques, Saturation Techniques for Condensed Phases, Applications of Saturation Techniques

UNIT III: COHERENT RAMAN SPECTROSCOPY

Introduction, Driving and Detecting a Raman Mode, Symmetry Considerations, Relationship between χR and the Spontaneous Cross Section, Wave-Vector Matching, Coherent Anti-Stokes Raman Spectroscopy, Raman-Induced Kerr Effect Spectroscopy, Stimulated Raman Gain and Loss Spectroscopy, Four-Wave Mixing, Applications.

UNIT IV: MULTIPHOTON ABSORPTION AND NON-LINEAR SPECTROSCOPY

Introduction, Doppler-Free Two- and Three-Photon Absorption, Multi-quantum Ionization, Nonlinear Mixing, Applications, Optical Coherent Transients, The Optical Free-Induction Decay, Optical Nutation, The Photon Echo, the Stimulated Echo, Ramsey Fringes, Second Harmonic generation, Third- andHigher-Order Sum and Harmonic generation, Raman Shifting, Spontaneous XUV Anti-Stokes, Infrared Spectro-photography, multiphoton ionization methods; life time measurements, Quantum beat spectroscopy, Henle effect; Pico second and femto-second spectroscopic techniques for probing ultra-fast dynamics, four wave mixing for determining dephasing times using intense incoherent light.

TEXTBOOKS

1. Introduction to Nonlinear Spectroscopy, M. D. Levenson
2. Nonlinear Laser Spectroscopy, V. S. Letokhov& V. P. Chebotayev

REFERENCE BOOKS

1. Laser Induced Dynamic Gratings, H. J. Eicher, P. Gunter & D. W. Pohl

ANALOGUE ELECTRONICS	
Course Code: 25PHMS309	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To acquire basic knowledge on microwave electronics.
2. To give the basic knowledge of Radar communication.
3. To develop understanding of the analog signal transmission.
4. To introduce the satellite communication techniques.

COURSE LEARNING OUTCOME

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion ofcourse, students would be:

1. Understanding of the Microwave characteristics and its detection techniques.
2. Understands the basic Radar communication and its performances.
3. The ability to understand the signal transmission by Amplitude and phase modulations.
4. Becomes familiar with the satellite communication techniques.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1	(shaded)			
CO2		(shaded)		
CO3			(shaded)	
CO4				(shaded)

COURSE CONTENTS

UNIT I: MICROWAVE ELECTRONICS

Microwave characteristic features & applications, Wave guide and cavity resonators, Two cavities Klystron, Reflex Klystron, Gunn diode characteristics, microwave antenna, Detection of microwave, Dielectric constant measurement, Isolator and circulator, PIN diode modulator

UNIT II: RADAR COMMUNICATION

Basic Radar systems, Radar range equation and performance factor, Radar Cross-section, Pulsed, Radar system, Duplexer, Radar display, Doppler Radar, CWIF Radar, FMCW Radar, Moving Target Indicator (MTI), Blind Speeds.

UNIT III: ANALOG SIGNAL TRANSMISSION

Introduction, Amplitude, Frequency & phase modulation; AM, FM modulating and e modulating circuits; AM, FM Receivers functioning (Block Diagram) and characteristic features; Pulse modulation; Sampling Processes, PAM, PWM and PPM modulation and demodulation, Quantization noise.

UNIT IV: SATELLITE COMMUNICATION

Principle of Satellite communication, Satellite frequency allocation and band spectrum, Satellite orbit, trajectory and its stability, Satellite link Design, Elements of Digital Satellite Communication, Multiple Access Technique, Antenna system.

TEXTBOOKS

1. Communication System, Simon Haykin.
2. Electronic Communication, Roddy and Coolen.
3. Microwave and Radar Engineering,M.Kulkarni.

REFERENCE BOOKS

1. Digital and Analog Communication systems, K. San Shanmugam.
2. Satellite Communication, Pratt and Bosterin.
3. Microwave, K.C. Gupta.

DIGITAL ELECTRONICS

Course Code: 25PHMS310	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P: 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To acquire basic knowledge on digital communication system and noise control.
2. To develop understanding of the signal communication in computer and network system.
3. To introduce the information theory and coding.
4. To make familiar with the principle involved in optical fiber communication
5. To introduce the concept of Optical Joints and Couplers

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge communication system and kinds of noises involves.
2. Get an understanding of working principle behind LAN, WAN, MAN and topology.
3. Able to understand the signal transmission in optical fibres.
4. Well-versed with the working and application of LED and diode LASERS.
5. Able to understand the concept of Optical Joints and Couplers

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: SIGNALS, SYSTEMS AND NOISE

Basics Elements of Communication Systems, Fourier Representation of Periodic and Non-Periodic Signals, Impulse and Step Response of Systems, Time and Frequency Domain Analysis of Systems, Ideal and Real

Filters, Noise in Communication Systems, Signal To Noise Ratio, Noise Equivalent Band Width and Noise Figure.

UNIT II: INFORMATION THEORY AND CODING

Introduction, Amount of Information, Average Information, Shannon Encoding Algorithm, Communication Channels, Rate of Information and Capacity of Discrete Memory Less Channels, Shanon-Hartley Theorem. Linear Block Cyclic Codes.

UNIT III: DIGITAL SIGNAL (DATA) TRANSMISSION

Introduction, Optimum Receiver for Binary Digital Modulation Schemes, Binary ASK, Binary FSK, Binary PSK and Differential PSK Signaling Schemes, Serial Data Communication in Computers USART 8251, Basics Communication Networks (LAN, WAN, MAN) And Its Topology.

UNIT IV: FIBRE OPTIC COMMUNICATION

Basic Optical Communication System, Wave Propagation in Optical Fiber Media, Step and Graded Index Fiber, Material Dispersion and Mode Propagation, Losses in Fiber, Optical Fiber Sources (LEDs and LASERs) And Detectors (PIN Photodiode, APD Photodiode), Optical Joints and Couplers.

TEXTBOOKS

1. Digital and Analog Communication Systems, K. San Shanmugam.
2. Communication Systems, Simon Haykin.

REFERENCE BOOKS

1. Optical Fibre Communication, Kaiser.

OPTOELECTRONICS

Course Code: 25PHMS311	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To acquire basic knowledge on optical wave guides and optical fibers.
2. To develop understanding of the optoelectronic effects.
3. To develop the understanding of the imaging and signal detection by photo detectors.
4. To introduce the principle and working behind the semiconductor lasers
5. To introduce the concept of quantum well devices

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge of the wave guide characteristics and basic structures
2. Get an understanding of the optical field confinement in the optical fibers
3. Able to understand the principles behind various optoelectronic devices
4. Well-versed with the working of semiconductor lasers
5. Able to understand the concept of quantum well devices

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: OPTICAL WAVEGUIDES

Planar slab waveguide and circular waveguide (optical fiber); modes, numerical aperture; attenuation and dispersion in waveguides; fabrication and characterization of waveguides; coupling between optical sources and waveguides, Basic semiconductor and device physics, optical properties of semiconductors, p-n junctions, optical absorption, amplification, semiconductor lasers, photo-detectors and noises, quantum well devices

UNIT II: DIELECTRIC WAVEGUIDES AND OPTICAL FIBERS

Symmetric planar dielectric slab waves, modal and waveguide dispersion in planar waveguides, step index optical fiber, step index optical fiber, Numerical Aperture, dispersion in single mode fibers, dispersion modified fiber and compensation, Bit rate, dispersion and electrical and optical bandwidth, the Graded index optical fiber, attenuation in optical fibers

UNIT III: OPTOELECTROINCS EFFECTS AND PHOTO DETECTORS

Polarization, light propagation in anisotropic medium, Birefringent optical devices, optical activity and circular birefringence, Liquid crystal displays, Electro-optic effect, Pockel's effect, Kerr effect, Integrated optical modulators, acousto optic modulators, Faraday Rotation and optical isolator, Principle of the pn unction photodiode, Shockley Ramo theorem and external photocurrent, Quantum efficiency and responsively, the pin photodiode, avalanche photodiode, heterojunction photodiodes, Schottky junction photo detectors, phototransistors, basic photodiode circuits, noise in photo detectors, image sensors.

UNIT IV: STIMULATED EMISSION DEVICES: OPTICAL AMPLIFIER AND LASERS

Stimulated emission, photon amplification and laser, stimulated emission rate and emission cross section, Erbium doped fiber amplifier, broadening of the optical gain curve and line width, principle of laser diode, heterostructure laser diodes, Quantum well devices, elementary laser diode characteristics, steady state semiconductor rate equations, single frequency semiconductor lasers, vertical cavity surface emitting lasers, semiconductor optical amplifier, direct modulation of laser diodes, holography

TEXTBOOKS

1. Introduction to fiber optics, A. Ghatak and K. Thyagarajan(Cambridge University Press, Cambridge, UK 1998)
2. Fundamentals of photonics, B.A. Saleh and M.C. Teich(Wiley Interscience, NJ, USA 2007)
3. Fundamentals of optoelectronics, C.R. Pollock (Irwin Inc., USA 1995)

REFERENCE BOOKS

1. Quantum electronics / Optical electronics, A. Yariv
2. Optoelectronics, Wilson and Hawkes
3. Optoelectronics and Photonics, Kasap& Fiber optic communications, Palais

NUCLEAR PHYSICS I

Course Code: 25PHMS312	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. Learning of kinematics of nuclear reactions and reaction cross section.
2. Understanding of Fission and Fusion reactions.
3. Knowledge of different reactors and their use.
4. Learning of accelerators.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Can differentiate different nuclear reactions and calculate cross section.
2. Can explain nuclear fission and fusion.
3. Well aware of different reactors available and their use.
4. Can explain different accelerators.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CL04
CO1				
CO2				
CO3				
CO4				

COURE CONTENTS

UNIT I

NUCLEAR REACTIONS I: Different types of nuclear reactions, Conservation laws in nuclear reactions, Collision between subatomic particles (Elastic and non elastic), Q value of nuclear reactions, Cross section of nuclear reactions, Resonance scattering and Breit-Wigner dispersion relation; Compound nucleus formation and break-up, Statistical theory o f nuclear reactions, evaporation probability

UNIT II

NUCLEAR REACTIONS II: Optical model,, Nuclear fission: fission reactions with example, spontaneous fission, liquid drop model, barrierpenetration, Nuclear fusion (proton-proton cycle, carbon-nitrogen cycle), thermonuclear reactions, Nucleosynthesis and abundance of elements

UNIT III:

NUCLEAR REACTORS: Basic types of reactors, components of Nuclear Reactor, Light Water Reactor, Gas cooled reactors, Fast Breeder Reactor and its scope in power generation, Basic design of fusion reactor, conditions for a fusion reactor, Lawson criterion, Plasma confinement, peaceful utilization of fusion power.

UNIT IV:

ACCELERATORS: Classification and performance characteristic of accelerators, ion sources, Eletrostatic accelerator: Cockcroft-Walton voltage generator, Van de Graaff voltage generator, Tandem accelerator, Pelletron accelerator, LINAC, Cyclotron, Betatron ,Synchrotron, Phase stability

TEXTBOOKS

1. Nuclear Physics: Principle and Application by John Lilley (Wiley Pub.).
2. Nuclear Physics by S. N. Ghoshal (S Chand)

REFERENCE BOOKS

1. Nuclear Energy: an introduction to the concepts, systems and application of nuclear proceses, by R. L. Murray and K. E. Holbert
2. Nuclear Physics: Theory and Experiment by R. R. Roy and B. P. Nigam

ASTROPHYSICS - I	
Course Code: 25PHMS313	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite: Knowledge of astrophysics	

Learning objectives

1. To discuss the basics of equilibrium and stability of stars.
2. To make the students familiar with the interior properties of stars.
3. To discuss the various aspects of Sun and its activity.
4. To gain a basic knowledge about the galaxies and quasi-staller objects.

Learning outcome

1. Able to understand the stability and equilibrium of stars.
2. Get an understanding of the various properties of starts.
3. Fluent with up-to date knowledge of the Sun, its various activity features and space weather.
4. Basic knowledge about the composition, structure and evolution of galaxies and related objects.

UNIT I:
EQUILIBRIUM AND STABILITY OF STARS

Hydrostatic equilibrium, virial Theorem, Polytrophic indices, Lane- Emden equation LTE, Radiative equilibrium, stability condition for convective and radiative equilibrium.

UNIT II:
INTERIOR PROPERTIES OF STARS

Continuous spectrum of star, Stellar opacity, Limb darkening and blanketing theory of Fraunhofer lines, curve of growth and line broadening .

UNIT III:
STUDY OF THE SUN

Solar structure, solar interior, core, radiative zone, convective zone, the photosphere, solar atmosphere, chromosphere, corona. Active regions, sunspot, Magnetic field of the Sun. Basics of Solar Magneto-hydrodynamics, solar cycle, butterfly diagram, solar flares, filament eruptions and coronal mass ejections. Helioseismology basics.

UNIT IV:
GALAXIES AND QUASI-STELLER OBJECTS

Classification of galaxies, Distributions of stars in the Milky way, Morphology, Kinematics, Interstellar medium, Galactic center, External galaxies, spiral structures, Dark matter and dark energy in spiral galaxies, Galactic rotation, Theory of AGNs, Syferts, Quasars and their energy generation and redshift anomaly, Different AGN models, radio lobes and jets, Gamma ray bursts, BL – Lac objects, concept of expanding universe.

