PHYSICS DEPARTMENT

Syllabus

Master of Science Physics

Program Code: MSC-PH

Part-I
(Semester: I, II)
2022-2023, 2023-24

Sri Guru Teg Bahadur Khalsa College
Sri Anandpur Sahib-140118, Punjab

*An Autonomous College, Affiliated to Punjabi University Patiala
*NAAC Accredited 'A' Grade
*College with Potential for Excellence Status by UGC
*STAR College Status by Department of Biotechnology, Govt. of India
*Department of Science & Technology-FIST Scheme, Govt. of India

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APPROVED
Board of Studies Meeting held on 1st August, 2022

SCHEME OF STUDIES

M.SC. PHYSICS PART-I
Program Code: MSC-PH

SEMESTER-I

Paper Code	Paper Title	Credits	Hours per Week	Marks		
				External	Internal	Total
Core Papers						
PH-1.1.1	Mathematical Methods of Physics– I	4	4	70	30	100
PH-1.1.2	Classical Mechanics	4	4	70	30	100
PH-1.1.3	Classical Electrodynamics	4	4	70	30	100
PH-1.1.4	Quantum Mechanics	4	4	70	30	100
Elective Papers* (Any One)						
PH-1.1.5*	(i) Electronics-I	4	4	70	30	100
	(ii) Remote Sensing	4	4	70	30	100
	(iii) Microwave and its Propagation	4	4	70	30	100
Laboratory Practice						
PH-1.1.6	Group I: Electronics Lab Group II: Laser and Optics Lab	6	12	70	30	100
	Total	**26**	**32**			**600**

*Each student has to choose any one elective paper. Options will be offered depending upon the availability of teaching staff.

SEMESTER II

Paper Code	Paper Title	Credits	Hours per Week	Marks		
				External	Internal	Total
Core Papers						
PH-1.2.1	Mathematical Methods of Physics– II	4	4	70	30	100
PH-1.2.2	Advanced Classical Mechanics and Electrodynamics	4	4	70	30	100
PH-1.2.3	Advanced Quantum Mechanics	4	4	70	30	100
PH-1.2.4	Statistical Mechanics	4	4	70	30	100
Elective Papers (Any One)**						
PH-1.2.5**	(iv) Electronics-II	4	4	70	30	100
	(v) Physics of Electronic Devices and Fabrication of Integrated Circuits and Systems	4	4	70	30	100
	(vi) Science and Technology of Solar Hydrogen and Other Renewable Energies	4	4	70	30	100
Laboratory Practice						
PH-1.2.6	Group I: Laser and Optics Lab Group II: Electronics Lab	6	12	70	30	100
	Total	**26**	**32**			**600**

**Each student has to choose any one elective paper. Options will be offered depending upon the availability of teaching staff.

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PROGRAM OVERVIEW

Program Code: MSC-PH

Duration: 2 Years

Master of Science (M.Sc.) in Physics program is designed to prepare students for a research career in academia or industry by introducing advanced ideas and techniques that are applicable in a wide range of research areas while emphasizing the underlying concepts of Physics. This course provides in-depth understanding of principles and concept of Physics, proficiency in experimentation to understand the theoretical and experimental dimensions of Physics.

Program Educational Objectives

1. The post graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications.
2. The post graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.
3. The post graduates will become effective researcher who will be able to provide lucid summation of the scientific literature on a given topic of study.
4. The post graduates will develop the skill to plan, execute and report the results of an extended experimental or theoretical Physics based project in a research environment.

Program Outcomes

At the end of the program the students will be able to:

- Apply theoretical knowledge of principles and concepts of Physics to practical problems.
- Use mathematical techniques and interpret mathematical models of physical behavior.
- Demonstrate the ability to plan, undertake, and report on a program of original work; including the planning and execution of experiments, the analysis and interpretation of experimental results.
- Assess the errors involved in an experimental work and make recommendations based on the results in an effective manner.
- Develop communication skills, both written and oral, for specialized and non-specialized audiences.

