SMIT SIKKIM MANIPAL UNIVERSITY

SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

INSPIRED BY LIFE

DEPARTMENT OF PHYSICS

SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

MAJITAR, EAST SIKKIM

INSPIRED BY LIFE

SYLLABUS – 2023 Batch onwards

CONTENT

Sikkim Manipal University (SMU)

VISION

- Global Leadership in Human Development, Excellence in Education and Healthcare.

MISSION

- Develop professionals of excellent technical caliber in the field of Health Sciences, Engineering, Management and Social Sciences with a humane approach capable of shouldering the responsibility of building the nation and be globally competent.

OBJEECTIVES

- To support, promote and undertake the advancement of academics
- To promote use of ICT and modern education technologies
- To encourage research, creation and dissemination of knowledge
- To facilitate extension and community service
- To empower people of Sikkim and contribute to human development in Northeast
- To create environmental and social responsibilities among students and employees
- To ensure steady growth of the University

Sikkim Manipal Institute of Technology (SMIT)

VISION

- To achieve eminence in the field of quality, technological, education and research.

MISSION

- To develop SMIT into an institute of excellence capable of producing competent techno-managers who can contribute effectively to the advancement of the society.

OBJECTIVES

- To provide wholesome education to meet the intellectual aspirations of the students.
- To equip students with techno-managerial skills to enable them to take their assigned role in the industry.
- To inculcate essential ethics and values to meet the spiritual needs to the students.
- To provide a sound institutional environment nurturing emotional strength, healthy mind, body and resilience amongst the students.

DEPARTMENT OF PHYSICS, SMIT

VISION

- To become a dynamic and an inclusive Centre of excellence in teaching, learning and research in Physical Sciences.

MISSION

- To impart high scientific temperament, academic excellence and contemporary research exposure in Physics.
- To produce high quality physicists who can contribute to the development of science and technology and meet the present challenges and demands of the society.
- To help the students to develop critical and creative thinking and problem solving skills.
- To build an academically vibrant environment for learning and exchange of ideas and knowledge.

OBJECTIVES

- To impart in-depth knowledge to the students to help them achieve academic excellence and over all developments to meet the global standards.
- To create an environment of active learning and effective communication and enable the students to acquire the recent advances of Physics.
- To provide opportunities that will enhance the level of participation in research, dissemination and preservation of knowledge for both academic and social development.

PROGRAM OUTCOMES, M. Sc. (Physics)

1. **Knowledge:** Demonstrate a knowledge and understanding of contemporary sciences and technologies, their applications and limitations, contemporary research in the broader context of physical sciences.
2. **Problem Analysis**: Identify, formulate, review research literature, and analyze complex problems in the field of Physical science.
3. **Investigation of research problems:** Use research-based knowledge and research methods and find innovative solutions for various problems.
4. **Environment and sustainability:** Understand the impact of scientific solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
5. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the scientific practice.
6. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
7. **Communication:** Communicate effectively on scientific problems with the scientific community and with society at large, make effective presentations and reports.
8. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific changes.
9. **Societal responsibility:** Use knowledge for the betterment of society.

SCHEMA: M. Sc. (Physics)

SEMESTER : I				
YEAR	New Subject Code	SUBJECT NAME	L-T-P	CREDIT
2023	PH501A1	MATHEMATICAL PHYSICS	3-1-0	4
2023	PH502A1	FUNDAMENTALS OF ELECTRONICS	3-1-0	4
2023	PH503A1	CLASSICAL MECHANICS	3-1-0	4
2023	PH504A1	QUANTUM MECHANICS I	3-1-0	4
2023	PH505A4	PHYSICS LAB I (GEN. PHYSICS)	0-0-6	3
2023	PH506A4	PHYSICS LAB II (PHOTONICS & SPECTROSCOPY)	0-0-6	3
		TOTAL (SEMESTER 1)	12-4-12	22
SEMESTER : II				
2023	PH511A1	CLASSICAL AND RELATIVISTIC ELECTRODYNAMICS	3-1-0	4
2023	PH512A1	CONDENSED MATTER PHYSICS	3-1-0	4
2023	PH513A1	COMPUTATIONAL PHYSICS - I	3-0-0	3
2023	PH514A1	QUANTUM MECHANICS II	3-1-0	4
2023	PH515A4	PHYSICS LABORATORY III (ELECTRONICS)	0-0-6	3
2023	PH516A4	PHYSICS LABORATORY IV (COMPUTATIONAL PHYSICS LAB - I)	0-0-6	3
2023	PH517A5	PROJECT BASED LEARNING – I	0-0-2	1
		TOTAL (SEMESTER 2)	12-3-14	**22**
SEMESTER : III, GROUP A (THEORY)				
2023	PH601A1	STATISTICAL MECHANICS	3-1-0	4
2023	PH602A1	NUCLEAR & PARTICLE PHYSICS	3-1-0	4
2023	PH603A1	COMPUTATIONAL PHYSICS - II	3-0-0	3
2023	PH604A3	ELECTIVE-I: PARTICLE PHYSICS I	3-1-0	4
2023	PH605A3	ELECTIVE-I: PLASMA PHYSICS I	3-1-0	4
2023	PH608A5	PROJECT BASED LEARNING – II	0-0-6	2
		TOTAL (SEMESTER 3: THEORY GROUP)	15-4-6	**21**
SEMESTER : III, GROUP B (EXPERIMENTAL)				
2023	PH601A1	STATISTICAL MECHANICS	3-1-0	4
2023	PH602A1	NUCLEAR & PARTICLE PHYSICS	3-1-0	4
2023	PH603A1	COMPUTATIONAL PHYSICS - II	3-0-0	3
2023	PH606A3	ELECTIVE-II: ELECTRONICS - I	3-1-0	4
2023	PH607A3	ELECTIVE-II: ELECTRONICS LAB - I	0-0-6	4

2023	PH608A5	PROJECT BASED LEARNING – II	0-0-4	2
		TOTAL (SEMESTER 3: EXPT. GROUP)	12-3-10	**21**
SEMESTER : IV, GROUP A (THEORY)				
2023	PH611A1	ATOMIC & MOLECULAR PHYSICS	3-1-0	4
2023	PH612A4	COMPUTATIONAL PHYSICS LAB II	0-0-6	3
2023	PH614A3	ELECTIVE-I: PARTICLE PHYSICS II	3-1-0	4
2023	PH615A3	ELECTIVE-I: PLASMA PHYSICS II	3-1-0	4
2023	PH618A6	*(DISSERTATION/ PROJECT)	0-0-10	5
		TOTAL (SEMESTER 4: THEORY GROUP)	9-3-16	**20**
SEMESTER : IV, GROUP B (EXPERIMENTAL)				
2023	PH611A1	ATOMIC & MOLECULAR PHYSICS	3-1-0	4
2023	PH612A4	COMPUTATIONAL PHYSICS LAB II	0-0-6	3
2023	PH616A3	ELECTIVE-II: ELECTRONICS - II	3-1-0	4
2023	PH617A3	ELECTIVE-II: ELECTRONICS LAB - II	0-0-6	4
2023	PH618A6	*(DISSERTATION/ PROJECT)	0-0-10	5
		TOTAL (SEMESTER 4: EXPT. GROUP)	6-2-22	**20**
TOTAL CUMULATIVE CREDIT AT END OF THE PROGRAM				**85**

M. Sc. (Physics)

1st SEMESTER

DEPARTMENT OF PHYSICS

PH501A1 Credit: 4 (L-3, T-1, P-0)

MATHEMATICAL PHYSICS

Questions to be set: 05 (All Compulsory)

Objectives: The course is focused on teaching different kind of mathematical techniques used in various kinds of physics problems.

Prerequisites: Students should have the knowledge of complex number system, basic various mathematical functions, different kind of coordinate systems, matrix operations, integration and differentiation.

Course Outcomes: After the completion of the complete syllabus, the student will be capable of the following:

- CO1. Solve tedious integrals using complex analytical method.
- CO2. Understand delta function, Fourier and Laplace transformation and their applications.
- CO3. Apply tensors to solve complex problems.
- CO4. Solve nonhomogeneous differential equations using Green's function.
- CO5. Explain the basic idea of group theory to understand the advance label of physics

Module	Topics	Hrs.
Module 1: Complex analysis	Functions of complex variables, regular and singular points. Cauchy-Riemann equations. Cauchy's theorem and consequences, integral formulae. Expansion of functions about singular points. Residue theorem – its application in evaluating integrals.	12
Module 2: Special functions and integral transform	Dirac's delta function; Fourier transforms, Laplace transform and their application.	6
Module 3: Linear vector space and matrices	Definition of vector space; dimension, basis, subspace; inner product, orthogonality and completeness.	4
Module 4: Tensors	Covariant, contravariant and mixed tensors. Tensor algebra, contraction, quotient law. Kronecker delta, metric tensors. Christoffel symbols and covariant derivative of tensors.	10
Module 5: Green's function	Nonhomogeneous boundary value problem and Green's function. Eigen function expansion of Green's function. Application to physical	5

	problems.	
Module 6: Group theory	Introduction, group multiplication table, discrete and continuous groups. Homomorphic and Isomorphic group. Group representation. Reducible and irreducible representation of groups, representation by unitary matrices, orthogonality theorem, rotation groups, unitary groups and Lorentz homogeneous groups.	7

Text Books:

T1. Mathematical Methods for Physicists, G.B. Arfken & H.J. Weber, Prism Books Pvt. Ltd.
T2. Complex variables, M.R Spiegel, Mc GRAW- Hill
T3. Mathematical Physics, P.K. Chattopadhyay, New Age International Pub.
T4. Higher Engineering Mathematics, Dr. B. S. Grewal.

Reference Books:

R1. Advanced Mathematics for Engineers & Sci., M.R Spiegel, Mc GRAW- Hill
R2. Mathematical Physics, B. S. Rajput, Pragati Prakashan Meerut.
R3. Higher Mathematical Physics, H. K. Das & R. Verma, S. Chand Pub.

DEPARTMENT OF PHYSICS

PH502A1 **Credit: 4 (L-3, T-1, P-0)**

FUNDAMENTALS OF ELECTRONICS

Questions to be set: 05(All Compulsory)

Objective:

1. The course focuses at developing the basic knowledge of electronics in physics.
2. It gives the fundamental knowledge of network analysis to make various electronics circuit.
3. This course also makes the strong theoretical base of different components used in electronics.
4. The course is designed in such a way that it can cope up with modern technology.

Pre-requisites:

Student should have the basic knowledge of electronics. Familiarity with the network analysis theorems and basic characteristics of diodes and transistors. They should have also done a course in mathematics involving calculus, simple differential equations, algebra, elementary number theory and trigonometry.

Scope: Develop the basic knowledge about developing the basic knowledge and application in the field of electronics and communications.

Course outcomes: Upon successful completion of this course, students can

CO1. Solve and analysis different electronic circuit networks such as filters.
CO2. Understand and analysis the I-V characteristics of active electronic components.
CO3. Design different electronic circuits using OP-AMP such as differentiator, integrator etc**.**
CO4. Design electronic digital circuits using different GATES.
CO5. Understand, analyze and design electronic circuits used for the modulation and demodulation for different waves.