TEXT BOOKS:

1. An Invitation to Astrophysics, T. Padmanabhan, World Scientic Publishing Co.
2. An Introduction to Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
3. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
4. Astrophysics in a Nutshell (Basic Astrophysics), Dan Maoz, Princeton University Press.
5. Foundations of Astrophysics, Barbara Ryden and Bradley M. Peterson, Addison Wesley.
6. Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press.

REFERENCE BOOKS

1. Astronomy and Astrophysics, A. B. Bhattacharya, S. Joardar, R. Bhattacharya, Overseas Press (India) Pvt.Ltd.
2. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan, Cambridge University Press.
3. K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New AgeInternational (p) Ltd, New Delhi,2002.
4. BaidyanathBasu, 'An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
5. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

CLASSICAL FIELD THEORY

CLASSICAL FIELD THEORY	
Course Code:25PHMS314	Continuous Evaluation: … Marks
Credits: 4	End Semester Examination: …… Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite: NIL	

COURSE OBJECTIVES

1. To develop a foundational understanding of field theory through the Lagrangian and Hamiltonian formalisms.
2. To explore the role of symmetry and conservation laws in classical field dynamics via Noether's theorem.
3. To analyze classical electromagnetic field theory using covariant notation and gauge principles.
4. To introduce the concept of spontaneous symmetry breaking and its consequences in field theory.
5. To examine applications of classical fields in physical systems and set the groundwork for quantum field theory.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Formulate and solve the Euler-Lagrange equations for classical fields including scalar and vector fields.
2. Derive and interpret conservation laws using Noether's theorem in classical field contexts.
3. Analyze electromagnetic fields in a covariant framework and understand the importance of gauge invariance.
4. Explain the mechanism of spontaneous symmetry breaking and the emergence of massless Goldstone bosons.
5. Identify real-world applications of classical field theory such as MOT systems, solitons, and the Higgs mechanism, and relate them to quantum field theory.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

UNIT I: INTRODUCTION TO CLASSICAL FIELD THEORY
Review of classical particle mechanics, Lagrangian formulation for fields, Euler-Lagrange equations for fields, Examples: Scalar fields and vector fields, Symmetries and conservation laws

UNIT II: HAMILTONIAN FORMALISM AND NOETHER'S THEOREM
Hamiltonian density and conjugate momenta, Canonical equations of motion for fields, Noether's theorem and conserved currents, Energy-momentum tensor, Examples from scalar and electromagnetic fields

UNIT III: CLASSICAL ELECTROMAGNETIC FIELD THEORY
Classical Maxwell's equations in covariant form, Lagrangian for the electromagnetic field, Field strength tensor and gauge invariance, Stress-energy tensor of EM fields, Dual field tensor and magnetic monopoles (introductory idea)

UNIT IV: SYMMETRIES AND SPONTANEOUS SYMMETRY BREAKING
Internal and spacetime symmetries, Continuous vs discrete symmetries, Spontaneous symmetry breaking, Goldstone's theorem and massless modes, Examples of Nambu-Goldstone bosons

UNIT V: CLASSICAL FIELD THEORY APPLICATIONS
Laser cooling and trapping (MOT: Magneto-Optical Traps), Higgs mechanism (qualitative introduction), Classical solutions: Solitons and topological defects (overview), Pathway from classical to quantum field theory, Review and conceptual bridge to QFT

TEXT BOOKS

1. **L. H. Ryder** – *Quantum Field Theory* (Chapters 1–4 focus on classical field theory foundations) Publisher: Cambridge University Press
2. **Mark Srednicki** – *Quantum Field Theory* (Early chapters cover classical field theory in detail) Publisher: Cambridge University Press
3. Amitabha Lahari, Palash B. Pal, A first book of Quantum Field Theory, Narosa publications, 2nd Edition, 2007.
4. Michael E. Peskin and Daniel V. Schroeder, An introduction to Quantum Field Theory, Westview Press Inc, 1st Edition, 1995.

5. Thomas Banks, Modern Quantum Field Theory, Cambridge University Press, 2008

REFERENCE BOOKS

1. Steven Weinberg, The Quantum Theory of Fields: foundations, volume 1, Cambridge University Press, 2005.
2. V. B. Berestetskii, E.M Lifshitz and L.P. Pitaevskii, Quantum Electrodynamics, Butterworth-Heinemann, 2nd Edition 1982
3. M. Maggiore, A modern introduction to Quantum Field Theory, Oxford University Press, 2005
4. David Tong – *Lecture Notes on Classical Field Theory*, https://www.damtp.cam.ac.uk/user/tong/.
5. N. M. J. Woodhouse – *Introduction to Analytical Dynamics*, Publisher: Clarendon Press
6. A. Zee – *Quantum Field Theory in a Nutshell*, Publisher: Princeton University Press
7. T.-P. Cheng & L.-F. Li – *Gauge Theory of Elementary Particle Physics*, Publisher: Oxford University Press

QUANTUM COMPUTATION I	
Course Code: 25PHMS315	Continuous Evaluation: …… Marks
Credits: 4	End Semester Examination: …… Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite: Quantum Mechanics	

COURSE OBJECTIVES

1. To introduce the foundational principles of quantum mechanics relevant to quantum computing, including quantum state representation and measurement.
2. To build a strong mathematical foundation using linear algebra, vector spaces, operators, and transformations essential for quantum computation.
3. To explore the nature and manipulation of qubits, entangled states, and their physical realizations across different quantum hardware platforms.
4. To understand interpretations of quantum mechanics, quantum nonlocality, and teleportation as a foundation for quantum communication protocols.
5. To train students in the theory and design of basic quantum circuits using standard quantum logic gates and reversible computing concepts.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Apply the postulates of quantum mechanics and Dirac notation to analyze and describe quantum states and their evolution.
2. Use linear vector space formalism to define quantum systems, operators, and transformations with physical significance.
3. Demonstrate understanding of qubits, entangled states, and implement their physical representations across various quantum technologies.
4. Interpret key quantum phenomena including wavefunction collapse, the EPR paradox, and teleportation using Bell states.
5. Construct and simulate basic quantum logic circuits using gates such as Pauli, Hadamard, Toffoli, and controlled gates, and assess their complexity.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO 4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

Unit I: **Foundations of Quantum Computing:**
Why Quantum Computing? Postulates of Quantum Mechanics, Dirac Notation: Kets and Bras, Superposition principle and Qubit measurement, Bloch Sphere Representation, Tensor Products and multi-qubit systems, Basics of Linear Algebra: Vectors, Complex Norms, Conjugates.

Unit II: Mathematical Structures
Linear Vector Space: addition and multiplication rules, Hilbert space, Dimension and Basis of a Vector Space, Dirac notation: scalar product, properties of kets, bras and bra-kets and their matrix representation, Operators: Hermitian Adjoint, properties of the Hermitian conjugate rules, Hermitian and skew-Hermitian, Projection operators, Commutators Algebra, uncertainty relation of operators, Inverse and Unitary operators, Infinitesimal and finite Unitary transformations, Eigen values and Eigen vectors of an operator, Parity Operator, Matrix representation of operators, Wave mechanics.

Unit III: Qubits and Quantum States
Dirac notation: bras, kets, and inner products, Superposition and normalization, Measurement and probability amplitudes, Multi-qubit states, tensor products, entangled states, Physical qubit implementations: Trapped Ions, Superconducting Qubits, Quantum Dots, GaAs and SQUID devices, NMR-based QC, Bose-Einstein Condensates for QC, Decoherence in hardware platforms, Supercooling and noise filtering techniques

Unit IV: **Quantum States and Interpretations**
Wave function collapse and measurement, Concept and physical implications of entanglement, Bell states and measurement outcomes, Einstein-Podolsky-Rosen (EPR) paradox, Bell inequality and CHSH game, Quantum teleportation: principles and circuits (intro), No-cloning theorem, Interpretations: Copenhagen, Many-Worlds

Chapter 5: Quantum Logic Gates and Circuits
Reversible logic, classical vs quantum logic, Pauli gates (X, Y, Z), Hadamard, phase gates, CNOT, CZ, SWAP gates, Quantum circuit diagrams and synthesis, Gate algebra and unitarity, Building simple quantum circuits Toffoli, Fredkin gates, Quantum circuit diagrams, Reversibility and Unitarity, Gate cascades and conditional operations, Classical algorithms and complexity classes (P, NP, etc.)

TEXTBOOKS

1. Michael A. Nielsen & Isaac L. Chuang – *Quantum Computation and Quantum Information,* Cambridge University Press
2. David J. Griffiths & Darrell F. Schroeter – *Introduction to Quantum Mechanics* (2nd or 3rd Edition), Pearson **Publisher.**
3. V. K. Thankappan – *Quantum Mechanics*, Publisher: New Age International

REFERENCE BOOKS

1. J. J. Sakurai & Jim Napolitano – *Modern Quantum Mechanics,* Cambridge University Press
2. Eleanor Rieffel & Wolfgang Polak – *Quantum Computing: A Gentle Introduction*: MIT Press
3. Mark M. Wilde – *Quantum Information Theory,* Cambridge University Press
4. Thomas G. Wong – *Introduction to Classical and Quantum Computing,* Springer
5. Chuck Easttom, Quantum Computing Fundamentals, Pearson Education, 1st Edition, 2022.
6. M.A. Nielsen and I.L. Chuang, Quantum computation and quantum information, Cambridge University Press, 2010.

CLASSICAL AND QUANTUM INFORMATICS	
Course Code: 25PHMS316	Continuous Evaluation: …….. Marks
Credits: 4	End Semester Examination: ………. Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To provide foundational understanding of classical information theory and its limitations in the context of quantum systems.
2. To introduce the formalism of the density matrix and explore various interpretations of quantum mechanics.
3. To explain the principles of quantum cryptography, quantum communication protocols, and their experimental foundations.
4. To familiarize students with the architecture of quantum networks and the classical-quantum interface challenges.
5. To equip students with skills in designing and simulating quantum circuits involving multi-qubit operations and quantum communication protocols using Qiskit.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Compare and contrast classical and quantum information theory, including the concepts of entropy, data compression, and computability.
2. Analyze quantum measurement processes using density matrices and explain key interpretations like Many-Worlds and hidden variable theories.
3. Demonstrate understanding of quantum cryptographic protocols including BB84, superdense coding, and quantum teleportation, and evaluate their theoretical and experimental implications.
4. Describe the layered architecture of a quantum network and identify design challenges at the interface of classical and quantum hardware.
5. Design, simulate, and test multi-qubit circuits involving entanglement, teleportation, and cryptographic protocols using Qiskit.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

Unit - I: Classical theory of information

Basic ideas of classical information theory, Measures of information (information content and entropy);Maxwell‟s Demon; Data compression; The binary symmetric channel; error correcting codes; Classical theory of computation; Universal computer; Turing machine; Computational complexity; Uncomputable functions; Shortcomings of classical information theory and necessity of information theory.

Unit - II: Density Matrix and Interpretation

Density Matrix – Bloch Sphere and Density Matrix – Measurement Postulates.

The measurement problem, Schrodinger's cat and Wigner's friend, Decoherence and the CNOT gate, The Many-Worlds Interpretation, The idea of hidden variables, The Bell Inequality and the CHSH game, The GHZ game Wiesner's quantum money scheme, BB84 quantum key distribution, Superdense quantum coding, Quantum teleportation, Ruling out quantum Random Access Codes , A version of Holevo's Theorem.