Core Paper-I

PH-1.1.1: MATHEMATICAL METHODS OF PHYSICS - I

Maximum Marks:	**100**	**Time Allowed:**	**3 Hours**
External Examination:	**70 Marks (Pass Marks: 25)**	**Pass Marks:**	**35%**
Internal Assessment:	**30 Marks (Pass Marks: 11)**	**Teaching Hours:**	**60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Section A

Gamma and beta functions: Definition of beta and gamma functions, Evaluation of -(1/2), Relation between beta and gamma functions, Evaluation of integrals using beta & gamma function

Legendre differential equation: Solution of Legendre differential equation, Legendre polynomials, Rodrigue's formula, Generating function for Legendre polynomials and recurrence relations, Orthogonality of Legendre polynomials.

Bessel functions: Definition of Bessel functions of 1st and 2nd kind, Generating function of Jn(x) and their recurrence relations and orthogonality, Definition of spherical Bessel functions and their asymptotic form.

Complex variables: Elements Complex analysis, Limit and continuity, Cauchy's Riemann equations, Complex integrations, Cauchy's theorem for simply and multiply connected regions, Cauchy's integral formula, Taylor and Laurents series, Poles and singularities, Cauchy's residue theorem and its application to evaluation of definite integrals.

Section B

Tensor: Cartesian tensors, Vector components and their transformation properties under three dimensional rotations in rectangular coordinates, Direct product of two and more tensors, Tensors of second and higher ranks, Symmetric and anti-symmetric tensors, Contraction and differentiation, Kronecker and alternating tensors and their isotropy property, Contra-variant and covariant tensors, Physical examples of second rank tensors.

Evaluation of Polynomials: Root finding; Bisection method, Regula falsi method, Newton method, System of linear equations. Gauss Seidal methods, Interpolation and Extrapolation: Lagrange's interpolation, least square fitting; Integration: Simpson and trapezoidal rules; Ordinary differential equation: Euler method, Taylor method, Solution of first order differential equation using Runge-Kutta method.

Text Books:

1. Cartesian Tensors, H. Jeffreys, Cambridge University, Press.
2. Numerical Methods: J.H. Mathew, Prentice Hall of India, New Delhi. Applied Mathematics, L.A. Pipes and Harwill, McGraw Hill Pub.
3. Mathematical Physics, Satya Prakash, Sultan Chand & Sons Educational Publishers.
4. Mathematical Physics: B.S. Rajput, Pragati Parkashan, Meerut.

Core Paper-II

PH-1.1.2: CLASSICAL MECHANICS

Maximum Marks:	**100**	**Time Allowed:**	**3 Hours**
External Examination:	**70 Marks (Pass Marks: 25)**	**Pass Marks:**	**35%**
Internal Assessment:	**30 Marks (Pass Marks: 11)**	**Teaching Hours:**	**60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objective: The purpose of the course is to train the students in the Newtonian Mechanics. Lagrangian and Hamiltonion formalisms to an extent that they can use in the modern branches of Physics.

Instructional delivery strategy/Pedagogy: The course will be taught using lectures followed up by homework assignments and periodic tests. Discussions of course topics during lectures are encouraged.

Section A

Lagrangian formulation: Conservation laws of linear, angular momentum and energy for a single particle and system of particles, Constraints and generalized coordinates, Principle of virtual work, D'Alembert principle, Lagrange's equations of motion, Velocity dependent potential and dissipation function.

Problems: Lagrangian and equations of motion for systems like motion of single particle in space, on the surface of a sphere, cone & cylinder, Atwood's machine, Bead sliding on rotating wire, Simple, spherical and compound pendulums, Projectile motion and harmonic oscillator.

Variational principle: Hamilton's principle, Calculus of variations, Lagrange's equations from Hamilton principle. Generalized momentum, Cyclic coordinates, Symmetry properties and Conservation theorems.