Module	Topics	Hrs.
Module 1: Complex analysis	Topological descriptions of different commonly used networks, Π to T and T to Π conversions, reduction of a complicated network into its equivalent T and Π form. L filter, Π filter. Junction Field Effect Transistor (JFET) - Device structure, Pinch-off and saturation, Gate control, current-voltage characteristics. MOSFET - Device structure, operation with no gate voltage, creating a channel, Application of small VDS, Derivation of iD - VDS relationship, p channel enhancement MOSFET, iD - VDS characteristics of n channel enhancement MOSFET, Finite output resistance in saturation, and characteristics of the p-channel	12

	MOSFET, Complementary MOSFET (CMOS).	
Module 2: (Digital Electronics)	Karnaugh mapping : Methods of minimization (reduction) of Product of Sum (POS) and Sum of Products (SOP Boolean expression, Logical implementations, Digital techniques and applications (registers, counters, comparators and similar circuits).	10
Module 3: (Diode devices:)	Optoelectronic devices, photo-diodes (solar cells), negative-resistance devices (Zener diodes used as voltage regulators) Light-emitting diodes	4
Module 4: (Operational Amplifier (without internal circuit):)	Characteristics of an ideal op-amp, as well as practical op-amp. Open-loop op-amp configuration: Differential, inverting and non-inverting amplifier., differential with one op-amp. Applications of Op-Amp: AC Amplifier; summing, scaling multiplier and divider, differentiator, integrator etc. Close-loop op-amp configuration (with negative feedback): voltage- series feedback, voltage- shunt feedback	8
Module 5: (Multivibrators: and Elements of Communication)	Astable and monostable (principles, Circuits and operation) using Transistors, and IC 555 Communications system, Modulation and Demodulation, Transmission Frequencies: Bandwidth requirement and information capacity. Introduction to optical communication. Astable (principles, Circuits and operation) using IC 555	10

Text Books:

T1. Integrated Electronics, Millman and Halkias, McGrawhill, New York, 1998.
T2. Electronics Principles, A.P. Malvino (6^{th} Edition), Tata McGrawhill.
T3. Digital Computer Electronics – A.P. Malvino, Tata McGraw Hill.

References:

R1. Network & Systems, D. Roy Choudhury, New Age Int. Publisher.
R2. Electronic Devices and Circuit, Allen Mottershead, Prentice Hall of India.
R3. Networks, Lines and Fields, J.D. Ryder, Prentice Hall.
R4. Basic Electronics: *Devices, Circuits & IT Fundamentals*: Santiram Kal, Prentice Hall of India, May 2008.

DEPARTMENT OF PHYSICS

PH503A1 **Credit: 4 (L-3, T-1, P-0)**

CLASSICAL MECHANICS

Questions to be set: 05(All Compulsory)

Objective: The primary objective is to teach the students Classical Mechanics at a level more advanced than what they have learnt in under graduate course. This is a course which forms the basis of Physics of many areas of Physics.

Pre-requisites: Knowledge of Mathematical Physics and classical mechanics in under graduate level.

Course Outcomes: By the end of the course, the student will be able to following:

- CO1. Solve the mechanical problems by using Lagrangian & Hamiltonian methods.
- CO2. Apply the concept of canonical transformations and Poisson's brackets in solving problems of physics.
- CO3. Solve the dynamical systems by applying the Hamilton-Jacobi techniques.
- CO4. Solve Lagrange's equation of motion for small oscillations.
- CO5. Understand classical approach to deal with dynamic of rigid bodies.
- CO6. Understand the basics of nonlinear dynamics.

Module	Topics	Hrs.
Module 1: Lagrangian and Hamiltonian mechanics	Generalized Coordinates, Lagrange's Equations, Simple applications of the Lagrangian formulation, Cyclic coordinates and conservation theorem Calculus of variation, Hamilton's variational principle, derivation of Lagrange's and Hamilton's equations from Hamilton's principle, symmetry properties and conversation laws, applications to problems including relativistic problems. Lagrangian and Hamiltonian formulation for Continuous system.	11
Module 2: Canonical transformations	Introduction, Generating function, properties and examples of canonical transformation, Liouville's Theorem.	5
Module 3: Poisson Bracket	Introduction, Definition, Identities, Poisson bracket formulation of some equation of motions, Poisson's theorems and examples, invariance, Lagrange bracket.	6
Module 4: Hamilton-Jacobi theory	Hamilton-Jacobi equation and its solution, Jacobi's theorem, connection with CT, application of simple harmonic oscillator and two dimensional Planetary motion, Swinging Atwood's machine. Action-angle variables, application to	7

	simple harmonic oscillator and the Kepler problem, Classical-quantum analogies.	
Module 5: Small Oscillation	Stable and unstable equilibrium oscillators, Lagrange's equation of motion for small oscillations, Normal coordinate and its applications to compound pendulum, chain molecules and other problems.	6
Module 6: Rigid Body Dynamics	Degrees of freedom of a free Rigid body, Euler's and Chasles' theorem, frames of reference, kinetic energy and moment of inertia, transformation of moment of inertia, examples to calculate the moment of inertia, Euler's equation of motion, Euler angles, motion of symmetric top.	5
Module 7: Non-linear motion	Duffing and van der Pol oscillators, phase diagram. Basic idea of chaotic solutions; fixed points and attractors; bifurcations; strange attractors; logistic maps, fractal dimensions and Lyapunov exponent.	4

Text Book:

T1. Classical Mechanics, N.C Rana and P.S Joag, Tata- McGraw Hill, 1991.
T2. Classical Mechanics. H. Goldstein, Addison Wesley. 1992
T3. Introduction to Classical Mechanics, R.G. Takwale & P.S. Puranik, Tata- McGraw Hill, 1987.
T4. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering, Steven H. Strogatz, 2nd Edition Special Indian Edition, CRC Press.

Reference Books:

R1. Classical Mechanics of Particles & Rigid Bodies, Kiran O. Gupta, New Age International.
R2. Classical Mechanics, A. K. Raychaudhury, Oxford University Press.
R3. Classical Mechanics, John and Taylor, University Science Books.
R4. Mechanics, L. D. Landau and E. M. Lifshitz, Pergamon Press
R5. The Feynman Lectures on Physics, Vol-I, Indian print, Pearson.

DEPARTMENT OF PHYSICS

PH504A1 **Credit: 4 (L-3, T-1, P-0)**

QUNATUM MECHANICS-I

Questions to be set: 05(All Compulsory)

Objective: This course will help to develop appropriate competence and a working knowledge of quantum physics. It will also help the students to understand atomic and sub-atomic physics. Students develop the ability to identify and apply the appropriate analytic, numerical, computational, and other mathematical tools necessary to solve quantum problems. This course will also develop a familiarity with the current state of research in quantum physics, including the most significant research questions being pursued by today's physicists**.**

Prerequisites: Students should have the basic knowledge of Newtonian Mechanics, Lagrangian and Hamiltonian Mechanics Students should have the basic knowledge of mathematics involving Algebra, Integral and differential calculus, Simple Differential Equations, Linear Vector Space, Different Polynomials, Fourier Transformations, and Dirac Delta Function.

Course Outcomes: After completion of the complete syllabus, the students will be able to do the following:

- CO1. Understand the mathematical preliminaries needed to study quantum mechanics.
- CO2. Understand the Concepts like matter waves, uncertainty principle, operator algebra, wave function.
- CO3. Solve the time independent Schrodinger equations for simple quantum systems like free particle motion, bound states, tunneling problem, hydrogen atom, linear harmonic oscillator.
- CO4. Understand the concepts of quantum harmonic oscillator.
- CO5. Apply the concepts of symmetry in quantum mechanics.
- CO6. Understand the concepts of rotational and spin angular momentum.

Module	Topics	Hrs.
Module 1: Mathematical foundation of Quantum Mechanics	Overview of Linear vector space, Hilbert space, Dirac's kets & bra notation, compatible and incompatible observables, Linear Operators, Position, Momentum, Angular Momentum Operators, Commutation operator, Projection operator, Parity operator, Adjoint operator, Identity operator, Inverse operator, Matrix representation of operators, Eigen vectors and Eigen values, Infinite dimensional vector spaces.	8
Module 2: Basics of Quantum Mechanics	Motivation, Inadequacies of Classical Mechanics, De-Broglie hypothesis, group and phase velocity of de Broglie wave, Uncertainty Principle and its applications, Postulates of QM,	6

	Expectation value, Ehrenfest theorem, stationary state solutions, continuity Equation, Schrodinger picture and Heisenberg picture	
Module 3: Simple application of Schrödinger Equation	Free particle, Infinite Square Well, Finite Square well, Penetration of Barrier, Hydrogen atom and spherical harmonics.	8
Module 4: Harmonic oscillator	Harmonic Oscillator in 1-Dimension, solution of Schrodinger Equation, Probability distribution of quantum oscillators, Creation & Annihilation operators, Matrix formulation, Selection rule for transition, Oscillator in higher dimension.	6
Module 5: Symmetries and their consequences	Symmetries in Classical Mechanics, Symmetries in Quantum Mechanics, Groups, Parity, Rotations.	4
Module 6: Identical particles and spin	Identical particles and spin, symmetric and anti-symmetric wave function, exchange degeneracy, Pauli's exclusion principle, experimental need for electron spin, Pauli's spin matrices for electron and commutation relation between them., Pauli operators, Statistical weight.	5
Module 7: Angular Momentum	Rotation in 3-dimension, Orbital angular momentum, Ladder operators, Commutation relations of angular momentum operators and their Eigen value equations, Matrix representation of angular momentum operators. Addition of Angular momenta. Clebsch- Gordon coefficients.	7

Text Book:

T1. Quantum Mechanics, A. Ghatak and S. Loknathan, Macmillan India Ltd
T2. Quantum Mechanics, Satya Prakash, Kedar Nath Ram Nath & Co
T3. Principles of Quantum Mechanics, P.A.M. Dirac, Oxford University Press

Reference Books:

R1. Quantum Mechanics, E. Merzbacher 3rd Edition, John Wiley & Sons, INC
R2. Quantum Mechanics An Introduction, W. Greiner, Springer –Verlag
R3. Quantum Mechanics, Mathews and Venkateshan
R4. Angular Momentum, M.E. Rose
R5. Quantum Mechanics, J.J. Sakurai
R6. Lectures on Quantum Mechanics, Ashok Das, Hindustan Book Agency
R7. The Feynman Lectures on Physics, Vol-III, Indian print, Pearson.

DEPARTMENT OF PHYSICS

PH505A4 **Credit: 3 (L-0, T-0, P-6)**

PHYSICS LAB – I (GENERAL PHYSICS LAB)

Max Marks: 100
There will be **TWO** laboratory class of 3 hours duration per week. There are **13 weeks** expected in a semester.
Note: Minimum of **TWELVE** experiments to be completed from all **FIVE MODULES.**

Objectives: This laboratory is considered to be General Physics laboratory. This course covers begins advanced level experiments of the theories covered in the UG level and theories offered in the first two semesters at PG level. Different experiments from thermodynamics, electromagnetic theory, condensed matter physics, atomic physics, nuclear physics and quantum mechanics will be covered to understand some of the basic laws of physics in these areas.

Prerequisites: Student should have the basic knowledge of UG level experiments taught at B.Sc. (Hons/Pass) Physics. They should have adequate knowledge of basic laws of physics.

Course Outcomes: By the end of the course, the student will be able to following:

CO1. Apply wave properties for characterization of materials.
CO2. Determine the thermal, electrical and magnetic properties of matters.
CO3. Understand crystal structure and different distributions of radioactive decay.
CO4. Analyze semiconducting and conducting materials for various applications.
CO5. Understand electron associated various experiments for atomic and spectral analysis.