Unit - III: Quantum Information and Quantum Cryptography

Classical Information theory, Shannon Entropy, Shannon's Noiseless Coding Theorem, Ven Neumann Entropy – EPR and Bell's inequalities – Cryptography – RSA Algorithm – Quantum Cryptography – Experimental Aspects of Quantum Computing

Unit IV: Quantum Network Architecture

Quantum data plane, measurement plane, control plane, Control processor architecture, Classical-quantum interface challenges, Quantum buses and interconnects, Real-time control and timing in QC systems

Unit V: Quantum Programming with Multiple Qubits

Building entangled state circuits, Complex circuits: teleportation, entanglement swapping, Quantum Adder and Reversible circuits, Qiskit multi-qubit programming, Visualizing quantum state evolution

TEXT BOOKS

1. Nielsen, M. A. & Chuang, I. L. – *Quantum Computation and Quantum Information,* Cambridge University Press
2. Mark M. Wilde – *Quantum Information Theory,* Cambridge University Press
3. Rieffel, E. & Polak, W. – *Quantum Computing: A Gentle Introduction,* MIT Press
4. Chuck Easttom, Quantum Computing Fundamentals, Pearson Education, 1st Edition, 2022.
5. M.A. Nielsen and I.L. Chuang, Quantum computation and quantum information, Cambridge University Press, 2010.
6. J. Preskill, Quantum information and Computation, CIT lecture notes.
7. E.Horowitz , Sahni & Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", Galgotia Publications,1997

REFERENCE BOOKS

1. John Watrous – *The Theory of Quantum Information,* Publisher: Cambridge University Press
1. Shannon, C. E. – *A Mathematical Theory of Communication*
2. Michael Ben-Or et al. – *The Surface Code: A Blueprint for a Quantum Computer* (Preprint)
3. Qiskit Textbook (IBM Quantum) – *Learn Quantum Computation using Qiskit.* URL: https://qiskit.org/textbook
4. Asher Peres, Quantum theory: concepts and methods, Kluwer Academic Publishers.
5. Phillip Kaye, Raymond Laflamme, Michele Mosca, An introduction to quantum computing, Oxford University Press.
6. Aho, Ullman & Hopcraft, "*The Design and Analysis of Algorithms*", Pearson Education, 2001
7. S.E.Goodman, S.T.Hedetniemi, "*Introduction to the Design and Analysis of Algorithms*", McGraw Hill , 2002
8. Sara Baase, "*Computer Algorithms - Introduction to design and analysis",* Pearson

ADVANCED SOLID STATE PHYSICS II	
Course Code: 25PHMS402	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To discuss general concepts of advanced Condensed Matter Physics.
2. To illustrate the properties and applications of glasses and polymers.
3. To highlight the phase transitions in solid state materials.
4. To make students familiar with theoretical and experimental topics in solid state physics.
5. To make familiar with the theory of quantum Hall effect

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge on the glasses and polymers.
2. Get an understanding of structure of liquid crystals.
3. Able to understand the phase transitions in solid state materials.
4. Well-versed with the knowledge of surface physics.
5. Able to understand the theory of quantum Hall effect

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: GLASSES AND POLYMERS

Glass formation, types of glasses and glass transition, radial distribution function and amorphous semiconductors, electronic structure of amorphous solids, localized and extended states, mobility edges, Density of states and their determination, transport in extended and localized states, Optical properties of amorphous, semiconductors. Structure of polymers, polymerization mechanism, characterization, techniques, optical, electrical, thermal and dielectric properties of polymers.

UNIT II: LIQUID CRYSTALS

Liquid Crystals. Structural peculiarities and applications, Thermotropic, liquid crystals; Classification, Phases and phase transitions; anisotropic materials; symmetry aspects; optics; electro-optics of liquid crystals; ferro-, and antiferroelectric liquid crystals; examples of LCs in nanoscience, photonics and microwave electronics, display devices.

CARBON BASED MATERIALS: Fullerenes, C60, C80 and C240 Nanostructures; Properties and Applications (mechanical, optical and electrical). CNT-single walled and multiwalled, grapheme.

UNIT III: PHASE TRANSITIONS IN SOLIDS

Landau's theory, Critical exponents. Ginzburg Criterion. Critical dimensionality, first order and second order transition, order parameter and critical exponents, examples of phase transition: Solid-liquid, liquid-gas, magnetic transitions, ferroelectric-paraelectric, ferromagnetic – paramagnetic, superconducting transition, liquid crystals, glass transitions

Kadonoff's scaling hypothesis. The renormalization group, renormalization group for the Ising chain. Fixed points. Calculation of fixed point for the 2D Ising model on the triangular lattice

UNIT IV: INTRODUCTION TO SURFACE PHYSICS

Reconstruction and relaxation, surface electronic structure; Heterostructures; Self-assembled monolayers, Electrified interfaces, Charge transfer at the liquid-solid interfaces.

SPECIAL TOPICS: Integral and fractional quantum Hall effect: electron in a strongmagnetic field, Landau levels and their degeneracy, simple explanation of IQHE; Metal-Insulator transitions: Mott-Hubbard and impurity induced; Landau theory of Fermi liquid, Mott variable range hopping, Bose- Einstein condensation

TEXTBOOKS

1. Solid State Physics, Neil W. Aschroft& N. David Mermin (Ist Ed., Cengage Learning, 2003)
2. Solid State Physics, Gerald Burns (Academic Press, 1985)
3. Solid State Physics, Wlater A. Harrison (Dover Publications, 1980)
4. Solid State Physics : An introductlion to Principles of Materials Science, Harald
5. Physics of Amorphous Solids, R. Zallen (John Wiley and sons, 1983)
6. Introduction to Polymer Physics, Ulrich Eisele and Stephen D. Pask (Springer-Verlag, 1990)
7. The physics of liquid crystals, Pierre-Gilles de Gennes (2nd Ed., Oxford University Press, 2003)

REFERENCE BOOKS

1. Introduction to Liquid Crystals, Peter J. Wojtowicz, E. Priestly, Ping Sheng (Plenum press, 1975)
2. Carbon Nanotubes: Properties and Applications, Michael J. O'Connell (CRC press, 2006)
3. The Physics of Phase Transitions - Concepts and Applications, P. Papon, J. Leblond, and Paul H. E. Meijer(2nd Ed., Springer-Verlag, 2006)
4. Physical Methods for Materials Characterization, P. E. J. Flewitt, R. K. Wild, (2^{nd} Ed., CRC Press, 2015)
5. Encyclopedia of materials characterization: surfaces, interfaces, thin films, R. C. Brundle et al. (Butterworth-Heinemann, 1992)

CHARACTERIZATION OF MATERIALS	
Course Code: 25PHMS403	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To discuss general structural analysis of materials.
2. To illustrate the working of electron microscopy
3. To highlight the optical microscopy working and its applications.
4. To develop understanding about the NMR and ESR
5. To make students familiar Laser as a source of radiation and its characteristics

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge on the structural analysis of materials
2. Get an understanding of working principle and application of electron microscopes.
3. Able to understand the working and different imaging modes of optical microscopes.
4. Well-versed with the trace level detection techniques of NMR and ESR.
5. Get familiar with laser as a source of radiation and its characteristics

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: STRUCTURAL ANALYSIS

X-ray characterization of imperfections in crystals, Basic concepts of small angle X-ray scattering and its application in evaluation of shape and size of surface particles. Neutron scattering and diffraction with reference to light elements and magnetic structures.

UNIT II: ELECTRON SPECTROSCOPY TECHNIQUES

LEED (Low Energy Electron Diffraction) for surface structures, Surface Topography, Elementary Concepts of Scanning and Scanning Tunneling Microscopic Techniques for chemical analysis. Methods. RBS (Rutherford Back Scattering)

UNIT III: OPTICAL SPECTROSCOPIC TECHNIQUES

Double Beam IR Spectrometers, Basic Concepts of Raman Spectrography in Solids, Sensitive Detectors such as CCD Camera, Concept of Space Group and Point Group, Identification and Analysis of Optic and Acoustic Modes in Solids. Electronic Absorption Study for Band Gap determination.

UNIT III: ANALYSIS OF TRACE ELEMENTS

Basic of nuclear magnetic resonance (NMR) and electronic spin resonance (ESR) spectroscopy, Mossbauer spectroscopy, Microwave spectroscopy, Photo acoustic spectroscopy and their applications. Laser as a source of radiation and its characteristics Laser fluorescence and absorption spectroscopy, Multiphoton ionization and separation of isotopes.

TEXTBOOKS

1. Analytical Techniques for Thin Films-Treatise on Material Science and Technology, Vol. 27, K.N. Tu and R. Rosenberg (ed).
2. Electron Microprobe Analysis, S.J.B. Reed.

REFERENCE BOOKS

1. Topics in Applied Physics, Vol. 4: R. Gomer (ed.).
2. Analysis of high Temperature Materials, Van Der Biest (ed.)

NANOMAGNETISM AND SPINTRONICS

Course Code: 25PHMS404	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To acquire the basic knowledge of magnetism and principle of nanomagnetism.
2. To understand the basics of domain wall dynamics in nanomagnetic system.
3. To illustrate the basics laws of spintronics spin dependent transport processes in spintronics devices.
4. To make student familiar with Advances in spintronic materials, technology, and futuristic materials.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge on the concepts of magnetism and nanomagnetism.
2. Get an understanding of domain wall dynamics in nanomagnetic systems.
3. Able to understand the spin dependent transport processes in spintronics devices.
4. Well-versed with the advances in spintronic materials, technology.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CL04
CO1				
CO2				
CO3				
CO4				

COURE CONTENTS

Unit I BASICS OF MAGNETISM & INTRODUCTION TO NANOMAGNETISM:
Magnetic fields and magnetic materials, Units in Magnetism, The various types of magnetic energy (magnetostatic energy, magnetocrystalline energy, magnetostrictive energy), domain walls, demagnetizing field, magnetization process. the Bloch domain wall. Why magnetism at nanoscale? The origin of Nanomagnetic behavior. Dimensionality and Density of Electronic states.

Unit II MAGNETIZATION DYNAMICS IN NANOMAGNETIC SYSTEMS:
Magnetic Domains, Elements of Micromagnetism, Magnetism of small particles, Superparamagnetism, Stoner-Wohlfarth Model, Precessional dynamics of magnetization, Ferromagnetic resonance and Landau-Lifshitz-Gilbert equation, Spin waves, Precessional switching of macrospins driven by magnetic field, Precessional motion of domain walls and vortices driven by a magnetic field.

Unit III: INTRODUCTION TO SPINTRONICS:
Transport in magnetic materials. Magneto-transport in metals, Anisotropic magnetoresistance, Giant magnetoresistance, Colossal Magnetoresistance, Spintronic materials. Qualitative description of spin transfer torque, spin transfer driven magnetization dynamics, Current driven switching of magnetization, domain wall scattering. Spin injection: Spin current, Spin injection, spin accumulation, Spin Hall effect and Inverse Spin Hall effect

Unit IV: SPINTRONIC DEVICES:
Spin Valve transistor, Spin FET, Spin – tunneling devices (TMR devices), Magnetic Memories: GMR technology, MRAM, Read Heads, MRAMS, Field Sensors, Spintronic Biosensors, Quantum Computing with spins.

TEXT BOOKS:

1. Principles of Nanomagnetism, Alberto P. Guimaraes, Springer, 2009.
2. Nanomagnetism and spintronics, edited by Teruya Shinjo, Elsevier, 2013.
3. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press, 2009.
4. Introduction to Spintronics, SupriyoBandyopadhyay and Marc Cahay, CRC press, 2008.

REFERENCE BOOKS:

1. Spin Waves: Theory and Applications, Daniel D. Stancil, Anil Prabhakar Springer Science, 2009.
2. Relaxation Processes in Micromagnetics, Harry Suhl, Oxford University Press, 2007.
3. Spin Electronics, D. Awschalom, Robert A. Buhrman, James M. Daughton, Stephan von Molnár, Michael L. Roukes (Editors), Springer, 2004.

FIBER OPTICS SENSORS	
Course Code: 25PHMS405	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To illustrate basic knowledge on optical fibers structure and principle of wave guiding.
2. To highlight the dispersion phenomenon in fiber optics signals.
3. To develop the students understanding about the optical fiber sensor applications.
4. To highlight the application of the fiber sensors
5. To develop knowledge on health-based applications of fiber sensors

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Able to understand the wave guide characteristics and basic structures of optical fibres.
2. Able to understand the principle behind the signal dispersion of the guided mode of optical fiber
3. Well-versed with the principles behind spectroscopic application of optical fibers.
4. Fluent with good knowledge of the optical fiber application
5. Well versed with health-based applications of fiber sensors

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: FUNDAMENTALS OF FIBER OPTICS

Optical Fiber: Principles-Physical structure, Wave guide parameter (V-Number), Optical Fiber Types: Multi mode and single mode optical fibers. Optical Fiber Profiles-Step Index & Parabolic Index, Concept of optical modes-Field Patterns of some low order guided modes, Fabrication of optical fiber.

UNIT II: DISPERSION IN OPTICAL FIBER

Pulse Dispersion in Multimode Optical fiber-Ray & Material Dispersion in Step Index fiber, Laser optimized multimode optical fiber. Pulse Dispersion in Multimode Optical fiber-Intramodal Dispersion, Waveguide dispersion, Optical Fibers for dispersion compensation, Polarization mode Dispersion, Fiber Amplifiers.

UNIT III: TECHNIQUES IN OPTICAL FIBERSENSOR (OFS)

Intrinsic & Extrinsic Sensors, Basic Optical Fiber Sensor Components-Isolators, Couplers, Modulators. Optical Fiber Sensor (OFS) based on principles: Fiber Braggs Grating, Evanescent Wave, Raman Spectroscopy, SERS, Laser Induced Fluorescence (LIF) Spectroscopy.

UNIT IV: OPTICAL FIBER SENSOR (OFS) APPLICATIONS

Health Monitoring-Endoscopy, Photo Dynamic Therapy (PDT), Fiber Optic Current Sensor, Photonic Crystal Fibers- Refractive Index Sensing & Clinical Diagnostic. Fiber Optic Micro Bend Sensors, Spectroscopy based OFS: Molecular Markers & Detector

TEXTBOOKS

1. Fiber Optic Sensors: Principles and Applications, B. D. Gupta
2. Introduction to Fiber Optics, A.Ghatak and K.Thyagrajan

REFERENCE BOOKS

1. Fiber Optic Essentials, A. Ghatak and K.Thyagrajan
2. Optical Fiber Sensors: Advanced Techniques and Applications, G. Rajan
3. Fiber Optics: Physics and Technology,F. Mitsch

APPLIED OPTICS

Course Code: 25PHMS406	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To develop the understanding of the photonic concepts.
2. To illustrate the basic concepts of Physical Optics
3. To highlight about the Photonic crystals and Meta materials
4. To impart the optical and imaging techniques
5. To make students familiar with nonlinear optical microscopy

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge of photonic materials
2. Get an understanding of the basic concepts of Physical optics
3. Able to understand the light behavior in Photonic crystals and Meta materials
4. Well-versed with the optical and imaging techniques
5. Familiar with the concept of nonlinear optical microscopy

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I PHYSICAL OPTICS

Wave motion, superposition of waves, interference, diffraction, basics of coherence theory, temporal and spatial coherence, Michelson and Fabry-Perot interferometer, statistical properties of laser speckle patterns.