Problems: Applications of calculus of variations for geodesics of a plane and sphere, Minimum surface of revolution, Brachistochrone and harmonic oscillator-problems.

Rigid body kinematics: Kinematics of rotation of rigid body about a point, Orthogonal transformation and properties of transformation matrix, Euler angles and Euler theorem, Infinitesimal rotations, Rate of change of vector in rotating frame.

Problem: Components of angular velocity along space and body set of axes.

Section B

Rigid body dynamics: Angular momentum and kinetic energy of rotation of rigid body about a point, Inertia tensor and its eigen values, Principal moments, Principal axes transformation. Euler equations of motion, Heavy symmetrical top with one point fixed (analytical treatment only).

Hamiltonian formulation: Legendre transformation, Hamilton's equations of motion, Hamilton's equation from variational principle, Principle of least action.

Problems: Hamiltonian and equations of motion for system like simple and compound pendulum, Harmonic oscillator, Motion of particle in central force field, on the surface of a cone & cylinder, and near earth's surface, One-dimensional motion on a plane tangent to the earth's surface, Charged particle's motion in electromagnetic field.

Canonical transformation: Generating function, Poisson brackets and their canonical invariance, Equations of motion in Poisson bracket formulation, Poisson bracket relations between components of linear and angular momenta.

Problems: Harmonic oscillator problem, check for transformation to be canonical and determination of generating function

Course learning outcome: On successful completion of this course, students will be able to:

- Understand the concept of virtual work and displacement and D' Albert Principle.
- Understand the concept of Lagrange's equations of motion.

- Understand the Hamiltonian equations of motion.
- Acknowledge the concept of Poisson brackets and Canonical transformations.

Text Books:

1. Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
2. Classical Mechanics, J.C. Upadhyaya Revised Edition, Himalaya Publishing Company.
3. Classical Mechanics, Gupta Kumar Sharma, Pragati Prakashan

Reference Books:

- Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.
- The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
- Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
    - Classical Mechanics, N.C. Rana and P.S. Joag, Tata McGraw-Hill, N. Delhi, 1991

Core Paper-III

PH-1.1.3: CLASSICAL ELECTRODYNAMICS

Maximum Marks: 100 **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: To apprise the students regarding the concepts of electrodynamics and Maxwell equations and use them various situations.

Instructional delivery strategy/Pedagogy: The course will be taught using lectures followed up by homework assignments and periodic tests. Discussions of course topics during lectures are encouraged.

Section A

Electrostatics: Coulomb's Law, Electric Field, Gauss's Law and its applications, Evaluation of electric field due to uniformly charged sphere using Coulomb's law, Differential form of Gauss law, Dirac and delta function and its properties, Representation of charge density by Dirac Delta Function, Laplace and Poisson equations, Equations of Electrostatics, Scalar potential and potential due to arbitrary charge distribution, Discontinuity in electric field, Electric potential, Energy density.

Boundary Value problems: Dirichlet and Neumann Boundary conditions, Uniqueness Theorem, Green's Function, Method of Images, Point charge placed near a grounded sheet and near a grounded conducting sphere, Electrostatic of dielectric media, multipole expansion, Eigen function expansion of Green function and solution of Poisson equation, Microscopic and Macroscopic fields, Bound Charges and Bound Charge Densities.

Section B

Magnetostatics: Continuity equation, Biot and Savart Law, Differential equation of magnetostatic and Ampere's Law, Vector potential and magnetic fields of a localized current distribution. Magnetic moment, Force and torque on a magnetic dipole in an external field.

Time varying Fields: Faraday's law of electromagnetic induction, Maxwell's equations in free space and linear isotopic media, Energy in the magnetic field, Maxwell's displacement current, Scalar and vector potentials, Boundary conditions on the fields at interface, Lorentz gauge and Coulomb gauge, Poynting Theorem, Gauge invariance.