Module	Topics	Hrs.
Module 1: Study about wave with various applications.	1. To study the existence of different harmonics and measure their amplitude. 2. To find the velocity of sound in the given (i) liquid and (ii) solid using Ultrasonic Interferometer. 3. Study the i. dispersion relation for the mono-atomic lattice and comparison with theory and ii. determination of the cut-off frequency of the mono-atomic lattice. 4. To determine the compressibility of a given liquid using ultrasonic diffraction.	12
Module 2:	5. To determine the heat capacity of the given sample.	15

Thermal, electrical and magnetic properties.	6. To determine the resistivity of the given sample using Four Probe method. 7. To determine the Curie temperature of the given Ferroelectric material. 8. To determine the dielectric constant of a given (i) solid and (ii) polar liquid. 9. To display the B-H hysteresis curve on CRO screen and to determine magnetic Permeability of free space. 10. To determine the capacitance of the given capacitor and to find the Permittivity of free space.	
Module 3: Structure study of crystal and radioactivity	11. To study the structure of NaCl monocrystals with different orientations. Structure factor (ii) Atomic form factor (iii) Bragg Scattering (iv) Reciprocal Lattice (v) Miller Indices (vi) Crystal structures (vii) Energy levels (viii) Characteristics X-ray radiation. 12. To determine Passion's and Gaussian distribution of Radioactive decay and determine (i) Poisson Distribution (ii) Gaussian distribution (iii) Standard deviation (iv) Expected value of Pulse rate (v) Different symmetric of distribution (vi) Dead time (vii) Recovering time and resolution time of a counter tube.	6
Module 4: Semiconducting and conducting materials study	13. To determine the Hall coefficient of the given semiconductor and its charge carrier density. 14. To study the Hall Effect in metals and study (i) Normal Hall Effect (ii) Anomalous Hall Effect (iii) Charge carrier density (iv) Hall mobility (v) Electrons (vi) Defect Electrons 15. To study the various characteristic of P-N junction. (i) Determination of the reverse saturation current Io and material constant ŋ. (ii) Determination of Temperature Coefficient of junction voltage and Energy Band gap.	9
Module 5: Electron associated various experiments.	16. To find out the value of e/m and study (i) Cathode Rays (ii) Lorentz force (iii) Electron in crossed fields (iv) Electron Mass (v) Electron charge 17. To determine the Electron spin resonance and study i. Zeeman effect (ii) Energy quantum (iii) Quantum number (iv) Resonance (v) G-factor (vi) Lande factor 18. To study Frank – Hertz experiment with Hg – tube and determine i. Energy quantum (ii) Electron collision frequency (iii) Excitation energy 19. To study superconductivity in solids and determine	12

i. Meissner-Ochesenfeld effect (ii) Measure the transition temperature of high temperature superconductor.

References:

R1. General Physics Manual for M.Sc. Physics.
R2. Advanced Practical Physics, B. L. Worsnop and H. T. Flint, Pub. Methuen & Co, Ltd., London

DEPARTMENT OF PHYSICS

PH506A4 **Credit: 3 (L-0, T-0, P-6)**

PHYSICS LAB – II (PHOTONICS & SPECTROSCOPY)

Max Marks: 100

There will be **TWO** laboratory class of 3 hours duration per week. There are **13 weeks** expected in a semester.

Note: Minimum of **TWELVE** experiments to be completed from all **FIVE** modules, at least two experiments from each module**.**

Objectives: The Physics Lab-II paper is designed to cover the areas of laser optics and study the effects of light on some materials. The students will be able to get a first-hand experience in the field of photonics and appreciate the various spectroscopic effects which are covered in the lectures of the program. It will also enable the students to apply analytical techniques, statistical analysis and graphical analysis to the experiments.

Prerequisites: The students must have completed a course of Modern Physics in the B. Sc. Program so that they have a preliminary knowledge of the basic principles of lasers, optics, fiber optics and spectroscopy.

Course Outcomes: After completion of the complete syllabus, the students will be able to do following:

CO1. Implement the working principle of optoelectronic devices.
CO2. Understand the phenomena of photoelectric effect and find Planck's constant.
CO3. Analyse the properties of lasers, optical fiber and some select materials.
CO4. Understand the principle of interference, diffraction and polarization through experimentation.
CO5. Analyse the spectrum of some atomic systems.

Module	**Topics**	**Hrs.**
Module 1: Optoelectronic Devices	1. To study the solar cell characteristics. 2. (i) To design a simple solar thermal system. (ii) To calculate effective power and collector efficiency. (iii) To study the effect of angle of incidence and irradiation intensity on effective power. 3. To study the characteristics of opto-electronic devices: (i) Light Emitting Diode (LED). (ii) Photo Diode. (iii) Photo Transistor. (iv)Light Dependent Resistor (LDR).	**3 hrs. each**
Module 2: Planck's	4. To determine Planck's constant '*h*' by measuring the radiation in a fixed spectral range.	**3 hrs. each**

consant	5. (i) To measure the absorption coefficient of laser light (6328Å) through the filters of different colours. (ii) To study the photo cell characteristics. (iii) To determine the value of Planck's constant '*h*' by Photo cell.	
Module 3: Study of laser beam, optical fiber and material properties	6. To study the laser beam characteristics: (i) To measure the divergence of the laser beam by the sized spots. (ii) To measure the divergence of laser beam by lens. (iii) To measure the beam diameter. (iv) To study the intensity distribution of laser beam. 7. To study the optical fiber characteristic: (i) To measure the numerical aperture of an optical fiber. (ii) To measure the attenuation or propagation loss in an optical fiber. 8. To study the material properties: (i) To determine of optical rotation of quartz disc. (ii) To examine of optic axis of lithium niobate disc. (iii) To demonstrate the homogeneity of a rod of transparent material. (iv) To observe the strain in glass by using cross polarizer.	**3 hrs. each**
Module 4: Optics	8. To measure the wavelength of He-Ne laser beam using Fresnel Biprism. 9. (i) To determine the wavelength of the laser light by using transmission grating and the number of lines in transmission grating. (ii) To determine the particle size by diode laser. 11. To measure the Brewster angle of a glass plate and hence the refractive index of the glass. 10. To measure the thermal expansion coefficient of Quartz crystal (rod) using Michelson interferometer. 11. To study the Nature of Polarization of Laser Light using Photocell and Quarter wave plate.	**3 hrs. each**
Module 5: Spectroscopy	12. To study Zeeman Effect. 13. To study Hydrogen spectrum and determine Rydberg's constant. 14. To study fine structure of one-electron and two-electron spectra. (i) To calibrate spectrometer using He-spectrum and determination of grating element. (ii) To determine spectrum of Na (iii) To determine fine structure splitting (iv) To determine the most intense spectral lines of Hg, Cd and Zn. 15. To study Gamma ray –spectroscopy for (i) detecting gamma radiation with scintillation counter (ii) Recording and callibrating gamma ray spectrum (iii) Absorption of gamma rays.	**3 hrs. each**

References:

R1. Optics: Ajoy Ghatak, Tata McGraw Hill Education

R2. An Introduction to Fiber Optics: Ajoy Ghatak, K. Thyagarajan, Cambridge University Press

R3. Laser and Non Linear Optics, B. B. Laud, Wiley Eastern Limited

R4. Basic Electronics: Devices, Circuits and its Fundamentals: Santiram Kal, PHI Learning Pvt. Ltd.

M. Sc. (Physics)

2^{nd} SEMESTER

DEPARTMENT OF PHYSICS

PH511A1 **Credit: 4 (L-3, T-1, P-0)**

CLASSICAL & RELATIVISTIC ELECTRODYNAMICS

Questions to be set: 05(All Compulsory)

Course Objectives: The course focuses at developing the basic knowledge of electrodynamics in physics. It gives a understanding of fundamental principle and laws of electromagnetism to pursue research work in future that take into account electromagnetic propagation and radiation effects. Also it will get the students ready for advanced courses both theoretical and application oriented.

Pre-requisites: Student should have the basic knowledge of electric field and magnetic field. Student should have the basic knowledge of mathematics. They should have also done a course in mathematics involving calculus, simple differential equations, algebra, elementary number theory and trigonometry. A proper understanding of vector calculus is desired.

Course Outcomes: Upon successful completion of this course, students should be able to do following:

- CO1. Enhance the knowledge of electric and magnetic fields.
- CO2. Understand the motion of charged particle in presence of various combination of non-uniform electric and magnetic fields.
- CO3. Understand propagation of electromagnetic waves through bound systems like wave guide and transmission line.
- CO4. Understand the theory of radiation by point charge/dipoles.
- CO5. Understand the relativistic formulation of electrodynamics.
- CO6. Understand the theory of scattering process of electromagnetic waves by free or bound charge.

Module	Topics	Hrs
Module 1: Electric and Magnetic field	Bound charge and current. Maxwell's equation in free space and inside matter, boundary conditions. Electromagnetic energy. Scalar and vector potential, Gauge transformation. Poynting's theorem, Maxwell's stress tensor, conservation of momentum. Propagation and attenuation of electromagnetic wave in a conductor.	9
Module 2: Charged particle dynamics in electromagnetic fields:	Charged particle motion in uniform electric and magnetic fields. Particle drifts in non-uniform static electric and magnetic fields. Adiabatic invariance of magnetic moment of a charged particle	5
Module 3: Wave guide and	Wave guide, rectangular and spherical wave guide, TE, TM, and TEM modes. Transmission line, equations of	8

transmission line:	transmission line, characteristic impedance, impedance matching, SWR, power, Introduction to dielectric wave guides.	
Module 4: Electromagnetic Radiation	Retarded potentials, radiation form an oscillating electric and magnetic dipoles, radiation from an arbitrary distribution of charges, Lienard-Wiechert potential, fields of a point charge in motion, power radiated by a point charge, radiation reaction.	10
Module 5: Relativistic Electrodynamics	Review of special theory of relativity, magnetism as a relativistic phenomenon, electromagnetic field transformation, field tensor, electrodynamics in tensor notation, potential formulation of relativistic electrodynamics	8
Module 6: Scattering and Dispersion	Scattering of radiation by free charge, scattering of radiation by bound charge, dispersion in dilute gases, dispersion in liquids and solids.	4

Text Book:

T1. Introduction to Electrodynamics, D.J Griffith (2nd Edition), Prentice Hall of India Pvt. Ltd. 1991

T2. Elements of electromagnetic, M.N.O Sadiku, Oxford University Press. 1990

T3. Electromagnetic, B.B Laud (3rd Edition), New Age Int. Publications. 2011

T4. Optoelectronics and introduction, John Wilson and John Hawkes, 3rd edn. Prentice Hall.

Reference Books:

R1. Classical Electrodynamics, J.D Jackson (2nd Edition), Willey Estern Ltd. 1975

R2. Electromagnetic with applications, Kraus & Fleisch, McGraw-Hill International.

R3. Classical theory of fields, Landau & Lifshitz, Pergamon press – Butterworth-Heinemann.

R4. The special theory of relativity, S. Banerje and A. Banerji, PHI, 2010

R5. The Feynman Lectures on Physics, Vol-II, Indian print, Pearson.

DEPARTMENT OF PHYSICS

PH512A1 **Credit: 4 (L-3, T-1, P-0)**

CONDENSED MATTER PHYSICS

Question to be set: 05 (All Compulsory)

Objectives: The course focuses at developing the basic knowledge of condensed matter physics. It give a preliminary idea about the conduction in metals, crystal structure and thermal properties of solids in its unit – I. In unit-II it gives the fundamentals of dielectric properties and magnetic properties of materials along with the introduction of superconductivity and nano-materials. This course also emphasize in developing problem solving skills in related topics of it.

Prerequisites: St5udent should have the basic knowledge of solid state physics. Student should have the basic knowledge of mathematics the laws of physics in different areas of physics like waves, geometrical optics, atomic physics, states of matter and basic laws of heat and thermodynamics. They should have also done a course in mathematics involving calculus, simple differential equations, algebra, elementary number theory and trigonometry.