UNIT II: PHOTONIC CRYSTALS AND METAMATERIALS

Photonics crystals- 2D & 3D, colloidal photonic crystals, light propagation through disordered media, localization of light, photonic glass, optical metamaterials, negative index metamaterials, nonlinear optics with metamaterials.

UNIT III: APPLICATIONS OF OPTICAL TECHNIQUES

Mie scattering technique, static & dynamic light scattering technique, optical tweezers, AFM colloidal probe technique, knife edge scanning to measure laser beam profile.

UNIT IV: OPTICAL MICROSCOPY & IMAGING TECHNIQUES

Basics of optical microscopy, bright field and dark field microscopy, polarizing microscopy, fluorescence microscopy, fluorescence confocal microscopy, nonlinear optical microscopy, two photon fluorescence microscopies.

TEXTBOOKS

1. Optical Electronics, A. Ghatak and K.Thyagrajan
2. Principles of Optics, M. Bornand, E. Wolf
3. Optics, A. Ghatak

REFERENCE BOOKS

1. Optical Metamaterials: Fundamentals & Applications, V. Shalaevand , W. Cai
2. Modern Optical Engineering, W.J. Smith
3. Optics, E. Hecht

ROTATIONAL & VIBRATIONAL SPECTROSCOPY

ROTATIONAL & VIBRATIONAL SPECTROSCOPY	
Course Code: 25PHMS407	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To impart the about Group Theory
2. To illustrate the Rotational Spectroscopy of molecules.
3. To impart the knowledge of the Vibrational Spectroscopy of molecules
4. To highlights the selection rules in Raman and infrared spectroscopy
5. To develop the understanding on Vibration-rotation spectroscopy

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge of Molecular Symmetry and Group Theory
2. Get an understanding of. the Rotational and Vibrational Spectroscopy of diatomic/polyatomic molecules
3. Able to understand the vibrational spectroscopy of diatomic and polyatomic molecules
4. Well-versed with the Various Selection Rules in Raman and Infrared Spectroscopy
5. Able to understand Vibration-rotation spectroscopy

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: MOLECULAR SYMMETRY & GROUP THEORY
Elements of Symmetry-n-fold axis of symmetry, Plane of symmetry Centre of inversion, n-fold rotation-reflection axis of symmetry, Identity element of symmetry. Point Groups (Cn, Sn,Cnv, Dn, Cnh, Dndetc), Character tables for C2v, C3v point groups, Symmetry and dipole moments.

UNIT II: ROTATIONAL SPECTROSCOPY

Linear, symmetric rotor, spherical rotor and asymmetric rotor molecules, Rotational infrared, millimeter wave and microwave spectra-Diatomic & linear polyatomic molecules, Symmetric & asymmetric rotor molecules. Rotational Raman Spectroscopy-Theory, Rotational Raman spectra of diatomic, linear polyatomic, symmetric and asymmetric rotor molecules

UNIT III: VIBRATIONAL SPECTROSCOPY OF DIATOMIC MOLECULES

Diatomic molecules-Infrared spectra, Raman spectra, Anharmonicity- electrical anharmonicity, mechanical Anharmonicity. Vibration-rotation spectroscopy- Infrared spectra, Raman spectra, Transition rules.

UNIT IV: VIBRATIONAL SPECTROSCOPY OF POLYATOMIC MOLECULES

Group vibrations, Number of normal vibrations of each symmetry species-Non-degenerate and Degenerate vibrations. Vibration selection rules for infrared and Raman spectra. Vibration-rotation spectroscopy-Infrared spectra of linear molecules, symmetric, spherical and asymmetric rotors. Anharmonicity-Potential energy surfaces, vibrational term values.

TEXTBOOKS

1. Modern Spectroscopy, J. M. Hollas
2. Fundamental of Molecular spectroscopy, C.N. Banwell
3. Physics of Atoms and Molecule,Bransden and Joachain

REFRENCE BOOKS

1. Molecular spectroscopy, J. M. Brown
2. Introduction to Molecular spectroscopy, G. M. Barrow
3. Spectra of Atoms and Molecule, P.F. Bemath

NOVEL AND SMART MATERIALS	
Course Code: 25PHMS408	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To learn about Electronic, Nano and Magnetic Materials
2. To impart the physical mechanism in electronic materials
3. To learn about Integrated Circuit Fabrication.
4. To impart the properties and application of magnetic material.
5. To introduce the concept of magnetic bubbles

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge about the Physics of Electronic, Nano and Magnetic Materials
2. Able to understand the physical mechanism in electronic materials
3. Get an understanding of Integrated Circuit (IC) Technology and their Fabrication
4. Able to understand the properties and applications of magnetic materials
5. Get an understanding about magnetic bubbles

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: PHYSICAL MECHANISM IN ELECTRONIC MATERIALS

Crystal Structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy band consideration in solids in relation to semiconductors, Direct and Indirect bands in Semiconductor, Electron/Hole concentration and Fermi energy in Intrinsic/Extrinsic semiconductor, continuity equation, Carrier mobility in Semiconductors, Carrier Trapping and recombination/generation in semiconductors, Shockley theory of recombination, Defect related electronics states characterization by C-V characteristics of electronic junction devices.

UNIT II: INTEGRATED CIRCUIT FABRICATION

Introduction to IC technology, Basic monolithic integrated circuit epitaxial growth, diffusion of impurities, masking and etching, Fabrication of monolithic ICs, Active and Passive components, advantages of IC s, MSI, LSI, Application of IC and Clean Room Specification.

UNIT III: NANOMATERIALS

Introduction to Nanomaterial, comparison of properties of nano-and bulk materials, top-down and bottom up approach, methods used for synthesis of nano-materials. Nano-thin films: development and applications, Carbon Nano-tubes: synthesis and properties. Applications of nano-materials.

UNIT IV: ENGINEERING MAGNETIC MATERIALS

Hard and soft Magnetic materials, ferrites, Types of Ferrites, Rare earth compounds and bonded magnets. Materials for antenna, inductor and transformer cores. Magnetic recording fundamentals. Particulate and thin film recording media. Recording heads: ferrite heads, metal in gap heads, thin film heads and magneto resistive heads. Fundamentals opto magneto opto recording. Magneto optic recording media and heads. Introduction to magnetic bubbles.

TEXTBOOKS

1. Physics of Semiconductor Devices, S.M. Sze
2. Solid State Electron Devices Ben G Streetman, Sanjay Kumar Banerjee
3. Semiconductor Devices Basic Principles, Jasprit Singh
4. Quantum Theory Of Magnetism Magnetic Properties Of Materials, Rober M. White
5. Metal/Semiconductor Schottky Barrier Junction and their Applications, B.L. Sharma.

REFERENCE BOOKS

1. Encyclopedia of Applied Physics, G.L. Trig Vol. 9, G.L. Trigg (V.CH Publishers).
2. Linear Integrated Circuits, D. Roy Choudhury and SahilB. Jain, (New Age Int. Pub).
3. Integrated Electronics,Millman and Halkias (Tata McGraw-Hill).

MICROPROCESSOR AND INTERFACING	
Course Code: 25PHMS409	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To acquire basic knowledge on architecture and programming in microprocessor 8085
2. To acquire basic knowledge on architecture and programming in microprocessor 8086
3. To make familiar with the programmable and nonprogrammable ICs.
4. To give knowledge on various applications of microprocessor
5. To give more knowledge on waveform generation and frequency measurement

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge of programming in microprocessor 8085.
2. Get an understanding of programming in microprocessor 8086.
3. Able to understand the working with ICs 8051, 8253, 8259 and 8279.
4. Well-versed with the use microprocessor in the application of temperature, water level, traffic light control etc.
5. Able to receive more information on waveform generation and frequency measurement

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: MICROPROCESSOR 8085

Introduction to microcomputer, Microprocessor (μP) 8085 Architecture, addressing modes, memory interfacing, interfacing I/O device. Instruction set and classification, op code and operand, fetch and execute cycle, timing diagram for memory read and memory write, machine cycle, instruction cycle and T states, Assembly language Programming examples.

UNIT II: MICROPROCESSOR 8086

Architecture, Pin description for minimum and maximum modes, internal operation, Instruction Execution timing diagram, Addressing modes, Instruction format for constructing machine language codes. Instruction set and directives, Stacks, Procedures, Macros and interrupts. I/O interfacing and data transfer scheme. Programming example.

UNIT III: PROGRAMMABLE AND NON PROGRAMMABLE ICS

Introduction to microcontroller 8051. Block diagram and PSW for: - 8253(timer and counters controllers), 8259 (interrupt controller), 8279 (keyboard and display controller). Brief idea of Architecture and memory management of 80286.

UNIT IV: MICROPROCESSOR BASED MEASUREMENT/CONTROL CIRCUITS

D/A and A/D Converters, PPI 8255 Data Acquisition and storage, Microprocessor based traffic light controller, Temperature and water level indicator/controller. DC and steper motor speed measurements, Waveform generation and frequency measurement.

TEXTBOOKS

1. Fundamentals of Microprocessor and Microcomputer, B. Ram.
2. Microprocessor System the 8086/8088 Family, Liu and Gibson.
3. Microprocessor Architecture Programming and Application, R.S. Goanker.

REFERENCE BOOKS

1. Introduction to microprocessor, A.P. Mathur.
2. Microprocessor and Interfacing, D.V. Hal

SEMICONDUCTOR PHYSICS	
Course Code: 25PHMS410	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To impart the basic knowledge on band theory of solids and conductivity in semiconductors.
2. To develop understanding of the role Fermi level in semiconductors.
3. To develop the understanding of the various semiconductor device working.
4. To impart the knowledge on IC fabrication technology
5. To make students familiar with the concept of Lithography

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge the conductivity in intrinsic and extrinsic semiconductors
2. Get an understanding of the concept of direct and indirect band gap semiconductors
3. Able to understand the with the conductivity at the metal semiconductor interface
4. Well-versed with the principles behind FET, MOSFET, JFET, CMOS, RAM.
5. Able to get knowledge on Lithography.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I: BAND THEORY OF SOLIDS

Kronig-Penny model, Bandgaps in semiconductors - Holes and effective mass concept, Fermi distribution and energy - Density of states - Valance and conduction band density of states - intrinsic carrier concentration - intrinsic Fermi level. Extrinsic semiconductors: n and p type doping - Densities of carriers in extrinsic semiconductors and their temperature dependence - extrinsic semiconductor Fermi energy level - Degenerate and non - degenerate semiconductors - Bandgap engineering.

UNIT II: CURRENTS IN SEMICONDUCTOR

Thermal motion of carriers, Carrier motion under electric field, Drift current, Mobility and conductivity, Velocity saturation, Diffusion of carriers, General expression for currents in semiconductor, Carrier concentration and mobility, and the Van der Paw technique. drift current density – mobility effects – conductivity – carrier diffusion – diffusion current density – total current density – graded impurity distribution – induced electric field – Einstein relation – Hall Effect.

UNIT III: CARRIER DYNAMICS IN SEMICONDUCTORS

Electronic transitions in semiconductor, Radiative transition, Direct and indirect bandgap semiconductors, Roosbroeck-Shockley relationship, Radiative transition rate at non-equilibrium, Minority carrier lifetime, Localized states, Recombination center and trap, Shockley-Hall-Reed recombination, Surface recombination, Auger recombination, Derivation of continuity equation, Non-equilibrium carrier concentration, Quasi-Fermi level, Current and quasi-Fermi level, Non-uniform doping, and Non-uniform bandgap.

UNIT IV: SEMICONDUCTOR DEVICES AND IC FABRICATION TECHNOLOGY

Metal-semiconductor and Semiconductor heterojunctions – Schottky Barrier Diode – metal-semiconductor ohmic contacts – heterojunctions – bipolar transistor – Metal-Oxide semiconductor Field-Effect Transistor – Junction Field-Effect Transistor – MOSFET (n-MOS, p-MOS) and CMOS. Static and dynamic RAM, nonvolatile memories. Optical and magnetic memories Solar cell- basic characteristics – spectral response – recombination current and series resistance. MOSFET fabrication process. Substrate, dielectric, conducting and resistive layers. Lithography. Diffusion of impurities and deposition techniques.

TEXTBOOKS

1. Semiconductors, R.A. Smith (Academic Publishers).
2. Semiconductor Physics And Devices, Donald A. Neamen(Tata McGraw-Hill).
3. Fundamentals of Semiconductor Devices by Joseph Lindmayer, Charles Y. Wrigly(Litton Educational Publishing Inc.).