Course Outcomes: Upon successful completion of this course, students should be able to do following:

- CO1. Understand the conduction process in metals and energy the band gap.
- CO2. Understand, analyze, and calculate the lattice structure, different factor eg. miller indices, diffraction angle etc. of different solids.
- CO3. Understand the theory of vibration of lattice in a solid.
- CO4. Understand the thermal and dielectric properties for different solids
- CO5. Understand the theory for different magnetic materials and calculate different parameters related to magnetic properties of solids.
- CO6. Understand the theory for superconductivity and nanostructures.

Module	**Topics**	**Hrs.**
Module 1: Conduction in Metals	A simple model of a conductor, Energy distribution of electrons in a metal, The Fermi level in a metal, Conduction processes in metals, The Drude Lorentz theory, Allowed energy bands of electrons in solids.	4
Module 2: Crystal Structure	Lattice, basis and unit cell, crystal system, Point group and symmetry, centered lattices, Miller indices, Bragg and Laue's Treatment, reciprocal lattices, atomic and geometrical factor, experimental methods of X-ray diffraction.	8
Module 3: Lattice Dynamics	Elastic vibrations in one-dimensional homogeneous line, one-dimensional line of atoms and the vibrational modes, the linear	4

	diatomic lattice.	
Module 4: Thermal Properties of Solids	Lattice specific heat- Classical theory, Einstein's Theory, Debye Theory and Born's Modification, Thermal conductivity, mean free path of phonons, thermal expansion and Gruneisen relation.	6
Module 5: Dielectric Properties of Insulators	Polarization, Microscopic models of polarization processes, the internal field in solids and liquids, the relationship between polarizability and permittivity, the relative permittivity of polar materials, Ferroelectrics, Piezoelectric, Dielectric in Alternating fields, Complex permittivity of lossy dielectric, loss angle and loss tangent.	6
Module 6: Magnetic Properties of Materials	Magnetic permeability, Magnetization, Bohr Magnetron, Theory of diamagnetism, Langevin's theory of Para magnetism, Curie-Weiss theory, Ferromagnetism, Spontaneous magnetization of ferromagnetic materials, Weiss Hypothesis, Anti Ferromagnetism, Ferrimagnetism, Garnets, magnetic bubbles.	8
Module 7: Superconductivity:	Experimental facts, Theoretical approaches, Thermodynamics of superconductors, the two fluid model, London's equations, Brief idea of BCS Theory. Applications of superconductors.	6
Module 8: Nano Materials:	Introduction, nano challenges, science behind nanotechnology, applications of nanotechnology- Sensors, smart materials	4

Text Books:

T1. Introduction to Solid State Physics, C. Kittel, John Wiley and sons.
T2. Solid State Physics, S.O. Pillai, New Age International.
T3. Solid state Physics, A.J. Dekker, MacMillan.

Reference Books:

R1. Solid State Physics, A. Rao, Asiatech Publication.

DEPARTMENT OF PHYSICS

PH513A1 **Credit: 3 (L-3, T-0, P-0)**

COMPUTATIONAL PHYSICS-I

Question to be set: 05 (All Compulsory)

Objectives: The course focuses at developing the basic knowledge of computation in physics. It introduces the programming language C. The fundamental structures of the programming language and application of basic numerical methods for solving problems of physics will be emphasized. Overall the course aims at developing the programming skills and its application in physics that will be required for learning advanced computational physics.

Prerequisites: Student should have the basic knowledge of computer. A work experience with computer in any form like MS Word is expected. Student should have the basic knowledge of mathematics the laws of physics in different areas of physics like waves, geometrical optics, atomic physics, states of matter and basic laws of heat and thermodynamics. They should have also done a course in mathematics involving calculus, simple differential equations, algebra, elementary number theory and trigonometry.

Course Outcomes: After the completion of the complete syllabus, the student will be capable of the following:

- CO1. Develop the skill to write basic programs using C language.
- CO2. Understand the various conditional statements and loops, Arrays, Pointers, structures and Errors.
- CO3. Solve problems using loops and arrays in C.
- CO4. Solve nonlinear equation using C.
- CO5. Explain the interpolation and extrapolation techniques.
- CO6. Understand various curve fitting techniques.

Module	Topics	Hrs
Module 1: 'C' Fundamentals and **Data s**	Introduction to C programming language and Linux operating system. The 'C' character set, identifiers and keywords. Data types, Operators & Expressions: Arithmetic, relational and logical operators, increment and decrement operators, precedence & associativity of operators. Standard and formatted input-output.	5
Module 2: Flow of control and Functions	Statements and blocks, if-else, else-if, nested if-else, switch, ternary operator, unconditional and conditional looping, while loop, do-while loop, for loop, nested loop, break and continue statements, go to statements. Types, storage class, and recursive function, library functions, preprocessor, #include, #define directive.	8

Module 3: Arrays, Pointers, structures and Errors	One dimensional and two dimensional arrays. Its relation with functions, arrays and character strings, pointer arrays, concept of structure and its usages. Truncation and round-off errors, absolute and relative errors, floating point computations, accuracy and stability.	9
Module 4: Application of loops and arrays	plot of radioactive decay, standing waves, Van-der Waals relation, matrix multiplication, matrix transpose, Row-Column operations, Gram-Schmidt's process.	5
Module 5: Roots of equation	Bisection, successive approximation method, Newton-Raphson method, Solution of linear and quadratic equations, Leonard Jones potential, Morse potential, square well potential.	4
Module 6: Interpolation and extrapolation	Lagrange interpolation, Newton-Gregory interpolation, Application to Bessel function to find Airy pattern, Hall effect, population, thermal and electrical conductivity.	4
Module 7: Least square curve fitting	Linear, polynomial regression, fitting exponential, trigonometric functions, fit curves for acceleration due to gravity, fit to different experimental data from four probe, hall effect, I-V characteristics of resistance, diode, capacitor discharge.	5

TEXT BOOK:

T1. Programming in C by D. Ravichandran.
T2. Programming with 'C', Byron S. Gottfried, Schaum's outline series.
T3. A First Course In Computational Physics (Indian print) by Javier Hasbun, Paul Devries, 2nd edition, Jones and Bartlett Learning, Delhi
T4. Computational Physics, 2nd edition Nicholas J. Giordano, Hisao Nakanishi, Pearson

REFERENCES:

R1. Programming in 'C', Balguruswamy, Tata McGraw Hill publication.
R2. Computational Physics, Steven E Koonin and Dawn C. Meredith, Westview Press, Advanced Book Program, 1990.

DEPARTMENT OF PHYSICS

PH514A1 **Credit: 4 (L-3, T-1, P-0)**

QUNATUM MECHANICS-II

Question to be set: 05 (All Compulsory)

Objective: This course will help to develop appropriate competence and a working knowledge of quantum physics. It will also help the students to understand atomic and sub-atomic physics. Students develop the ability to identify and apply the appropriate analytic, numerical, computational, and other mathematical tools necessary to solve quantum problems. This course will also develop a familiarity with the current state of research in quantum physics, including the most significant research questions being pursued by today's physicists**.**

Prerequisites: Students should have the basic knowledge of Newtonian Mechanics, Lagrangian and Hamiltonian Mechanics Students should have the basic knowledge of mathematics involving Algebra, Integral and differential calculus, Simple Differential Equations, Linear Vector Space, Different Polynomials, Fourier Transformations, and Dirac Delta Function.

Course Outcome: After completion of the complete syllabus, the students will be able to

- CO1. Understand the different approximation methods like time independent perturbation method, time dependent perturbation method, WKB method and variational method.
- CO2. Apply different approximation methods to solve mathematical calculation on complex quantum systems.
- CO3. Understand Stark effect, Zeeman effect and different quantum mechanical phenomena.
- CO4. Develop the basic knowledge on scattering theory and relativistic quantum mechanics.
- CO5. Implement the relativistic and non-relativistic equations to solve atomic structural problems.

Module	Topics	Hrs
Module 1: Approximation Methods	Time-independent perturbation theory, Non-degenerate, Near degenerate and Degenerate perturbation, Hydrogen Atom & the Stark Effect, Zeeman effect, Ground state of Helium, Doubly degenerate level and Resonance, Fine structure of Hydrogen levels. Variational Method, applications of variational methods on different systems like Harmonic Oscillator, Hydrogen Atom, and Ground State of Helium Atom. WKB Approximation, Connection formulae, Bohr-Sommerfeld quantization condition and its application, Penetration of Barrier, Applications of Tunneling.	14

Module 2: Time-dependent Perturbation Theory	Interaction picture. Time-dependent perturbation theory. Constant and harmonic perturbations, Transition from discrete level to continuum, Fermi's Golden Rule, Ionization of Hydrogen, Adiabatic and sudden approximations. Dynamics of two-level systems – exact and approximate treatment.	8
Module 3: Scattering Theory	Quantum Theory of scattering, Resonance scattering, Inelastic scattering, Wave packet description of scattering, Generalized Optical theorem, Integral Equation for scattering, Green's function, Born approximation, Coulomb scattering, scattering of identical particles.	12
Module 4: Relativistic Quantum Mechanics	Relativistic 1-particle equations, Klein Gordon Equation, Motivation for Dirac equation, Continuity Equation, Dirac's Hole theory, Properties of Dirac matrices. Plane wave solutions of Dirac equation. Spin and magnetic moment of the electron, Non relativistic reduction of the Dirac equation, Spin-orbit coupling, Energy levels in a Coulomb field.	10

Text Book:

T1. Quantum Mechanics, A. Ghatak and S. Loknathan, Macmillan India Ltd
T2. Quantum Mechanics, Satya Prakash, Kedar Nath Ram Nath & Co
T3. Principles of Quantum Mechanics, P.A.M. Dirac, Oxford University Press

Reference Books:

R1. Quantum Mechanics, E. Merzbacher 3rd Edition, John Wiley & Sons, INC
R2. Quantum Mechanics An Introduction, W. Greiner, Springer –Verlag
R3. Quantum Mechanics, Mathews and Venkateshan
R4. Angular Momentum, M.E. Rose
R5. Quantum Mechanics, J.J. Sakurai
R6. Lectures on Quantum Mechanics, Ashok Das, Hindustan Book Agency
R7. Quantum Mechanics, Gupta, Kumar, Sharma, Jai Prakash Nath Publication
R8. The Feynman Lectures on Physics, Vol-III, Indian print, Pearson.

DEPARTMENT OF PHYSICS

PH515A4 **Credit: 3 (L-0, T-0, P-6)**

PHYSICS LAB III (ELECTRONICS)

Max Marks: 100

There will be **TWO** laboratory class of 3 hours duration per week. There are **13 weeks** expected in a semester.

Note: TWELVE experiments to be completed selecting at least one experiment from each **MODULE.**

Objectives: The objective of the lab being learning, the course has been designed such that the students are able to apply the scientific method to experiments in the laboratory and verify the theoretical ideas and concepts covered in lecture by completing a host of experiments. It will also enable the students to apply analytical techniques, statistical analysis and graphical analysis to the experiments. In this laboratory, the course emphasis is on the understanding of basic principles of electronics: characteristic properties for semiconductor diodes and their application in filter circuits, transistor, MOSFET, JFET,OP-AMP, multivibrator etc.

Prerequisites: The students should have completed a course of Physics at Degree level and thereby has an understanding of the basic principles of electronic circuits with the behavior of its various active and passive components.