REFERENCE BOOKS

1. Physics of Semiconductor Devices, S.M.Sze (John Wily & Sons).
2. The Physics of Semiconductors, K. F. Brennan (Cambridge Univ.Press).
3. Fundamentals of Semiconductors, P. Y. Yu and M. Cardona, (Springer)

NUCLEAR PHYSICS II	
Course Code: 25PHMS411	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To explain interaction of charged particles.
2. To give knowledge of gas detectors.
3. To give knowledge of semiconductor detectors
4. To explain light sensing detectors

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Can explain interaction of charged particles.
2. Well versed with the knowledge of gas detectors.
3. Good knowledge of semiconductor detectors
4. Can explain light sensing detectors

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)				
	CLO1	CLO2	CLO3	CL04	CL05
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURE CONTENTS

UNIT I:

INTERACTION OF CHARGED PARTICLES: Interaction of heavy charged particles with matter in low, medium and high velocity region. Range-Energy relationship for heavy charged particles, Energy and range straggling. Interaction of fast electrons in matter. Basic idea of gamma ray interaction with matter (Elastic scattering, Rayleigh scattering, Resonance scattering, Compton Scattering, photo electric effect, pair production, positron annihilation, photo nuclear reactions, absorption of gamma rays) .

UNIT II:

GAS DETECTORS: Features of Gas Ionization detectors, Gas multiplication and modes of operation of gas detectors, Ionization chamber: Mode of operation, integrated type of ion chambers, pulse-mode operated ionization chambers, Proportional counters, Geiger-Muller Counters: Geiger discharge, Counter characteristics: development of pulse and quenching, dead time, Geiger Plateau, Counter efficiency

UNIT III:

SEMICONDUTOR DETECTORS: Interaction of heavy charged particles, electrons and photons with semiconductor (silicon and germanium), production of electron-hole pairs. Diode detector, Diffused junction silicon detectors, Surface barrier detectors, Lithium-Drifted silicon detectors, Si(Li),. Lithium-Drifted Germanium detectors, Ge(Li), HPGE detector

UNIT IV:

LIGHT SENSING DETECTORS: Scintillation detectors**:** Scintillation mechanism and classification of scintillation materials, modes of energy transfer, Organic scintillators, Inorganic scintillators, Time characteristics of scintillator output, Photomultiplier tubes**,** Scintillation counter, Cherenkov detector.

TEXTBOOKS

1. Nuclear Radiation Detector by S. S. Kapoor and V. S. Ramamurthy(New Age Int.).
2. Techniques for Nuclear and Particle Physics Experiments by W. R. Leo (Springer-Verlag).

REFERENCE BOOKS

1. Nuclear Radiation Detection, Measurements and Analysis by K. Muraleedhara Varier (Narosa).
2. Nuclear Physics by S. N. Ghoshal (S. Chand).

ASTROPHYSICS - II	
Course Code: 25PHMS412	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

Learning objectives

1. To discuss the basics of observing the universe.
2. To make the students familiar with the basic parameters of the stars.
3. To discuss the various properties of star cluster.
4. To gain a detail knowledge of staller evolution.

Learning outcome

1. Able to understand the basics concepts of observation of the universe.
2. Get an understanding of the basic measurement of starts.
3. Fluent with up-to date knowledge of the start cluster.
4. Detail knowledge about the evolution of the star.

UNIT I:
OBSERVING THE UNIVERSE

Celestial sphere, Brief idea of constellations and Solar system, Study of planets, asteroids, meteors, comets and their origin. Right Ascension, Declination, Greenwich Sideral time, Local Sideral time, Hour angle, Different types of detectors: photographic plate, Photomultiplier tube, CCD, Astronomical telescopes

UNIT II:
BASIC MEASUREMENT OF STARS
Basic parameters of the star: Mass, radius, Distance, Luminosity and temperature, Magnitude systems and colour indices, Hertzsprung-Russel diagram (H-R Diagram), classification of stellar spectra, classification of Luminosity class.

UNIT III:
THE STAR CLUSTERS

Star Clusters - open, globular and stellar associations, stellar population, population I and population II type objects, inter-stellar extinction, Reddening determination from colour–colour diagram, age and distance determinations of star clusters, Luminosity function, Mass function, Mass segregation, dynamical evolution in clusters, Mass-Luminosity relation.

UNIT IV:
STELLAR EVOLUTION

Birth of stars, protostar, nebula, Hyashi tracks, Zero age main sequence, (ZAMS) main sequence life time, energy generation in stars – gravitational contraction, pp chain, CN cycle and triple alpha process, stellar life cycles-Premain sequence, main sequence, giants, white dwarf etc., Chandrashekhar mass limit, Low, medium mass stars and high mass stars, Death of high mass stars, supernova remnants, Pulsars and idea of black holes using relativistic astrophysics

TEXT BOOKS:

1. An Invitation to Astrophysics, T. Padmanabhan, World Scientic Publishing Co.
2. An Introduction to Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
3. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
4. Astrophysics in a Nutshell (Basic Astrophysics), Dan Maoz, Princeton University Press.
5. Foundations of Astrophysics, Barbara Ryden and Bradley M. Peterson, Addison Wesley.
6. Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press.
7. Astronomy and Astrophysics, A. B. Bhattacharya, S. Joardar, R. Bhattacharya, Overseas Press (India) Pvt.Ltd.

REFERENCE BOOKS

1. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan, Cambridge University Press.
2. K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New AgeInternational (p) Ltd, New Delhi,2002.
3. BaidyanathBasu, 'An introduction to Astro physics', Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
4. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

QUANTUM FIELD THEORY	
Course Code:25PHBS413	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite: NIL	

COURSE OBJECTIVES

1. To introduce students to the canonical quantization of scalar and spinor fields, leading to a quantum description of particles.
2. To enable students to compute scattering amplitudes and decay rates using Feynman diagrams and quantum interaction theory.
3. To develop a foundational understanding of quantum electrodynamics (QED), including photon quantization and lowest-order processes.
4. To provide a conceptual and technical understanding of divergences and renormalization techniques in QED.
5. To explore advanced applications of QFT such as loop corrections, the Higgs mechanism, and connections to the Standard Model.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Quantize scalar and Dirac fields using canonical formalism and interpret the role of normal ordering and Fock space.
2. Apply Feynman rules to calculate transition amplitudes, decay rates, and scattering cross-sections.
3. Analyze physical processes in QED including electron scattering and photon interactions with matter.
4. Explain the need for renormalization, use Ward-Takahashi identity, and identify divergent diagrams.
5. Discuss the significance of form factors, loop corrections, symmetry principles, and the Higgs mechanism in modern quantum field theory.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENT

UNIT I: CANONICAL QUANTIZATION OF FIELDS

Canonical quantization of scalar fields, Fourier decomposition, normal ordering, Fock space and particle interpretation, Complex scalar field and propagator, Quantization of Dirac fields, Dirac equation, Plane wave solutions, projection operators

UNIT II: INTERACTIONS, FEYNMAN DIAGRAMS AND CROSS SECTIONS

Yukawa interaction, Decay processes: scalar particle decay, Matrix elements and transition amplitudes, Feynman diagrams and Feynman rules, Virtual particles, decay rate, scattering cross sections, Mandelstam variables and 2-to-2 scattering.

UNIT III: QUANTUM ELECTRODYNAMICS (QED)

Quantization of the electromagnetic field, Problems and gauge fixing, Physical photon states and propagators, Local gauge invariance in QED, Lowest order QED processes:
$e^-e^- \rightarrow e^-e^-$, $e^+e^- \rightarrow \mu^+\mu^-$, Compton scattering, Bremsstrahlung.

UNIT IV: RENORMALIZATION IN QED

Divergences and regularization, Degree of divergence in diagrams, Electromagnetic vertex function and form factors, Anomalous magnetic moment of the electron, Ward-Takahashi identity, Renormalization procedure (outline).

UNIT V: ADVANCED TOPICS AND APPLICATIONS

Charge form factor and electron-proton scattering, Overview of loop corrections, Higgs mechanism (in context of QFT), Role of symmetry in renormalization, Modern extensions and outlook (Standard Model connection)

.

TEXT BOOKS

1. Amitabha Lahari, Palash B. Pal, A first book of Quantum Field Theory, Narosa publications, 2nd Edition, 2007.
2. Michael E. Peskin and Daniel V. Schroeder, An introduction to Quantum Field Theory, Westview Press Inc, 1st Edition, 1995.
3. Thomas Banks, Modern Quantum Field Theory, Cambridge University Press, 2008
4. Michael E. Peskin & Daniel V. Schroeder – *An Introduction to Quantum Field Theory*, Publisher: Addison-Wesley
5. Mark Srednicki – *Quantum Field Theory*, Publisher: Cambridge University Press

REFERENCE BOOKS

1. Steven Weinberg, The Quantum Theory of Fields: foundations, volume 1, Cambridge University Press, 2005.
2. V. B. Berestetskii, E.M Lifshitz and L.P. Pitaevskii, Quantum Electrodynamics, Butterworth-Heinemann, 2nd Edition 1982
3. M. Maggiore, A modern introduction to Quantum Field Theory, Oxford University Press, 2005.

4. Lewis H. Ryder – *Quantum Field Theory*, Publisher: Cambridge University Press
5. Franz Mandl & Graham Shaw – *Quantum Field Theory* (2nd Ed.), Publisher: Wiley
6. Ta-Pei Cheng & Ling-Fong Li – *Gauge Theory of Elementary Particle Physics,* Oxford University Press
7. Steven Weinberg – *The Quantum Theory of Fields* (Vol. I & II), Cambridge University Press

Quantum Computation II	
Course Code: 25PHMS414	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To enable students to understand and analyze foundational and advanced quantum algorithms, including Shor's and Grover's algorithms.
2. To explain the working principles and mathematical structures behind the Quantum Fourier Transform and phase estimation.
3. To develop students' ability to design and evaluate quantum oracles and search techniques using tools like Qiskit.
4. To introduce students to the limitations and possibilities of quantum computing within the NISQ (Noisy Intermediate-Scale Quantum) era.
5. To equip students with theoretical and practical understanding of quantum error correction codes and error mitigation techniques in real quantum devices.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Analyze and implement key quantum algorithms (Deutsch-Jozsa, Simon, Shor, Bernstein-Vazirani, Grover) for problem-solving using quantum circuits.
2. Describe the mathematical formulation of QFT and apply it in understanding Shor's algorithm and quantum phase estimation.
3. Design oracle-based circuits and interpret search efficiency gains in Grover's algorithm with limitations of current hardware.
4. Assess performance metrics, resource allocation, and optimization techniques for quantum algorithms on NISQ devices.
5. Evaluate and apply quantum error correction codes such as Shor's code, Steane code, and surface codes in practical scenarios involving quantum noise and fault tolerance.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	(shaded)				
CO2		(shaded)			
CO3			(shaded)		
CO4				(shaded)	
CO5					(shaded)

COURSE CONTENT

Unit I: Algorithmic Foundations and Interference

Shannon's counting argument and quantum advantage, Deutsch Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazirani Algorithm, Simon's Problem and Algorithm

Unit II: Shor's Algorithm and Quantum Fourier Transform

Modular arithmetic and periodicity, Quantum Phase Estimation, Quantum Fourier Transform and its implementation, Continued Fractions and Order Finding, Shor's algorithm for factorization

Unit III: Grover's Algorithm and Oracle Design

Unstructured search and classical limits, Amplitude amplification, Grover operator and iteration steps, BBBV Theorem, Oracle construction in Qiskit, Comments about limitations of quantum computers, Comments about implementation of quantum computers.

Unit IV: NISQ Devices and Variational Algorithms

NISQ model and constraints, Benchmarking and fidelity measurement, Variational Quantum Eigensolver (VQE), Quantum Approximate Optimization Algorithm (QAOA), Maxcut problem implementation

Unit V: Quantum Error Correction Techniques

Quantum noise and error types, Shor's 3-qubit and 9-qubit codes, Steane code and threshold theorem, Concatenated codes and scalable architectures, Surface code and decoding cycles, Syndrome extraction and scalable recovery. Device Level metrics, System Level Metrics, Benchmarking, NISQ model of computing: Current machines (5-50 qubit), NISQ model, NISQ Metrics, Qubit Mapping, Qubit Allocation problem. Error Mitigation Techniques for NISQ: Variability-Aware Mapping Diversity-Aware Mapping Reducing Measurement Errors Reducing Idling Errors. Quantum Approximation Optimization Algorithm: Maxcut problem, optimization for QAOA.