Course Outcome: After completion of the complete syllabus, the students will be able to

CO1. Design circuits using diodes such as rectifiers and filters, clippers and clampers.
CO2. Design circuits using BJTs, JFETs and analyze the output characteristics curves.
CO3. Design of the analog circuits using OPAMP for various electronic applications analyze the output characteristics curves.
CO4. Design multivibrator circuits and analyze the output characteristics curves.
CO5. Able to identify and analyses basic digital electronics Circuits and its applications.

Module	**Topics**	**Hrs.**
Modile 1: Filters, Rectifiers, Clippers, Clampers, Amplifiers	1. Design of different rectifiers circuits with and without filters. 2. Study of clipper, clamper and voltage multipliers using diodes. 3. Design of Amplifiers using transistors and to study the frequency response.	3 Hrs each
Module2: IV characteristics	4. MOSFET Characteristics. 5. JFET Characteristics. 6. BJT characteristics. Determination of h-parameters in the CE configuration using the measured input and output characteristics of a BJT (e.g.2N 2218). 7. To design a circuit diagram and study the voltage gain, input impedance, and power gain of an emitter	3 Hrs. each

	follower.	
Module3: Multivibrators	8. Multivibrators – Bistable, Monostable and Free Running multivibrators using BJT's (e.g.2N 2218). 9. 555 IC timer. Free Running and Monostable Multivibrators, Sawtooth wave generator.	3 Hrs. each
Module4: Applications of OP-Amp	10. Verify the typical transfer characteristics of the OP-AMP both inverting and non-inverting configuration. 11. OP-AMP as Buffer amplifier (voltage follower). 12. Study differentiator and integrator using OP-AMPS. 13. Study the analog addition and subtraction using OP-AMPS. 14. To study OP-AMP as a function generator, i.e. as (a) square wave generator (b) triangular wave generator. 15. To construct a Wein-Bridge oscillator using OP-AMP and to study its output waveform and frequency for various RC values.	3 Hrs. each
Module 5: Digital electronics: Gates	16. To study the representation of basic logic gates: AND, OR, INVERT, NAND and NOR functions by truth tables, logic diagrams and Boolean algebra.	3 Hrs. each

References:

R1. Networks, Lines and Fields, J.D. Ryder, Prentice Hall.
R2. Digital Computer electronics – A. P. Malvino, Tata McGraw Hill
R3. Basic Electronics: Devices, Circuits & IT Fundamentals: Santiram Kal, Prentice Hall of India, May 2008.

DEPARTMENT OF PHYSICS

PH516A4 **Credit: 3 (L-0, T-0, P-6)**

PHYSICS LAB – IV (COMPUTATIONAL PHYSICS LAB-I)

Max Marks: 100

6 hours per week with 3 hours per lab. There are 13 weeks expected in a semester. Student should compulsory do exercises from both the section. Problem will be given by the teacher in-charge on the basis of the exercises mentioned in the syllabus.

Objectives: The course focuses at developing the basic knowledge of computation in physics. It introduces the programming language C. The fundamental structures of the programming language and application of basic numerical methods for solving problems of physics will be emphasized. Overall the course aims at developing the programming skills and its application in physics that will be required for learning advanced computational physics.

Prerequisites: Student should have the basic knowledge of computer. A work experience with computer in any form like MS Word is expected.

Course Outcomes: After the completion of the complete syllabus, the student will be capable of the following:

CO1. Understand the basic C programming techniques
CO2. Explain the usage of functions, arrays, pointers and stuctures.
CO3. Understand the different numerical root finding techniques.
CO4. Explain the procedure of interpolation and extrapolation in C.
CO5. Understand the numerical curve fitting techniques.

Module	Topics	Hrs.
Module 1: Simple Programs	Familiarization to Linux commands and Gnuplot. To find simple & compound interest, averaging, addition for equivalent resistance, capacitance, etc. Factorial of a number, solving algebraic equations, series summation. Evaluating and plot of radioactive decay, standing waves, Van-der Waals relation, Solving some simple physics/electronics problems. Problems based on understanding of various statements, macro substitution. Problems using various loops.	10
Module 2: Functions Arrays, Pointers and Structures	Programs for different types of function, programs using recursive functions. Sorting of arrays, manipulation of one and multidimensional arrays, programs for matrix multiplication, matrix transpose, Row-Column operations, Gram-Schmidt’s process. Simple problems using arrays to	10

	demonstrate its relation with function, mathematical operations of complex numbers and simple exercises. File opening and file closing.	
Module 3: Root Findings	Use of Bisection, successive approximation method, Newton-Raphson method, Solution of linear and quadratic equations, Leonard Jones potential, Morse potential, square well potential.	8
Module 4: Interpolation and Extrapolation	Lagrange interpolation, Newton-Gregory interpolation, Application to Bessel function to find Airy pattern, Hall effect, population, thermal and electrical conductivity	8
Module 5: Least Square Curve Fitting	Linear, polynomial regression, fitting exponential, trigonometric functions, fit curves for acceleration due to gravity, fit to different experimental data from four probe, Hall effect,, I-V characteristics of resistance, diode, capacitor discharge	4

TEXT BOOK:

T1. Programming in C by D. Ravichandran.
T2. Programming with 'C', Byron S. Gottfried, Schaum's outline series.
T3. A First Course In Computational Physics (Indian edition) by Javier Hasbun (Author), Paul Devries, 2nd edition, Jones and Bartlett Learning, Delhi
T4. Computational Physics, 2nd edition Nicholas J. Giordano (Author), Hisao Nakanishi, Pearson

REFERENCES:

R1. Programming in 'C', Balguruswamy, Tata McGraw Hill publication.
R2. Computational Physics, Steven E Koonin and Dawn C. Meredith, Westview Press, Advanced Book Program, 1990.

M. Sc. (Physics)

3rd SEMESTER

DEPARTMENT OF PHYSICS

PH601A1 **Credit: 4 (L-3, T-1, P-0)**

STATISTICAL MECHANICS

Question to be set: 05 (All Compulsory)

Objectives: This course begins with introduction to statistical physics and lays the foundation for the advanced statistical mechanics. The basic of statistical mechanics is introduced and a thorough study of the classical statistical mechanics is given. The application of the classical theory will be covered in detail. The short comings of the classical theory are discussed and Quantum statistical mechanics is introduced. The application of quantum statistical mechanics to understand the thermodynamics of various physical phenomena will be covered. The foundation for advanced statistical mechanics will be introduced.

Prerequisites: Student should have the basic knowledge of UG level thermodynamics taught at B.Sc. (Hons) Physics. They should have adequate knowledge of mathematical methods of advanced differential and integral calculus, algebra and probability.

Course Outcomes: After the completion of the complete syllabus, the student will be capable of the following
:

CO1. Develop understanding of correlation between the macroscopic thermodynamics of a system with the microscopic dynamics of constituents.
CO2. Understand the different kinds of statistical systems.
CO3. Understand the basics of quantum statistics.
CO4. Explains the basics of ideal Bose and Fermi gas.
CO5. Explain the classical and modern theories of phase transitions.

Module	Topics	Hrs
Module 1: Introduction to Statistical Physics	Introduction to Statistical Physics, Random Walk and probability distribution, Microscopic and macroscopic states, Phase space, Liouville's equation, Erdogic hypothesis.	4
Module 2: Classical Ensemble Theory	Micro-canonical, canonical and grand-canonical ensembles, connection with thermodynamics, fluctuations, Boltzmann relation for entropy. application to ideal gas, solid of Einstein and Boltzmann gas, Application to classical system of interacting particles and monoatomic ideal gas.	9
Module 3: Quantum Ensemble Theory	Density operator, Quantum Liouville's equation. Density operator for equilibrium micro-canonical, canonical and grand canonical ensembles. Calculation of grand partition function and distribution function, Electron in a	6

	magnetic field, free particle in a box.	
Module 4: Introductory Quantum Statistics	System of indistinguishable particles, Wave function representation of indistinguishable particles, Bose-Einstein statistics, Fermi-Dirac statistics and Classical limit.	3
Module 5: Ideal Fermi Gas	Fermi-Dirac distribution, FD function, completely degenerate ideal Fermi gas, Fermi pressure, Fermi temperature, degenerate ideal Fermi gas, specific heat, Pauli paramagnetism.	6
Module 6: Ideal Bose Gas	Bose-Einstein distribution Bose-Einstein condensation, free bosons in the normal region and its thermodynamics, Elementary excitations in Liquid Helium**.**	6
Module 7: Introduction to Phase Transitions	Simple fluids and order parameter, Vander Waals equation, Curie-Weiss phenomenological model, Landau's theory. Critical exponents, Scale invariance, Critical dimensionality. Concept of universality of phase transitions. Ising One-dim model and Heisenberg models, Bethe approximation, Introduction to irreversible processes and their applications.	10

Text Books:

T1. Introduction to Statistical Physics, Silvio R.A. Salinas, Springer.
T2. Statistical Mechanics, R.K. Pathria, B.H.Publication

References:

R1. Statistical Physics, Landau & Liftsutz
R2. Statistical Physics, Berkeley Physics course
R3. Statistical Mechanics, K. Huang, Wiley Eastern Pub
R4. Statistical and Thermal Physics, Reif, Mc Graw Hill
R5. Fundamentals of Statistical Mechanics by BB Laud, New Age International
R6. Introduction to Statistical Mechanics, Rogev Bowling & Mariana Sanchez, Oxford Sc.

DEPARTMENT OF PHYSICS

PH602A1 **Credit: 4 (L-3, T-1, P-0)**

NUCLEAR AND PARTICLE PHYSICS

Question to be set: 05 (All Compulsory)

Course Objectives: The course focuses at developing the basic knowledge of nuclear and particle physics, aspiring to pursue a carrier in physics. The main emphasis has been the field of low energy nuclear physics, the basic discussion on elementary particles is also highlighted. Overall, the course aims at developing the basic knowledge and numerical proficiency that will be required for learning nuclear physics.

Prerequisites: Student should have the basic knowledge of nuclear physics at undergraduate level. They should have also done a course in mathematics involving calculus, simple differential equations, algebra, elementary number theory and other common mathematical operations. Basic knowledge of quantum physics is essential.

Course Outcomes (CO): After the completion of the complete syllabus, the student will be capable of the following:

- CO1. Understand the ground state properties of the nucleus.
- CO2. Explain about nuclear forces and their dependence on various parameters.
- CO3. Establish the need for various nuclear models and deduce properties of the nucleus from the models.
- CO4. Explain the nuclear interaction and mechanism of nuclear reactions.
- CO5. Implement the basic knowledge of particle physics.

MODULE	Topics to be covered	Hrs.
MODULE 1: Static properties of Nuclei	Nuclear mass & binding energy, nuclear size and its determination from electron scattering, nuclear form-factors. Nuclear magnetic and electric moments. Angular momentum of the nucleus, spin and moments of nuclei.	6
MODULE 2: Nuclear forces and two Nucleon system	Ground state of deuteron, Low energy neutron-proton scattering, spin dependence of n-p scattering, Non-central forces, S-wave effective range theory. Qualitative discussion on Proton-proton scattering, Evidence for hardcore potential.	7
MODULE 3: Nuclear Models	Liquid Drop Model, The Shell Model, Nilsson's Unified Model.	8
MODULE 4: Nuclear Decays	Gamow's theory of alpha decay, alpha ray energies and fine structure of alpha rays, decay schemes, Fermi theory of beta decay, Kurie plot. Fermi and Gamow-Teller transitions. Parity	8

	violation in beta-decay, Electromagnetic decays: Selection rules, Electromagnetic interaction with nuclei.	
MODULE 5: Nuclear Reactions	Conservation laws, reaction energetics, relativistic and non-relativistic Q- value equation,Induced radioactivity, cross-section of nuclear reactions (theoretical considerations) theories of nuclear reaction, Breit Wigner formula.	7
MODULE 6: Elementary Particles	Classification of fundamental forces, Spin and parity assignments, isospin, strangeness; Gell-Mann-Nishijima formula; C, P, and T invariance and applications of symmetry arguments to particle reactions, Properties of quarks and their classification. Elementary ideas of SU (2) and SU (3) symmetry groups and hadron classification. Introduction to the standard model. Electroweak interaction-W & Z Bosons**.**	6

Text Books:

T1. Nuclear Physics, S.N. Ghoshal, S. Chand and Company.
T2. Nuclear Physics, D.C. Tayal, Himalaya Publishing House.