TEXT BOOKS

1. Michael A. Nielsen & Isaac L. Chuang – *Quantum Computation and Quantum Information,* Cambridge University Press
2. Thomas G. Wong – *Introduction to Classical and Quantum Computing,* Springer
3. Géza Giedke and Jens Eisert – *Quantum Error Correction* (Lecture Notes)
4. Sara Baase, "*Computer Algorithms - Introduction to design and analysis",* Pearson
5. Aho, Ullman & Hopcraft, "*The Design and Analysis of Algorithms*", Pearson Education, 2001

REFERENCE BOOKS

1. Eleanor Rieffel & Wolfgang Polak – *Quantum Computing: A Gentle Introduction*, Publisher: MIT Press
2. Mark M. Wilde – *Quantum Information Theory*, Publisher: Cambridge University Press.
3. Ashley Montanaro & Dominic Horsman (eds.) – *Quantum Algorithms: A Survey*, Publisher: Cambridge University Press (2021)
4. Asher Peres, Quantum theory: concepts and methods, Kluwer Academic Publishers.
5. Phillip Kaye, Raymond Laflamme, Michele Mosca, An introduction to quantum computing, Oxford University Press. T.H Cormen, Introduction to Algorithms, The MIT Press, 3rd Edition, 2009.
6. Richard Johnsonbaugh, Marcus Schaefer, "*Algorithms*", Pearson Education, 3rd edition, 2006

QUANTUM MACHINE LEARNING	
Course Code: 25PHMS415	Continuous Evaluation: 60 Marks
Credits: 4	End Semester Examination: 40 Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Lab**
Prerequisite:	

COURSE OBJECTIVES

1. Gain knowledge about quantum computing, quantum mechanics and analyze the quantum circuits
2. Learn about the fundamentals of Machine Learning
3. Utilize Qiskit for supervised learning
4. Learn unsupervised learning with Qiskit
5. Utilize the quantum neural networks with Pennylane

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Identify the need of quantum computing and quantum gates
2. Compare Classical vs. Quantum Machine Learning
3. Develop the Quantum Machine Learning programs
4. Incorporate the Unsupervised learning with Qiskit
5. Demonstrate the QNN, QCNN, QGAN using Qiskit and Pennylane

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	■				
CO2		■			
CO3			■		
CO4				■	
CO5					■

COURSE CONTENTS

Unit-1 Introduction to Quantum Computing- Introduction to Superposition- Classical superposition- Quantum superposition- What is a Qubit?- Mathematical Representation on Qubits- Bloch Sphere- Quantum Gates- Entanglement-Multi-Qubits states-CNOT gate

Unit-2 Classical vs. Quantum Machine Learning- Examples of Typical Machine Learning Problems- The Three Ingredients of a Learning Problem- Risk minimization in Supervised Learning- Training in Unsupervised Learning- Methods in Machine LearningLinear Models- Neural Networks- Graphical and Kernel methods

Unit-3 Introduction to Quantum Machine Learning- Four approaches to QML-Parameterized quantum circuits (PQC)- Quantum Information Encoding- Training parameterized quantum circuits- Supervised learning- Quantum variational classification- Quantum kernel estimation- Quantum feature map and kernels- Quantum Support Vector classification (QSVM)

Unit-4 Introduction to Unsupervised learning- Principal Component Analysis- Clustering- Classifiers used in QML- Problem solving session- QML programming concepts in Qiskit- Analysis of Qiskit- Analysis of exercises created by Qiskit- Discussion about IBM Qiskit Summer School Challenge exercises

Unit-5 Introduction to Quantum Neural Networks- Quantum Convolutional Neural Networks (QCNN)- Hybrid QNN- Problem solving session on a real dataset- Classical Generative Adversarial Networks (GAN)- Quantum Generative Adversarial Networks (QGAN)- QGAN in Qiskit- Problem Solving session- Pennylane and AWS Quantum Braket introduction- Use cases in QML

TEXT BOOKS

1. Quantum Computation and Quantum Information. M. A. Nielsen and I. L. Chuang, Cambridge University Press
2. Ciaran Hughes, Joshua Isaacson, Anastatsia Perry, Ranbel F. Sun, Jessica Turner, “Quantum Computing for the Quantum Curious”, Springer, 2021
3. Maria Schuld and Francesco Petruccione, “Machine Learning with Quantum Computers”, Second Edition, Springer, 2021
4. Maria Schuld and Francesco Petruccione, “Supervised Learning with Quantum Computers”, Springer, 2018
5. Peter Wittek, “Quantum Machine Learning – What Quantum Computing Means to Data Mining”, Elsevier

REFERENCE BOOKS

1. An Introduction to Quantum Computing. P. Kaye, R. Laflamme, and M. Mosca, Oxford University Press, New York
2. Quantum Computer Science. N. David Mermin:, Cambridge University Press
3. Michael A. Nielsen and Issac L. Chuang," Quantum Computation and Information, Cambridge, 2002
4. Mikio Nakahara and Tetsuo Ohmi,"Quantum Computing", CRC Press, 2008
5. N. David Mermin, "Quantum Computer Science", Cambridge, 2007

DISCIPLINE-SPECIFIC PRACTICAL COURSES

1. Advanced Solid State Physics I (25PHMS352)
2. Laser & Spectroscopy Lab I (25PHMS353)
3. Electronic Lab I (25PHMS354)
4. Quantum Computation lab I (25PHMS355)
5. Advanced Solid State Physics II (25PHMS451)
6. Laser & Spectroscopy Lab II (25PHMS452)
7. Electronics Lab II (25PHMS453)
8. Quantum Computation lab I (25PHMS454)
9. Astrophysics Lab (25PHMS455)

ADVANCED SOLID STATE PHYSICS LAB I	
Course Code: 25PHMS352	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 0 0 8	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To discuss general structural detections of solids.
2. To illustrate the optical and electrical properties of solids.
3. To highlight thermo-gravimetric analysis of materials
4. To make students familiar with theoretical and experimental topics in solid state physics.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge structural detection of solid state materials.
2. Get an understanding of experimental techniques for finding the optical and electrical properties of materials.
3. Able to understand the thermo-gravimetric analysis of materials.
4. Well-versed with the extent of error involved in the experimental techniques.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1	■			
CO2	■	■		
CO3		■	■	
CO4				■

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ___ of experiments)

1. Measurement of lattice parameter and indexing of powder photograph.
2. Identification of unknown sample using powder diffraction method.

3. To study the ferroelectric transitions in TGS crystal and measurement of Curie temperature.
4. To measure the superconductivity transition temperature and transition width of a high temperature superconductor.
5. Band gap measurement of oxide film using UV spectroscopy
6. To study the heat capacity of solids.
7. To study electric properties of thin films of metals & oxides.
8. To determine magneto resistance of a Bismuth crystal as a function of magnetic field.
9. To find the 'g' factor of DPPH using electron spin resonance.
10. To determine Hall Voltage, concentration of charge carrier and the type of semiconductor in the Hall effect experiment.
11. Study of crystalline properties of materials using XRD
12. B-H Curve of magnetic material.
13. To calculate the resistivity by Four Probe method.
14. To investigate the lattice dynamics of monoatomic and diatomic molecules.
15. To calculate the forbidden energy gap for Si, Ge and LED.
16. To perform the Fourier analysis of square wave and triangular wave.
17. To determine the dielectric constant.
18. To determine the magnetic susceptibility of a paramagnetic solution by Quinck's tube method.

TEXTBOOKS

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt. Ltd.
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company).

REFERENCE BOOKS

2. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
3. Electronic transport in mesoscopic systems by Supriyo Datta (1997) Cambridge University Press.

LASER & SPECTROSCOPY LAB I	
Course Code: 25PHMS353	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 0 0 8	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To discuss the experimental techniques related to the optical properties of alkali materials.
2. To illustrate optical properties of the materials such as refractive index and cauchy's constants.
3. To develop understanding about the electrical transport, dielectric, optical, and magnetic properties of solids.
4. To make students familiar with theoretical and experimental topics in solid state physics.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge of experiments related to the optical properties of alkali materials
2. Get an understanding of experimental techniques to determine the optical properties of materials
3. Able to understand the band structure of few solids.
4. Well-versed with the extent of error involved in the experimental techniques.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ____ of experiments)

1. Verification of Hartmann formula for prism spectrogram
2. Measurement of optical spectrum of an alkali atom

3. Determination of metallic component of an inorganic salt
4. To determine the variation of refractive index of the material of prism with wavelength and to verify Cauchy's dispersion formula.
5. To determine the wavelength of laser using Michelson Interferometer.
6. Measurement of optical spectrum of alkaline earth atoms
7. Measurement of Band positions and determination of vibrational constants of AlO molecule
8. Measurement and analysis of fluorescence spectrum of I_2vapour
9. Determination of characteristic parameters of an optical fiber
10. Measurement of Raman spectrum of CCl_4.

TEXTBOOKS

1. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
2. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).

REFERENCE BOOKS

1. Electronic transport in mesoscopic systems by Supriyo Datta (1997) Cambridge University Press.
2. Solid State Physics, M. A. Wahab, 2011, Narosa Publications.
3. Solid State Physics by J. R. Hall and H. E. Hall, 2nd edition (2014) Wiley.

ELECTRONICS LAB I

Course Code: 25PHMS354	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 0 0 8	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To discuss general experimental techniques related to optical fibers.
2. To illustrate the experiments related to filter applications and modulation techniques.
3. To highlight effect of noise in the signal processing.
4. To make students familiar with theoretical and experimental topics in solid state devices.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with good knowledge of general experimental techniques related to optical fibers
2. Get an understanding of experiments related to filter applications and modulation techniques
3. Able to understand the effect of noise in the signal processing.
4. Well-versed with the extent of error involved in the experimental techniques.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

LIST OF EXPERIMENTS

(A Student is supposed to complete/perform minimum ____ of experiments)

1. To obtain the intensity modulation of given sinusoidal optical fiber signal.
2. To obtain the intensity modulation of given digital optical fiber signal.

3. Study of the low pass, high pass and band pass filters using the passive elements and active elements.
4. (i) To study the power dissipation in the SSB and DSB side bands of AM wave. (ii) To
5. study the demodulation of AM wave. (iii) To study various aspects of modulation and demodulation.
6. Design of Regulated power supply and study of its characteristics.
7. To study various displays and drivers on a bread-board – Assembling circuits on breadboard.
8. To study the effect of noise on various analog system, calculate signal to noise ratio,
9. noise figure, noise power and noise power spectral density.
10. Microwave characteristics and measurements.
11. To study the characteristic, propagation modes, wavelength, and phase velocity in a
12. wave guide.
13. PLL characteristics and its applications.
14. A/D converter interfacing and AC/DC voltage/current measurement using microprocessor 8085/8086.
15. PPI 8251 interfacing with microprocessor for serial communication.
16. To setup logic conditions for the input and the output at data bus port of BBCmicrocomputer.

TEXTBOOKS

1. Chauhan and Singh , " Advanced practical physics", Revised edition, Pragati Prakashan Meerut, 1985

REFERENCE BOOKS

1. Chattopadhyay, D., Rakshit, P. C and Saha, B., "An advanced Course in Practical Physics", 2nd edition, Books & Allied Ltd, Calcutta, 1990.

Quantum Computation Lab I	
Course Code: 25PHMS355	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: ……….. Marks
L T P : 0 0 8	Course Type: Minor Stream Course Lab
Prerequisite:	

COURSE OBJECTIVES

1. To introduce students to the Qiskit programming environment and the simulation of quantum circuits.
2. To develop conceptual and practical understanding of single- and two-qubit gates and their operations.
3. To provide hands-on experience in building and measuring quantum states, including superposition and entanglement.
4. To explore the relationship between classical and quantum logic through circuit design and visualization.
5. To enable students to observe quantum interference, phase effects, and measurement collapse through experiments.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Construct and simulate single-qubit and multi-qubit circuits using Qiskit and visualize their quantum state evolution.
2. Apply basic quantum logic gates (X, Y, Z, H, S, T, CNOT) and interpret their effects using Bloch sphere and measurement histograms.
3. Demonstrate the principles of superposition, entanglement, and measurement collapse in simple quantum systems.
4. Compare classical logic operations with quantum counterparts through XOR and NOT gate simulations.
5. Explain quantum phenomena such as phase kickback, interference, and the no-cloning theorem using practical circuit implementations.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

(A Student is supposed to complete/perform minimum ____ of experiments)

1. Create a single qubit circuit and apply an X gate. Simulate and measure the output.
2. Implement the Hadamard gate and plot the output state on the Bloch Sphere.
3. Build a two-qubit entangled Bell state using H and CNOT gates. Measure the qubits.
4. Simulate quantum measurement collapse using a superposition state.
5. Use Qiskit to visualize the statevector and measurement histogram of a basic circuit.
6. Create and measure the output of a circuit using Pauli Y and Z gates.
7. Design a circuit to verify the no-cloning theorem.
8. Write a Python function that simulates a classical XOR gate and compare with quantum XOR.
9. Compare classical and quantum representations of a NOT operation.
10. Demonstrate the effect of phase gates (S, T) on a qubit state.
11. Apply a sequence of gates (X, H, S) to a single qubit and observe interference.
12. Build a 3-qubit circuit with various gate operations and visualize measurement.
13. Simulate the output of a Hadamard followed by Z gate and explain phase kickback.
14. Implement a basic circuit with controlled operations and measure outcomes.
15. Construct and simulate a circuit showing basis change using Hadamard gates.

TEXT BOOKS

1. M A Nielsen and I L Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010.
2. Giuliano Benenti, Giulio Casati and Giuliano Strini, Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific, 2004.
3. Arthur O. Pittenger, An Introduction to Quantum Computing, Birkhauser Boston Inc; 1st Edition, 2000.
4. P Kaye, R Laflamme and M Mosca, An Introduction to Quantum Computing, Oxford University Press, 2006.

REFERENCE BOOKS

1. G. Strang, Linear Algebra and its Applications, Cengage India Private Limited; 4th Edition, 2005.
2. Rajender. Bhatia, Matrix Analysis, Springer, 1997.
3. Zdzislaw Meglicki, William Gropp, Ewing Lusk, Quantum Computing without Magic, MIT Press, 2008.
4. DAVID McMAHON, Quantum Computing Explained, Wiley-IEEE Computer Society, 1st Edition, 2008.
5. Marco Lanzagorta, Jeffrey Uhlmann, Quantum Computer Science, Springer, 2008.