References:

R1. Nuclear Physics by I. Kaplan, Narosa.
R2. Nuclear Physics by RR Roy and BP Nigam, Wiley Eastern Ltd.
R3. Introductory Nuclear Physics, Kenneth S. Krane, Wiley India Pvt. Ltd.

DEPARTMENT OF PHYSICS

PH603A1 **Credit: 3 (L-3, T-0, P-0)**

COMPUTATIONAL PHYSICS-II

Question to be set: 05 (All Compulsory)

Objectives: The course focuses at developing the basic knowledge of solving mathematical problems numerically which cannot be solved using analytical methods. This subject also is intended to develop the skill to formulate algorithms to solve problems using computers.

Prerequisites: Basic knowledge of mathematics at undergraduate level is essential. Knowledge of differentiation, integration, ordinary and partial differential equation, matrices, infinite series etc. is necessary.

Learning Outcomes: After the completion of the complete syllabus, the student will be capable of the following:

- CO1. Develop the skill of numerically solving Simultaneous linear equations.
- CO2. Able to solve numerically differentiation and integration.
- CO3. Able to solve numerical problems related to ODE.
- CO4. Able to solve numerical problems related to PDE.
- CO5. Develop the skill to formulate algorithms to generate random numbers by different techniques.
- CO6. Understand the numerical process using Monte Carlo method and the basic concept of parallel computing.

Module	Topics	Hrs.
Module 1: (Simultaneous linear equation:)	Gauss elimination method, iterative method, Application to solve simultaneous linear equations, matrix inversion, eigen vectors, eigen values. Application to solve simultaneous matrix inversion	4
Module 2: (Numerical differentiation And Numerical Integration:)	Newton's forward and backward formula, Newton-Gregory formula, Central difference method. Applications to mathematical functions, equations, Trapezoidal rule, Simpson's 1/3 and 3/8 rule, Application to surface integration, volume integration, Applications evaluation of speed, acceleration, force, fields. Fourier Analysis, specific heat, potential and fields.	11
Module 3: (Solution of	Taylor series method, 4^{th} order Runge-Kutta method, Predictor-corrector, leap frog method, Applications to	7

O.D.E:)	different types of oscillations, Projectile motions, Nonlinear In Class motions, chaos, quantum mechanics Applications Nonlinear Class motions, chaos, quantum mechanics	
Module 4: (Solution of P.D.E:)	Difference method, accuracy, stability, Lax method, Two-step Lax-Wendroff method, FTCS application to wave equation, Adective equation, Diffusion equation, Poisson equation. Fast Fourier transforms	12
Module 5: (Random numbers: Monte Carlo Techniques: Parallel Computation:)	Properties of random numbers, generation of random numbers. Introduction, Monte Carlo Evaluation of integrals, area of circle, ellipse, volume of sphere, ellipsoidal, Use of Monte Carlo technique in statistical Physics. Introduction, different advantages over serial computation, introduction to parallel computing methods, introduction to applications.	10

Text Books:

T1. Computer oriented numerical methods, V. Rajaraman, PHI
T2. A First Course In Computational Physics (Indian edition) by Javier Hasbun (Author), Paul Devries, 2nd edition, Jones and Bartlett Learning, Delhi
T3. Computational Physics, 2nd edition Nicholas J. Giordano (Author), Hisao Nakanishi, Pearson
T4. Parallel Computing, 2008, Moreshwar R. Bhujade, New Age International.
T5. Explorations in Monte Carlo Methods, 2009, by Ronald W. Shonkwiler (Author), Franklin Mendivil, Springer

References:

R1. Numerical Analysis, S. S. Sastry, PHI
R2. Numerical Recepies in C, W.H Press, S.A. Tenkolsky, W.Vetterling and B.P Flannery, Cambridge University Press
R3. Numerical Methods for Physics, 2nd Edition, Alejandro Garcia, Prentice Hall
R4. Computational Physics, Steven E. Koonin and Dawn C. Meredith, 1990 ABP (West View Press)
R5. An Introduction to Parallel Computing: Design and Analysis of Algorithms, 2nd Edn, by Grama, Pearson
R6. Monte Carlo Simulation in Statistical Physics: An Introduction, 5th Edn. Kurt Binder, Dieter W. Heermann, Springer.
R7. Introduction to Monte Carlo Methods, https://arxiv.org/pdf/0905.1629.pdf
R8. Monte Carlo Methods in Statistical Physics 1st Edition, M. E. J. Newman (Author), G. T. Barkema, OUP

DEPARTMENT OF PHYSICS

PH604A3 **Credit: 4 (L-3, T-1, P-0)**

PARTICLE PHYSICS I (ELECTIVES-I)

Question to be set: 05 (All Compulsory)

Objectives: The course focuses at developing the basic knowledge of Particle Physics and Quantum Field Theory. It helps students to understand the basic constituents of all the matters in the Universe and the interaction among themselves.

Prerequisites: Knowledge in Quantum Mechanic-I (Non-relativistic), Quantum Mechanics-II (Relativistic), Classical Mechanics, Classical electrodynamics, Mathematical Methods in Physics are essential.

Course Outcomes: After the completion of the complete syllabus, the student will be capable of the following:

- CO1. Explain fundamental constituents of matter.
- CO2. Explain fundamental interactions among the elementary particles.
- CO3. Apply the advanced quantum mechanics to explain the various processes in particle physics.
- CO4. Understand the field theory and its application to various physical processes.
- CO5. Apply concept of symmetry to explain different aspect of various physical processes

Module	Topics	Hrs.
Module-1: Introduction to Particle Physics	A preview of Particle Physics, Introduction to elementary particles, Nature of interactions, Characteristic lifetimes and strengths, The Eightfold way, Quark Model, Cosmology and particle physics.	12
Module-2: Relativistic Dynamics and Introduction to Field Theory	Review of Relativistic Quantum Mechanics, Elementary Particle Dynamics, Scalar, Dirac, Electromagnetic fields, invariance principles, Lorentz invariance of free fields, Quantization of free fields.	12
Module-3: Symmetries and Conservation law	Symmetries, Noether's theorem and its applications Groups and Conservation laws, Conservation laws in Quantum Mechanics, Symmetry and degeneracy.	6

Module-4: Discrete Symmetry	Parity, Charge Conjugation and time Reversal, CPT-theorem, CP violation, Properties of Bilinear covariants under C, P, T.	8
Module-5: Continues Symmetry & Quark model	Unitary Symmetry, SU (2) of spin, SU (3) of flavour and SU (6) Groups, Isospin, G-parity, Strange particles (Gell-Mann Nishijima Scheme), Quark Model of Hadrons.	6

Text Books:

T1. Introduction to High Energy Physics, D. H. Perkins
T2. Introduction to Particle Physics, Griffith , Wiley
T3. Quarks and Leptons, Halzen &Martin, Wiley

References:

R1. Introduction to Particle Physics, W. S. C. Williums
R2. Quantum Field Theory, Mandl & Shaw, John Wiley & Sons

DEPARTMENT OF PHYSICS

PH605A3 **Credit: 4 (L-3, T-1, P-0)**

PLASMA PHYSICS-I (ELECTIVE I)

Question to be set: 05 (All Compulsory)

Objectives: The course is focused on realization of new state of matter which is plasma. It gives idea of interdisciplinary subject.

Prerequisites: Students should have the basic knowledge of gas, solid and liquid state of matter. The wave nature and its propagation in the medium.

Course Outcomes: After the completion of the complete syllabus, the student will be capable of the following:

CO1. Understand the basic concept of phases of matter.
CO2. Understand the mode study in any medium.
CO3. Understand the stability and instability of a system.
CO4. Apply the Fourier method to solve problems in Plasma Physics.

Module	Topics	Hrs.
Module 1: Introduction	Definition of plasma, Debye shielding, plasma parameters, criteria for plasma.	3
Module 2: Single particle motions	Review for non-uniform E and B fields. Motion in time varying E field, time varying B field	4
Module 3: Fluid model of plasma	Concept of fluid element, fluid equations, Fluid drift perpendicular to B and parallel to B, plasma approximation.	3
Module 4: Linear Waves in plasmas	Plasma oscillation, electron plasma wave, ion waves, electrostatic and e-m waves without/with magnetic field. Hydromagnetic waves, Magnetosonic waves and Alfven waves.	13
Module 5: Plasma Diffusion	Ambipolar, resistivity, MHD equations. Generalized Ohm's law, classical and Bohm diffusions	5
Module 6:	Statistical description of plasma, Boltzmann-Vlasov	6

Kinetic theory of plasma	equation. Boltzmann and Landau collision integral, Fokker-Plank term. Solution of Boltzmann equation. Landau damping**.**	
Module 7: Stability of plasma	Classification of plasma instabilities. Methods of stability analysis, Two-stream instability. Gravitational instability. Rayleigh-Tayler and Kelvin Helmholtz instabilities. Pinch and Kink instabilities**.**	9

Text Books:

T1. Introduction to plasma physics and controlled fusion, F.F. Chen, Second edition, Plenum Press.

T2. Principles of plasma physics, N.A. Krall and A.W. Trivelpiece, McGraw Hill, (1973).

T3. Plasma Kinetic Theory, D.C. Montgomery and D.A. Tidman, McGraw Hill (1964).

References:

R1. The Theory of plasma Waves, T.H. Stix, McGraw Hill (1962).

R2. Introduction to unmagnetized plasma, C. Uberoi, PHI (1988).

DEPARTMENT OF PHYSICS

PH606A3 **Credit: 4 (L-3, T-1, P-0)**

ELECTRONICS-I (ELECTIVE-II)

Question to be set: 05 (All Compulsory)

Course Objectives: The course focuses at developing the basic knowledge of Very –Large-Scale integration (VLSI) technology. It gives a preliminary idea about the fabrication of integrated circuits(IC) and materializes the circuit design along with the requirement of miniaturization. It also introduces two unparalleled examples of ICs, Op-Amp and Microprocessor. The characteristics of Op-Amp and its use in analog circuits for different applications have been emphasized. The basic architecture of 8085, the associated programming language and its use in solving problems of real life applications will also be discussed. The 8086 microprocessor-Architecture, Pin details, memory segmentation, addressing modes, basic instructions, interrupts have been emphasized.

Pre-requisites: Students should have the basic knowledge of physics of semiconductor devices. Students should understand the operation of analog circuits containing active and passive components. They should have also done a course in mathematics involving calculus, simple differential equations, algebra and elementary number theory.

Course outcomes (CO): Upon successful completion of this course, students should be able to

CO1. Understand the basic knowledge about the VLSI based devices fabrication processes.
CO2. Understand the various operations like stick and layout diagrams of VLSI.
CO3. Apply the Designing process of the analog circuits using OPAMP for various real life applications.
CO4. Understand the basic architecture and various data transfer schemes of 8085 and 8086 microprocessor.
CO5. Implement the acquired knowledge skill in simple program writing for INTEL 8085.