ADVANCED SOLID STATE PHYSICS LAB II	
Course Code: 25PHMS451	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To make students familiar specific measurement instruments and experimental apparatuses used in the nano physics lab.
2. To develop students understanding about necessary precautions during measurements.
3. To create understanding on experimental data analysis and their estimation in detail.
4. To make students familiar with different sources of error.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with knowledge of measurement instruments and experimental apparatus used in nano physics lab
2. Get an understanding of precaution.
3. Able to analyze the data.
4. Able to estimate the error in measurements.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENTS

(A Student is supposed to complete/perform minimum ____ of experiments)

1. Synthesis of metal (Au/Ag) nanoparticles by chemical route and study its optical absorption properties.

2. Synthesis of semiconductor (CdS/ZnO/TiO2/Fe2O3etc) nanoparticles and study its XRD and optical absorption properties as a function of time.
3. Synthesis of nanoparticles by solid state mixed oxide technique. Example $BaTiO_3$
4. Synthesis of nanoparticles by co-precipitation technique. Example $PbZrTiO_3$.
5. Synthesis of nanoparticles by sol gel techniques.
6. Growth of thin film by spin coating.
7. Growth of thin film by dip coating.
8. Analysis of XRD pattern of nanomaterials and estimation of particle size.
9. To study the effect of size on color of nanomaterials.
10. To prepare composite of CNTs with other materials.
11. Growth of quantum dots by thermal evaporation.
12. Prepare a disc of ceramic of a compound and study its XRD.
13. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study its XRD and UV-Visible spectra.
14. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
15. Fabricate a PN junction diode by diffusing Al over the surface of N-type Si/Ge and study its V-I characteristic.

TEXT BOOKS

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt.Ltd..
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company).
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).

REFERENCE BOOKS

1. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
2. Electronic transport in mesoscopic systems by Supriyo Datta (1997) Cambridge University Press.
3. Solid State Physics, M. A. Wahab, 2011, Narosa Publications.
4. Solid State Physics by J. R. Hall and H. E. Hall, 2nd edition (2014) Wiley.

LASERS AND SPECTROSCOPY LAB II	
Course Code: 25PHMS452	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To make students familiar with experiments related to the optical properties of a thin film.
2. To develop students understanding about vibrational and defect modes study by Raman spectroscopy.
3. To create competency on estimation of physical parameters from the experiments.
4. To make students familiar with extent of error involved in the experimental techniques.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the knowledge of experiments for finding optical properties of thin films.
2. Get an understanding of vibrational and defect modes study by Raman spectroscopy.
3. Able estimate the physical parameters from the experimental data.
4. Fluent withdifferent error estimation.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENTS

(A Student is supposed to complete/perform minimum ____ of experiments)

1. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
2. Determination of optical bandgap of thin film.
3. Optical properties of thin film: Thickness & refractive index determination

4. To study the vibrational modes of amorphous silicon as a function temperature using Raman spectroscopy.
5. To study the defect modes of Graphene using Raman spectroscopy.
6. To study the photoluminescence characteristics of a ZnO .
7. To study the photoluminescence characteristics of a CdS.
8. Investigation of surface morphology of thin film by AFM.
9. Investigation of surface morphology of thin film by electron microscope in SEM configuration.

TEXTBOOKS

1. Chauhan and Singh, " Advanced practical physics", Revised edition, Pragati Prakashan Meerut, 1985

REFERENCE BOOKS

1. Chattopadhyay, D., Rakshit, P. C and Saha, B., "An advanced Course in Practical Physics", 2nd edition, Books & Allied Ltd, Calcutta, 1990.

ELECTRONICS LAB II	
Course Code: 25PHMS453	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite:	

COURSE OBJECTIVES

1. To make students familiar with transistor amplifier.
2. To develop students understanding about different electronic devices.
3. To create competency on designing of oscillators.
4. To make students familiar with different applications of Op-amp and microprocessor.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the knowledge of transistor application as an amplifier.
2. Get an understanding of different electronic devices.
3. Able todesign of oscillators.
4. Fluent withdifferent applications of Op-amp and microprocessor.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1				
CO2				
CO3				
CO4				

COURSE CONTENTS

(A Student is supposed to complete/perform minimum ____ of experiments)

1. Study of V-I & power curves of solar cells and find maximum power point & efficiency.
2. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
3. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
4. To design a Wien bridge oscillator for given frequency using an op-amp.

5. To design a phase shift oscillator of given specifications using BJT.
6. To study the Colpitt`s oscillator.
7. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
8. To design inverting amplifier using Op-amp (741,351) and study its frequency response
9. To design non-inverting amplifier using Op-amp (741,351), study its frequency response
10. To study the zero-crossing detector and comparator
11. To add two dc voltages using Op-amp in inverting and non-inverting mode
12. To design a precision Differential amplifier of given I/O specification using Op-amp.
13. To investigate the use of an op-amp as an Integrator.
14. To investigate the use of an op-amp as a Differentiator.
15. To design a circuit to simulate the solution of a 1st/2nd order differential equation
16. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
17. To build JK Master-slave flip-flop using Flip-Flop ICs
18. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
19. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
20. To design an astablemultivibrator of given specifications using 555 Timer.
21. To design a monostablemultivibrator of given specifications using 555 Timer.
22. Write the following programs using 8085 Microprocessor
    a. Addition and subtraction of numbers using direct addressing mode
    b. Addition and subtraction of numbers using indirect addressing mode
    c. Multiplication by repeated addition.
    d. Division by repeated subtraction.
    e. Handling of 16-bit Numbers.
    f. Use of CALL and RETURN Instruction.
    g. Block data handling.

TEXT BOOKS

1. Chauhan and Singh , " Advanced practical physics", Revised edition, Pragati Prakashan Meerut, 1985

REFERENCE BOOKS

1. Chattopadhyay, D., Rakshit, P. C and Saha, B., "An advanced Course in Practical Physics", 2nd edition, Books & Allied Ltd, Calcutta, 1990.

QUANTUM COMPUTATION LAB II	
Course Code: 25PHMS454	Continuous Evaluation: …. Marks
Credits: 4	End Semester Examination: ….. Marks
L T P : 0 0 8	**Course Type: Minor Stream Course Lab**
Prerequisite:	

COURSE OBJECTIVES

1. To enable students to design and analyze quantum circuits involving multi-qubit entanglement and quantum communication protocols.
2. To introduce the implementation of quantum teleportation, entanglement swapping, and superdense coding using Qiskit.
3. To explore real-world quantum cryptographic schemes such as BB84 and Wiesner's quantum money protocol.
4. To understand the effects of noise and decoherence on quantum systems and analyze fidelity degradation.
5. To investigate foundational quantum mechanics principles like Bell inequalities through simulation-based experiments.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

1. Construct and verify multi-qubit entangled states such as GHZ and Bell states, and perform quantum teleportation and entanglement swapping.
2. Implement and simulate quantum communication protocols like BB84 and superdense coding using Qiskit.
3. Analyze the behavior of quantum systems under noise and decoherence and assess fidelity using measurement outcomes.
4. Design and execute circuits for advanced quantum operations including fan-out, SWAP, and programmable gates.
5. Evaluate quantum non-locality through the CHSH test and interpret the results in the context of quantum entanglement and hidden variable theories.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')	Course Learning Outcomes (CLOs')				
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS
(A Student is supposed to complete/perform minimum ____ of experiments)

1. Design a quantum teleportation circuit and verify the transfer of state.
2. Build a 3-qubit GHZ state and perform full measurement.
3. Implement a SWAP gate using three CNOT gates.
4. Create a Qiskit circuit to demonstrate superdense coding.
5. Program a custom unitary gate and integrate it in a 2-qubit quantum circuit.
6. Construct a 4-qubit entangled circuit and analyze the results.
7. Simulate the BB84 protocol using Qiskit and demonstrate eavesdropping.
8. Create a circuit implementing entanglement swapping.
9. Demonstrate teleportation with noise and explore fidelity degradation.
10. Design a Qiskit program for Wiesner's quantum money scheme (simplified).
11. Simulate a 3-qubit circuit using CNOT and H gates to study quantum fan-out.
12. Construct a parity-check circuit and validate results using different inputs.
13. Simulate the effect of decoherence on an entangled state.
14. Design a programmable Bell-state generator.
15. Measure Bell inequality violation using CHSH test in Qiskit.

TEXT BOOKS

1. M A Nielsen and I L Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010.
2. Giuliano Benenti, Giulio Casati and Giuliano Strini, Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific, 2004.
3. Arthur O. Pittenger, An Introduction to Quantum Computing, Birkhauser Boston Inc; 1st Edition, 2000.
4. P Kaye, R Laflamme and M Mosca, An Introduction to Quantum Computing, Oxford University Press, 2006.

REFERENCE BOOKS

1. G. Strang, Linear Algebra and its Applications, Cengage India Private Limited; 4th Edition, 2005.
2. Rajender. Bhatia, Matrix Analysis, Springer, 1997.
3. Zdzislaw Meglicki, William Gropp, Ewing Lusk, Quantum Computing without Magic, MIT Press, 2008.
4. DAVID McMAHON, Quantum Computing Explained, Wiley-IEEE Computer Society, 1st Edition, 2008.
5. Marco Lanzagorta, Jeffrey Uhlmann, Quantum Computer Science, Springer, 2008.

<table>
<tr><th colspan="2">ASTROPHYSICS LAB</th></tr>
<tr><td>Course Code: 25PHMS455</td><td>Continuous Evaluation: ….. Marks</td></tr>
<tr><td>Credits: 4</td><td>End Semester Examination: ….. Marks</td></tr>
<tr><td>L T P : 0 0 8</td><td>Course Type: Discipline Specific Elective</td></tr>
<tr><td colspan="2">Prerequisite: Basic knowledge of Astrophysics</td></tr>
</table>

COURSE OBJECTIVES

1. Understand and apply solar observation techniques to analyze various solar parameters and activities.
2. Investigate solar cycle trends and their connection to solar-terrestrial interactions and space weather.
3. Utilize photometric and spectroscopic data to determine stellar properties and classify stars.
4. Construct and interpret key astrophysical diagrams such as the H-R diagram and Colour Magnitude Diagram (CMD) for cluster analysis.
5. Estimate astronomical distances and cosmological parameters using observational techniques and empirical relations.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Measure the Sun's rotation period and observe asymmetries in solar activity across hemispheres and longitudes.
2. Analyze sunspot and flare data to construct solar cycles and infer solar activity patterns.
3. Identify spectral lines in solar and stellar spectra and use them for classification and temperature estimation.
4. Use CMD and H-R diagram to estimate the distance and age of star clusters and understand stellar evolution stages.
5. Determine distances to astronomical objects using Cepheid variables and apply redshift-distance relation to calculate the Hubble constant.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

<table>
<tr><th rowspan="2">Course Objectives (COs)</th><th colspan="5">Course Learning Outcomes (CLOs)</th></tr>
<tr><th>CLO1</th><th>CLO2</th><th>CLO3</th><th>CLO4</th><th>CLO5</th></tr>
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<tr><td>CO4</td><td></td><td></td><td></td><td bgcolor="#c0c0c0"></td><td bgcolor="#c0c0c0"></td></tr>
<tr><td>CO5</td><td></td><td></td><td></td><td bgcolor="#c0c0c0"></td><td bgcolor="#c0c0c0"></td></tr>
</table>

List of experiments

1. To determine the rotation period of the Sun.
2. To determine the N-S asymmetry of solar activities.
3. To determine the E-W asymmetry of solar activities.
4. To determine the speed of the Coronal mass ejection.
5. To plot the solar cycle using solar flare data.
6. To plot the solar cycle using solar sunspot data.
7. Study of solar spectrum
8. To determine the distance and age of cluster using Colour Magnitude Diagram.
9. To study the space weather connection events.
10. To determine the Hubble constant.
11. To study the H-R diagram.
12. To determine the basics properties of the Stars.
13. To determine the energy generated in the nuclear reactions in the Stars.
14. To determine the diameter of the Sun.
15. To study the differential rotation of the Sun.
16. To get familiar with the spectra of different stars.
17. To measure astronomical distances using Cepheid variables.
18. In this project you will determine the distance and age of a cluster of stars using the measured values of apparent visual magnitudes, m_V, and the color index, B-V, for several stars within a cluster.

TEXT BOOKS:

8. An Invitation to Astrophysics, T. Padmanabhan, World Scientic Publishing Co.
9. An Introduction to Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
10. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
11. Astrophysics in a Nutshell (Basic Astrophysics), Dan Maoz, Princeton University Press.
12. Foundations of Astrophysics, Barbara Ryden and Bradley M. Peterson, Addison Wesley.
13. Astrophysics for Physicists, Arnab Rai Choudhuri, Cambridge University Press.