Module	Topics	Hrs.
Module 1: Integrated Circuit Fabrication	The monolithic integrated circuit technology, the planar processes, Bipolar transistor fabrication, fabrication of FET, CMOS technology, monolithic diodes; integrated-circuit resistors, capacitor and packaging; characteristics of IC components, microelectronic circuit layout.	7

Module 2: CMOS fabrication and MOS and BIMOS circuit design processes	p and n well processes, twin tub process, thermal aspects, Bi-CMOS technology, and production of E-beam masks. MOS layers, stick diagram, design rule and layouts, a brief introduction of layout diagrams.	7
Module 3: Basic Circuit Concepts and Scaling of MOS circuits	Sheet resistance, area capacitance of layers, standard unit of capacitance, delay unit, inverter delays, driving large capacitive loads, propagation delays, wiring capacitance, choice of layers. Scaling models and scaling factors. Scaling factors for device parameters. Limitations of scaling.	8
Module 4: Applications of Op-Amp	V to I and I to V converter, Log, anti-log amp. Comparator, square and triangular wave generator, V/F and F/V converter. Schmitt trigger, R-2R ladder D/A converter, RC phase shift and Wein Bridge oscillator.	3
Module 5: Introduction to8085and 8086 Microprocessor Architecture and Interfacing devices	8085 CPU Architecture, register organization, Memory Interfacing, 8085 instructions set, addressing modes, programming using 8085 instructions set, instruction cycle, machine cycles, timing diagrams. Basic Interfacing concepts, interfacing output displays, Input devices memory mapped I/O, Tristate devices, buffers, latches. Intel 8086/8088 Microprocessors Architecture, organization and Addressing Modes- Instruction set.	19

Text books:

T1. Basic VLSI design by Douglas A. Puncknell and Kamran Eshragjhian, PHI Learning Pvt. Ltd.

T2. Linear Integrated Circuits by S Salivahanan and V S Kanchana Bhaaskaran, McGraw-Hill Education.

T3. Microprocessor Architecture, Programming and Applications with the 8085—Ramesh S. Gaonkar, Penram International Publishing (India).

Reference Books:

R1. Microelectronics by Jacob Millman and Arvin Grabel, Mcgraw-Hill College; 2 Sub edition (1987).

R2. Microelectronic Circuits by Sedra and Smith Oxford Series..

R3. Microprocessor 8085 and its interfacing by Sunil Mathur , 2nd Edition, PHI Learning Pvt. Ltd.

R4. Op-Amps and Linear Integrated Circuits, Ramakant A. Gayakwad, Fourth Edition , Prentice Hall India Learning Private Limited

DEPARTMENT OF PHYSICS

PH607A3 **Credit: 4 (L-3, T-1, P-0)**

ELECTRONICS LAB-I (ELECTIVE-II)

Max Marks: 100

Note: 6 hours per week with 3 hours per lab. There are 13 weeks expected in a semester. Student should compulsory do exercises from both the section.

Note: Minimum of **TWELVE** experiments to be completed covering FIVE Modules**.**

Objectives: The objective of module 1 to 4 is to build simple OPAMP circuits to examine some of the basic characteristics and compare observed behavior with the theoretical one. Afterwards application of OPAMP will be studied to perform specific operations e.g. data conversion, solving of equation etc. The objective of module 5 is to introduce the assembly language program of 8085. Employing commonly used instructions elementary programming technique and their applications will be explored.

Prerequisites: Students should understand the operation of analog circuits containing active and passive components. They must know the basic architecture of 8085, specially the programing registers. They should have a clear understanding about the decimal, binary and hexadecimal number systems.

Course Outcomes:

After the completion of the course, student will be capable of the following:

CO1. Analyze the IC 741 operational amplifier and its characteristics.
CO2. Design the solution for linear & non-linear applications using IC741.
CO3. Analyze the working principle of various data converters.
CO4. Implement basic programs on 8085 microprocessors.
CO5. Understand the concepts related to I/O and memory interfacing.

Module	Topics	Hrs.
Module 1: Wave generator using IC741	1. To study the performance of the Schmitt trigger using Op-amp. 2. To construct and study triangular and square wave generator using Op-amp and related circuit elements	6

Module 2: Phase shifter phase shift Oscillator, I/V and V/I converter using IC741	3. Frequency response of the amplifier in the inverting configuration and study the phase shift with frequency. 4. Design and construct of RC phase shift oscillator using OP-AMP. 5. Design and construct current to voltage converter using OP-AMP. 6. Design and construct voltage to current converter using OP-AMP.	9
Module 3: Data converter using IC741	7. Design and construct the A/D converter using OP-AMP. 8. Design and construct the D/A converter using OP-AMP.	6
Module 4: Different linear equation solved using IC741	9. Find log and antilog of a given number using OP-AMP. 10. Solve two simultaneous equations using OP-AMP.	6
Module 5: Basic Program using 8085 microprocessor	11. Addition of two 8 bit numbers. 12. Subtraction of two 8 bit numbers. 13. Addition of two 16 bit numbers. 14. Subtraction of two 16 bit numbers. 15. Multiplication of two 8 bit numbers. 16. Division of two 8 bit numbers. 17. Multiplication of two 16 bit numbers. 18. Division of two 16 bit numbers. 19. Selection of the largest number from an array of numbers. 20. Selection of the smallest number from an array of numbers. 21. Find the square of a given number. 22. Find the square root of a given number.	15

Text Books:

T1. Practical Physics, Rakshit and Chattopadhay.
T2. 8085 Microprocessor, Gaonkar , Penram International

Reference Books:

R1. Microprocessors-Interfacing and applications, Renu Singh and B.P.Singh, New Age.
R2. Laboratory Manual for Op-amp and Linear ICs.

M. Sc. (Physics)

4^{th} SEMESTER

DEPARTMENT OF PHYSICS

PH611A1 **Credit: 4 (L-3, T-1, P-0)**

ATOMIC AND MOLECULAR PHYSICS

Question to be set: 05 (All Compulsory)

Course Objectives: The course focuses to develop the basic knowledge in atomic and molecular physics to an advanced level. This subject also is intended to explain the molecular spectra and principle of non-linear optics. The course develops the applicability of quantum mechanics in atomic systems.

Pre-requisites: Students should have the knowledge of basic quantum mechanics and techniques, including the treatment of angular momentum, perturbation theory, solution for the Schrodinger equation of the Hydrogen atom.

Course outcomes (CO): Upon successful completion of this course, students should be able to

- CO1. Determine the origin and nature of the fine structure of the spectrum of hydrogen –like atoms.
- CO2. Explain the build-up of multielectron atoms and the concept of *L-S* coupling, *j-j* coupling to derive the atomic terms.
- CO3. Determine the molecular structure, symmetry and energies of diatomic molecules.
- CO4. Apply molecular spectroscopy and resonance spectroscopic techniques to elucidate the molecular structure.
- CO5. Understand the phenomena of non-linear optics and application of laser optics.

MODULE	Topics to be covered	Hrs
MODULE 1: Atomic Physics	Fine structure of hydrogenic atoms, Mass correction, spin-orbit term, Darwin term. Intensity of fine structure lines. Lamb shift, Magnetic dipole hyperfine structure, energy shift, hyperfine transition on Hydrogen, Isotope shift (Qualitative discussion only) The idea of Hartee-Fock equations. Many electron atoms-LS and jj coupling schemes, Lande interval rule, Hund's rule. Electron spin resonance. Nuclear magnetic resonance, chemical shift.	12
MODULE 2: Molecular Physics	Molecular structure: Born-Oppenheimer separation for diatomic molecules, Rotation, vibration and electronic structure of diatomic molecules. Valence-bond and Molecular orbital theory: Applications to H_2^+ and H_2.	8
MODULE 3: Molecular Spectra	Rotation, vibration-rotation and electronic spectra of diatomic molecules. The Franck-Condon principle. Raman spectra of diatomic molecules. Idea of symmetry elements and point groups for simple molecules. Electron spin resonance. Nuclear magnetic resonance, chemical shift.	14
MODULE 4: Non	Non-linear phenomenon, Harmonic generation, Optical mixing,	2

linear optics	Self focusing of light.	
MODULE 5: Laser cooling and trapping of atoms	Principle of laser cooling, optical molasses technique, Doppler cooling limit, magneto optical trap. Introduction to the dipole force, theory of the dipole force, optical lattice. Description of Sisyphus cooling technique and its limit. Bose-Einstein condensation.	5

Text Books:

T1. Atomic Physics, S.N. Ghoshal, S. Chand Publishers.
T2. Lasers and Nonlinear Optics, B.B. Laud, New Age International
T3. Fundamentals of Molecular Spectroscopy , CN Banwell, Tata McGraw Hill

Reference Books:

R1. Physics of Atoms and Molecules, BH Bransden and CJ Joachain, Pearson Education
R2. Introduction to Atomic Spectra, HE White, McGraw Hill

DEPARTMENT OF PHYSICS

PH612A4 **Credit: 3 (L-0, T-0, P-6)**

COMPUTATIONAL PHYSICS LAB –II

Max Marks: 100
Note: 6 hours per week for lab. There are 13 weeks expected in a semester. Should Compulsory do exercises from all modules. Exact problem will be decided by the teacher in-charge.

Objectives: The course focuses on learning and applying the numerical techniques to solve and analyze problems in physics at an advanced level.

Prerequisites: Knowledge of numerical techniques of solving simultaneous equations, differentiation, integration, ordinary and partial differential equation, matrices, etc. is necessary. Should have the knowledge of a programming language C.

Course Outcomes: After the completion of the complete syllabus, the student will be capable of the following:

- CO1. Applying the knowledge gained by studying the Numerical Technique (Theory) to solve physics problems numerically using computer.
- CO2. Understands the significance of errors and its propagation in numerical calculations and how to minimize the errors, hence improving the accuracy.
- CO3. Develop skill to solve problems with numerical technics for differentiation, integration, from different areas of science and technology
- CO4. Develop skill to study the evolution of phenomena with numerical technics for solving ODE and PDE from different areas of science and technology.
- CO5. Develop the logical and reasoning aptitude to analyze the variation of parameters on different physical problems.
- CO6. Develop the skill to analyze data generated from experiments and understand the physics behind it.

Module	**Topic**
Module 1: Numerical differentiation	Use Newton's forward and backward formula, Newton-Gregory formula, Central difference method toward applications to mathematical functions, equations, evaluation of speed, acceleration, force, fields.
Module 2: Numerical Integration	Use of trapezoidal rule, Simpson's 1/3 and 3/8 rule, Application to surface integration, volume integration, Fourier Analysis, specific heat, potential and fields.
Module 3: Solution of O.D.E	Use of Euler method, 4^{th} order Runge-Kutta method, Predictor-corrector, leap frog method, for solving simple harmonic motion, damped harmonic motion forced oscillations, Projectile motions, Nonlinear motions, chaos,

quantum mechanics.

Module 4: Simultaneous linear equation	Use Gauss elimination method, iterative method to solve simultaneous linear equations, matrix inversion, eigen vectors, eigen values.
Module 5: Solution of P.D.E	Use difference method, Lax method, Two-step Lax-Wendroff method, FTCS application to wave equation, Adective equation, Diffusion equation, Poisson equation, fast Fourier transforms.
Module 6: Monte Carlo Techniques	Use your standard random number generator functions, generate random numbers using few methods discussed in theory. Use Monte Carlo method to evalute integrals, area of circle, ellipse, volume of sphere, ellipsoidal, Monte Carlo to solve Ising model, percolation, random motions.