REFERENCE BOOKS

6. Astronomy and Astrophysics, A. B. Bhattacharya, S. Joardar, R. Bhattacharya, Overseas Press (India) Pvt.Ltd.
7. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan, Cambridge University Press.
8. K.S. Krishnasamy, ‘Astro Physics a modern perspective,’ Reprint, New AgeInternational (p) Ltd, New Delhi,2002.
9. BaidyanathBasu, ‘An introduction to Astro physics’, Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
10. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication

GENERIC ELECTIVE (GE) THEORY COURSES

1. Clean and Renewable energy physics (24OEPH101)
2. Biophysics (21OEPH102)
3. MATLAB (21OEPH201)
4. Programming in C (21OEPH202)

CLEAN AND RENEWABLE ENERGY PHYSICS	
Course Code: 24OEPH101	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Discipline Specific Elective
Prerequisite: NIL	

COURSE OBJECTIVES

1. To discuss the fundamentals of renewable energy systems.
2. To understand the solar and biomass energy.
3. To make students familiar with hydrogen energy and different energy storage systems.
4. To develop an understanding about wind, thermoelectric, hydropower and ocean energy.
5. To make students familiar with the current energy scenario and the significance of renewable energy technology

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Fluent with the fundamentals of renewable energy systems.
2. Get an understanding of solar and biomass energy.
3. Able to understand the hydrogen energy and different energy storage systems.
4. Well-versed with the wind, thermoelectric, hydropower and ocean energy.
5. Able to understand the current energy scenario and the significance of renewable energy technology

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

<table>
<tr><th rowspan="2">Course Objectives (COs)</th><th colspan="5">Course Learning Outcomes (CLOs)</th></tr>
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<tr><td>CO3</td><td></td><td style="background:#c0c0c0"></td><td style="background:#c0c0c0"></td><td></td><td></td></tr>
<tr><td>CO4</td><td></td><td></td><td></td><td style="background:#c0c0c0"></td><td style="background:#c0c0c0"></td></tr>
<tr><td>CO5</td><td></td><td></td><td></td><td style="background:#c0c0c0"></td><td style="background:#c0c0c0"></td></tr>
</table>

COURE CONTENTS

UNIT I: FUNDAMENTALS OF RENEWABLE ENERGY SYSTEMS

Conventional and non-conventional energy sources. Current energy scenario. Introduction to renewable energy: significance, applications, advantages and disadvantages. Renewable energy

Technology. Different sources of renewable energy: solar, biomass, hydrogen, wind, thermoelectric, geothermal, hydropower and ocean. Energy management criteria. Impact on environment, social and economic development. Renewable energy access and security. Challenges in renewable energy technology. Role of bulk and nanomaterials for renewable energy application.

UNIT II: SOLAR AND BIOMASS ENERGY

Solar energy: definition and current scenario. Active and passive solar energy. Working principles, applications, advantages and limitations. Basic components of solar power. Photovoltaic and photothermal effect. Different solar cells, their working principles, efficiency, advantages and limitations: silicon solar cell, organic solar cell, cadmium telluride solar cell, solid-state solar cell, perovskite solar cell, thin-film solar cell and others. Numerical problems. Future and latest developments

Biomass energy: definition and sources. Working principles and efficiency. Applications, Advantages and limitations. Future and Latest Developments.

UNIT III: HYDROGEN ENERGY AND ENERGY STORAGE SYSTEMS

Hydrogen economy. Hydrogen as a carrier of renewable energy. Generation, storage and utilization of hydrogen energy. Working principles, efficiency and gravimetric density. Numerical problems. Conditions for hydrogen storage. Hydrogen storage in gaseous, liquid and in solid forms. Applications and prospects.

Applications, working principles, advantages and limitations of different energy storage systems: fuel cells, battery materials, supercapacitors. Solid oxide fuel cells, polymer electrolyte membrane fuel cells, direct methanol fuel cells, reversible fuel cells and others. Different rechargeable and non-rechargeable batteries. Li-ion, Na-ion, Zn-ion batteries. Bio-battery, CMOS battery, nanowire battery. Carbon nanomaterials for energy storage.

UNIT IV: OTHER RENEWABLE ENERGY SYSTEMS

Definition, working principles, efficiency, applications, advantages, limitations, future and latest developments of wind, thermoelectric, geothermal, hydropower and ocean energy. Choosing of materials for different renewable energy applications. Current developments and future prospects of magneto-electric, magneto-mechanical, piezoelectric and piezomagnetic energy conversions.

Nuclear power and working principles of nuclear energy. Nuclear fusion vs fission. Nuclear energy as green and clean energy. Renewability vs sustainability. Challenges and limitations. Future prospects.

TEXTBOOKS

1. Renewable energy: power for a sustainable future by Godfrey Boyle.
2. Renewable: the world-changing power of alternative energy by Jeremy Shere.
3. Renewable energy: a first course by Robert Ehrlich.
4. Renewable Energy: sustainable energy concepts for the energy change by Roland Wengenmayr.

REFERENCE BOOKS

1. Non-conventional Energy sources, G. D. RAI (4th edition), Khanna Publishers, Delhi.
2. Solar Energy, S.P. Sukhatme (second edition), Tata McGraw Hill Ltd, New Delhi.
3. Solar Energy Utilisation, G. D. RAI (5th edition), Khanna Publishers, Delhi.

BIOPHYSICS	
Course Code:21OEPH102	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Generic Elective
Prerequisite:	

COURSE OBJECTIVES

1. To make students familiar with Length and time scales in biology.
2. To develop students understanding about Cellular dynamics
3. To develop students understanding about thee brain & Information in living systems
4. To make students familiar with Ecosystems.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the knowledge of Length and time scales in biology.
2. Get an understanding of Cellular dynamics
3. Get an understanding of the brain & Information in living systems
4. Able to design of oscillators.
5. Fluent with knowledge on Ecosystems.

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MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)			
	CLO1	CLO2	CLO3	CLO4
CO1	(shaded)			
CO2		(shaded)		
CO3			(shaded)	
CO4				(shaded)

COURSE CONTENTS

UNIT I: LENGTH AND TIME SCALES IN BIOLOGY

Types, sizes and roles of biomolecules - metabolites, proteins, RNA, and DNA. Ranges of cell sizes and interdivision time scales. Ranges of organism sizes and lifetimes. Scaling laws in biology. Complexity of living systems. Timeline of life on Earth. Time scales in biological evolution

UNIT II: CELLULAR DYNAMICS
Dynamical systems. Coupled ordinary differential equations. Experiments on cellular physiology. Phenomena and models of intracellular chemical dynamics, metabolism and gene regulation, cell growth and division.

UNIT III: THE BRAIN & INFORMATION IN LIVING SYSTEMS
Dynamics of a single neuron. Neural networks. Learning. Memories as attractors of neural network dynamics. Probability, entropy and information. Applications of information theory in genetics, neuroscience, and ecology.

UNIT IV: ECOSYSTEMS
Growth of a bacterial colony. Ecological interactions. Lotka-Volterra and other ecological dynamics. Models of ecosystems.

TEXT BOOKS

1. Physics in Molecular Biology; Kim Sneppen and Giovanni Zocchi (CUP 2005).
2. Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004).
3. Biophysics: Searching for Principles; William Bialek (Princeton University Press, 2012).
4. Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013).

REFERENCE BOOKS

1. An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013).
2. Mathematical Biology: I. An Introduction (3rd Edition); J. D. Murray (Springer, NY, 2004).

MATLAB	
Course Code: 25OEPH201	Continuous Evaluation: ….. Marks
Credits: 4	End Semester Examination: ……….. Marks
L T P : 3 1 0	**Course Type: Minor Stream Course Theory**
Prerequisite:	

COURSE OBJECTIVES (CO):

1. To introduce students to the MATLAB programming environment, including variables, arrays, and mathematical operations.
2. To enable learners to perform matrix operations and create 2D and 3D plots for data visualization and analysis.
3. To develop proficiency in writing MATLAB scripts and function files for structured and modular programming.
4. To teach logical reasoning and algorithm development using control structures and conditional logic in MATLAB.
5. To familiarize students with practical applications of MATLAB in numerical analysis, curve fitting, file handling, and toolbox utilities.

COURSE LEARNING OUTCOMES (CLO):

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Navigate and utilize the MATLAB interface to create and manipulate variables, arrays, and matrices effectively.
2. Generate and format 2D and 3D plots, and apply data visualization techniques for interpreting scientific data.
3. Develop MATLAB scripts and user-defined functions to automate computational tasks and workflows.
4. Apply conditional statements, loops, and logical operations to implement algorithms and solve problems programmatically.
5. Use MATLAB for practical engineering/scientific tasks such as polynomial fitting, interpolation, solving equations, numerical integration, and exploring built-in toolboxes.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs')		Course Learning Outcomes (CLOs')			
	CLO1	CLO2	CLO3	CLO4	CLO5
CO1					
CO2					
CO3					
CO4					
CO5					

COURSE CONTENTS

Unit I: MATLAB basics

The MATLAB environment, scalar Variables and constants: useful commands for managing variables, 1D and 2D arrays: creating arrays, simple mathematical operations with arrays, operators/functions and simple calculations, Built-in functions for creating matrices, Handling arrays/matrices: adding, deleting elements and rows/columns.

Unit II: Matrices and plotting in MATLAB

Matrix and linear algebra/Matrix operations and functions in MATLAB, Strings: creating and handling strings (catenation, num2str etc commands), 2D Plots: plot and fplot commands, plotting multiple graphs in the same plot (plot, hold on and hold off, line commands), formatting a plot (labelling axes, titling, legends, linewidths, line colour, types etc), putting multiple plots on the same page. 3D plots: line plots, mesh and surface plots.

Unit III: Script and function files

MATLAB scripts and functions: creating, saving and accessing of these functions, Simple sequential algorithms; input and output commands: display, fprintf etc, importing and exporting data: load, save xlsread and xlswrite etc commands.

Unit IV: Programming in MATLAB

Relational and logical operators, Control structures: conditional statements, loops, nested loops, break and continue commands.

Unit V: Applications of MATLAB programming

File handling: file creation or loading, reading and writing data; Polynomial, curve fitting and interpolation; Numerical Analysis: Solving an equation (linear and nonlinear) with one variable, numerical integration; MATLAB Toolbox: Introduction to MATLAB Toolbox and its access, different toolboxes and their important functions.

TEXTBOOKS

1. MATLAB: An Introduction with Applications, Amos Gilat (Wiley).
2. MATLAB for Engineers, Holly Moore (Pearson).

REFERENCE BOOKS

1. Matlab: A Practical Introduction to Programming and Problem SolvingStormy Attaway (Butterworth-Heinemann)
2. Matlab for Beginners:A gentle Approach, Create space Independent Publishing Platform, Peter I. Kattan

PROGRAMMING IN C

Course Code: 21OEPH202	Continuous Evaluation: -- Marks
Credits: 4	End Semester Examination: -- Marks
L T P : 3 1 0	**Course Type:** Generic Elective
Prerequisite	

COURSE OBJECTIVES

1. To make students familiar with basic tools of C.
2. To develop skills of C programming.
3. To make students familiar with different C scripts.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

1. Equipped with the knowledge of basic tools in C.
2. Get an understanding of C programming.
3. Fluent with different C scripts.

MAPPING MATRIX OF COURSE OBJECTIVES & COURSE LEARNING OUTCOMES

Course Objectives (COs)	Course Learning Outcomes (CLOs)		
	CLO1	CLO2	CLO3
CO1			
CO2			
CO3			

COURSE CONTENTS

Unit I:
An overview of Programming, Programming Language, Classification, Basic structure of a C Program, C language preliminaries, Operators and Expressions, Two's compliment notation, Bit–ManipulationOperators, Bitwise Assignment Operators, Memory Operators.

Unit II:
Arrays and Pointers, Encryption and Decryption, Pointer Arithmetic,Passing Pointers as Function Arguments, Accessing Array Elements through Pointers, Passing Arrays as Function Arguments, Multidimensional Arrays, Arrays of Pointers, Pointers to Pointers.

Unit III:
Storage Classes –Fixed vs Automatic Duration, Scope, Global Variables, Definitions and Allusions, The register Specifier, ANSI rules for the Syntax and Semantics of the Storage-Class Keywords, Dynamic Memory Allocation, Structures and Unions, declarations, Passing Arguments to a Function, Declarations and Calls, Automatic Argument Conversions, Prototyping, Pointers to Functions.

Unit IV:
The C Preprocessors, Macro Substitution, Include Facility, Conditional Compilation, Line Control, Input and Output –Streams, Buffering, Error Handling, Opening and Closing a File, Reading and Writing Data, Selecting an I/O Method, Unbuffered I/O, Random Access, The Standard Library for I/O.

TEXT BOOKS

1. Peter A. Darnell and Philip E. Margolis, C: A Software Engineering Approach,Narosa Publishing House (Springer International Student Edition) 3rd edition 1996.
2. Samuel P. Harkison and Gly L. Steele Jr., C: A Reference Manual, Second Edition, Prentice Hall, 2008.

REFERENCE BOOKS

1. Brian W. Kernighan & Dennis M. Ritchie, The C Program Language, Second Edition, Prentice Hall, 2017.
2. Balagurusamy E., Programming in ANSI C, Third Edition, Tata McGraw-Hill Publishing Co. Ltd.
3. Byron, S. Gottfried, Theory and Problems of Programming with C, Second Edition, Tata McGraw-Hill Publishing Co. Ltd., 1990.
4. Venugopal K. R. and Prasad S. R.: Programming with C, Tata McGraw-Hill Publishing Co. Ltd.