Text Books:

T1. Computer oriented numerical methods, V. Rajaraman, PHI

T2. A First Course In Computational Physics (Indian edition) by Javier Hasbun (Author), Paul Devries, 2nd edition, Jones and Bartlett Learning, Delhi

T3. Computational Physics, 2nd edition Nicholas J. Giordano (Author), Hisao Nakanishi, Pearson

T4. Explorations in Monte Carlo Methods, 2009, by Ronald W. Shonkwiler (Author), Franklin Mendivil, Springer

DEPARTMENT OF PHYSICS

PH614A3 **Credit: 4 (L-3, T-1, P-0)**

PARTICLE PHYSICS II (ELECTIVES-I)

Question to be set: 05 (All Compulsory)

Objectives: The course focuses at developing the basic knowledge of Particle Physics and Quantum Field Theory. It helps students to understand the basic constituents of all the matters in the Universe and the interaction among themselves.

Prerequisites: Knowledge in Quantum Mechanic-I (Non-relativistic), Quantum Mechanics-II (Relativistic), Classical Mechanics, Classical electrodynamics, Mathematical Methods in Physics, Particle Physics-I are essential.

Course Outcomes: After the completion of the complete syllabus, the student will be capable of the following:

- CO1. Understand the theory of the weak interaction. Write the Lagrangian of weak interactions
- CO2. Perform gauge transformation. Correlate the gauge transformation and conservation laws associated.
- CO3. Understand the concept of spontaneous symmetry breaking and Higgs mechanism to different situations.
- CO4. Able to construct standard model- a local gauge invariant theory.
- CO5. Apply the concept of spontaneous symmetry breaking and Higgs mechanism to standard model.

Module	Topics	Hrs.
Module 1: Weak interaction	Theory of beta-decay, Pion and muon-decay, lepton conservation, types of neutrinos, conserved vector current hypothesis and related topics.	12
Module 2: Gauge Theory	Abelian gauge Transformation: U(1) Gauge symmetry, global and local gauge invariance, Electrodynamics of a Dirac Field, Non-Abelian gauge Transformations.	8
Module 3: Spontaneous Symmetry breaking	Spontaneous symmetry breaking, Goldstone theorem, Higgs mechanism	6
Module 4: Electro-weak mixing	Choice of the group SU (2) X U (1), two component left handed fermions, weak isospin and hypercharge assignment. Weak charged and neutral currents. Coupling of W and Z-bosons with leptons and quarks. Gauge vs. mass-eigen states	10

Module 5: Mass of gauge bosons and standard model	SU (2) X U(1) symmetry breaking via the Higgs mechanism. Masses of vector bosons. Cabibbo mixing**.**	6

Text Books:

T1. Introduction to Particle Physics, Griffith, Wiley
T2. Quarks and Leptons, Halzen &Martin, Wiley
T3. Introduction to Particle Physics, W. S. C. Willium

DEPARTMENT OF PHYSICS

PH615A3 **Credit: 4 (L-3, T-1, P-0)**

PLASMA PHYSICS-II (ELECTIVE I)

Question to be set: 05 (All Compulsory)

Objectives: The course is focused on realization of new state of matter which is plasma. It gives idea of interdisciplinary subject.

Prerequisites: Students should have the basic knowledge of gas, solid and liquid state of matter. The wave nature and its propagation in the medium.

Course Outcomes: By the end of the course, the student will be able to:

CO1. Understand the 4th state of matter i.e. plasma in nature and evaluate parameters.
CO2. Develop the ability of analysis of charge particle motion in different filed conditions.
CO3. Understand the plasma behavior by fluid theories and diffusion of plasma in different magnetic field conditions.
CO4. Analyze modes propagation in plasma in different physical conditions.
CO5. Understand the advantages of kinetic theory over fluid theory and implement the theory to solve the plasma problems.
CO6. Develop basic understanding of stability and instability of a fluid/plasma system and analyze the plasma instability problems.

Module	**Topics**	**Hrs.**
Module 1: Nonlinear phenomena	Introduction, Sheath, Ion Acoustic Shock Waves, Solitons, Pondermotive force, Parametric Instabilities, Plasma Echoes, Nonlinear Landau Damping.	11
Module 2: Plasma Diagnostics	Electric Probes, Single probe and double probe methods. Microwave method. Spectroscopic method. X-ray diagnostics.	10
Module 3: Introduction	Radiations from plasma.	2
Module 4: Plasma Production	Ionization of gas by collision, Townsend's theory of ionization, break down potential, cold-cathode discharge, thermionic arc discharge, RF-discharge, dense plasma focus, laser produced plasma.	7
Module 5: Thermonuclear Power reactor	Introduction to thermonuclear fusion, criteria for a reactor, Plasma production, heating of plasma, Tokamak, Magnetic mirror, Stellarator.	8

Module 6: MHD power generator	Basic theory, principle of working, configuration.	7

References:

R1. Plasma Physics, S.N. Sen, Pragati Prakashan.
R2. Principles of Plasma Physics, N.A. Krall and A.W. Trivelpiece, McGraw-Hill.
R3. Introduction to Plasma Physics, F.F. Chen, Vol. 1, Plenum Press.
R4. Plasma Diagnostics, W. Lochte-Holtgreven, North-Holland Pub.
R5. Plasma Technology, B. Gross, B. Gryez and K. Miklossy, Iliffe Books Ltd.

DEPARTMENT OF PHYSICS

PH616A3 **Credit: 4 (L-3, T-1, P-0)**

ELECTRONICS-II (ELECTIVE-II)

Question to be set: 05 (All Compulsory)

Course Objectives: The course is intended to familiarize students with the fundamentals of analog and digital communication systems. It provides students with tools for communication signal analysis and as well as familiarize students with various techniques for amplitude modulation and demodulation of analog signals. It helps to develop the students' ability to determine the effects of receiver frequency and phase errors in synchronous modulation systems and also familiarize students with techniques for generating and demodulating narrow-band and wide-band frequency and phase modulated signals. The course familiarizes students with basic techniques for generating and demodulating pulse code modulated signals and familiarize students with issues pertaining to the transmission of digital signals over bandwidth-limited communication channels. It also familiarizes students with an in-depth understanding Satellite Communication. The students are taught about the earth and space subsystems. The satellite services like broadcasting are dealt thoroughly. This will help the student to understand and appreciate the subject.

Pre-requisites: Students should have the basic knowledge of physics of semiconductor devices. Students should understand the operation of analog circuits containing active and passive components. They should have also done a course in mathematics involving calculus, simple differential equations, Fourier series, Fourier and Laplace transforms.

Course outcomes (CO): Upon successful completion of this course, students should be able to:

CO1. Acquaint with AM and FM basic functionalities and
CO2. Understand the influence of noise on the performance of analog communication systems.
CO3. Acquaint the theory of modern digital communications and systems.
CO4. Understand the modern digital data transmission concepts and optimization of receivers
CO5. Apply the data transmission concepts related as radar and mobile communications.

Module	Topics	Hrs.
Module 1: Analog Modulation Techniques	Linear modulation DSB, SSB, VSB, QAM techniques, Exponential modulation FM and PM; AM and FM modulators and demodulators.	7
Module 2: Noise	External noise, Internal noise: Thermal agitation noise, Shot noise etc., Noise calculations, Noise figure, Noise temperature, Estimation of signal to noise ratio.	5.
Module 3: Pulse	Pulse modulation, sampling theorem. Types: Pulse amplitude modulation, Pulse width modulation, Pulse	10

Communications	position modulation, Generation and Demodulation, Pulse-Code modulation, Quantizing noise, Commanding, Amplitude shift keying, Frequency shift keying, Phase shift keying.	
Module 4: Elements of Information Theory	Information, average information, information rate, Effect of coding on average information per bit; Shanon's theorem; Channel capacity, an optimum modulation system.	6
Module 5: Over view of Satellite Systems and Space link	Introduction, frequency allocation, INTEL Sat. Introduction, Kepler laws, definitions, orbital element, apogee and perigee heights, orbit perturbations, inclined orbits, calendars, universal time, sidereal time, orbital plane, local mean time and sun synchronous orbits, Geostationary orbit: Introduction, antenna, look angles, polar mix antenna, limits of visibility, earth eclipse of satellite, sun transit outage, landing orbits. Introduction, EIRP, transmission losses, link power budget, system noise, CNR, uplink, down link, effects of rain, combined CNR, atmospheric loss, ionospheric effects, rain attenuation, other impairments.	16

Text Books:

T1. Communication Sytems – B. P. Lathi, BSP
T2. Satellite Communications, Dennis Roddy, 4th Edition, McGraw-Hill International edition, 2006.

Reference Books:

R1. Analog and Digital Communication Systems, Martin S. Roden, Prentice Hall, New Jersey, 2nd ed.(1985).
R2. Electronic Communications Systems, Wayne Tomasi, Pearson Education Asia.
R3. Electronic Communication Systems, George Kennedy, Tata McGraw Hill.

DEPARTMENT OF PHYSICS

PH617A3 **Credit: 4 (L-0, T-0, P-6)**

ELECTRONICS LAB-II (ELECTIVE-II)

Max Marks: 100

Note: 6 hours per week with 3 hours per lab. There are 13 weeks expected in a semester. Student should compulsory do exercises from both the section.

Note: Minimum of **TWELVE** experiments to be completed selecting from all **FIVE** Modules**.**

Objectives: Primarily objective of this lab is to provide hands on experience of different modulation techniques. Later on, design and implementation of different types of filters will be conducted to study their output characteristic. Finally, PSPICE language will be introduced to design different analog circuits.

Prerequisites: Students should have the knowledge of basic electronic principles and OPAMP characteristic. To design the filters an understanding of basic mathematical analysis is required.

Course Outcomes:
After the completion of the complete syllabus, the student will be capable of the followings:

CO1. Design the solution for different 1st order active filters using IC741.
CO2. Design the solution for different 2nd order active filters using IC741.
CO3. Understand the basic knowledge associated with digital and analog communication systems.
CO4. Apply the practical working knowledge of Electrical and Electronics Simulation and Analysis using PSPICE
CO5. Analyze the basic Electrical and Electronics Circuits and Applications by PSPICE.

Module	**Topics**	**Hrs.**
Module 1: Design first /second order Active filter	1. Design and construct first order active low pass filter. 2. Design and construct first order active high pass filter. 3. Design and construct second order active low pass filter. 4. Design and construct second order active high pass filter.	6
Module 2: Design and construct first order active wide and	5. Design and construct first order active wide band pass filter. 6. Design and construct first order active narrow band pass filter.	6

narrow band filter		
Module 3: Design and construct first order active wide/narrow band reject and all pass filter.	7. Design and construct first order active wide band reject filter. 8. Design and construct first order active narrow band reject filter. 9. Design and construct first order active all pass filter.	6
Module 4: Different modulation and demodulation-based experiments	10. Study of Amplitude modulation & demodulation. 11. Study of Frequency modulation & demodulation. 12. Study of Pulse amplitude modulation, pulse width modulation and demodulation. 13. Study of Digital modulation and demodulation.	12
Module 5: Basic program using PSPICE	14. Simulate a circuit consisting of R, L and C using PSPICE. 15. Simulate diode and transistor characteristics using PSPICE. 16. Simulate voltage doublers, tripler and quadruple using PSPICE. 17. Simulate clipper and clamper using PSPICE. 18. Simulate an amplifier using PSPICE. 19. Simulate an oscillator using PSPICE.	12

References:

R1. Op-Amps and Linear Integrated Circuits, Ramakant. A. Gayakwad, PHI Learning.
R2. SPICE for Circuits and Electronics Using PSPICE, Muha

ANNEXURE