Course learning outcomes: Students will have achieved the ability to:

- Explain Coulomb's Law, Electric Field, Gauss's Law and its applications
- Explain Boundary Values Problems, Bound Charges and Bound Charge Densities.
- Use Maxwell equations in analyzing the electromagnetic field due to time varying charge and current distribution.
- Describe the nature of electromagnetic wave and its propagation through different media and interfaces.
- Explain charged particle dynamics and radiation from localized time varying electromagnetic sources.

Text Books:

1. Introduction to Electrodynamics – D. J. Griffiths – Pearson Education Ltd., New Delhi, 1991.
2. Classical Electrodynamic, S.P. Puri, Tata McGraw Hill, 1999.

References Books:

- Classical Electrodynamics – J. D. Jackson – John & Wiley Sons Pvt. Ltd. New York, 2004.
- Jordan, E.C. and Balmain, K.G., Electromagnetic Wave and radiating systems, PHI, 2007.

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Core Paper-IV

PH-1.1.4: QUANTUM MECHANICS

Maximum Marks: 100 | **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) | **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) | **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objective:

- To study the basic principles of quantum mechanics.
- Explain the operator formulation of quantum mechanics.
- Student will learn the concept of wave function.
- Student will learn Schrodinger equation and their applications.
- To study role of uncertainty in quantum Physics.

Section A

Motion in a Central Potential: Solution of the Schrodinger equation for the hydrogen atom, Eigen values and eigen vectors of orbital angular momentum, Spherical harmonics, Radial solutions, Hydrogen atom energy spectra. Rigid rotator, Solution for three dimensional square well potential.

Linear vector spaces: State vectors, Orthonormality, Hilbert spaces, Linear manifolds and subspaces, Hermitian, unitary and projection operators and commutators; Dirac Bra and Ket Notation: Matrix representations of bras and kets and operators; Continuous basis, Change of Basis-Representation theory. Coordinate and momentum representations. Fundamental postulates of quantum mechanics.

Generalized uncertainty principle; time energy uncertainty principle, Density matrix. Schrodinger, Heisenberg and interaction pictures.

Symmetry Principles: Symmetry and conservation laws, Space time translation and rotations. Conservation of linear momentum, energy and angular momentum. Unitary transformation, Symmetry and Degeneracy, space inversion and parity. Time reversal invariance.

Section B

Linear Harmonic Oscillator: Solution of Simple harmonic oscillator; Vibrational spectra of diatomic molecule; Anisotropic three dimensional oscillators in Cartesian coordinates, Isotropic three dimensional oscillators in spherical coordinates.

Matrix mechanical treatment of linear harmonic oscillator: Energy eigen values and eigen vectors of SHO, Matrix representation of creation and annihilation operators, Zero-point energy; Coherent states.

Angular momentum: Eigen values, Matrix representations of J^2, Jz, J_+, J_-; Spin: Pauli matrices and their properties, Addition of two angular momenta: Clebsch-Gordon coefficients and their properties, Spin wave functions for two spin-1/2 systems, Addition of spin and orbital momentum, derivation of C.G. coefficients for ½+1/2 and ½+1, addition, Spherical tensors and Wigner-Eckart theorem (Statement only).

Course Learning Outcomes: After the completion of the course, students will be able to:

- Understand and explain differences between classical and quantum mechanics.
- Understand the idea of wave function.
- Understand the uncertainty relations.
- Solve Schrodinger equation for simple potentials.
- Describe dynamics of systems that move under influence of spherically symmetric potential.

Text Books:

1. Quantum Mechanics Concepts and Applications: Nouredine Zettili, A John Wiley and Sons Ltd,
2. Advanced Quantum Mechanics: Satya Prakash, Kedar Nath Ram Nath , Meerut U.P. India, 2010

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Reference Books:

- Quantum Mechanics (2nd Ed.): V.K. Thankappan, New Age Int Pub, New Delhi, 1996.
- Quantum Mechanics: P.M. Mathews and K. Venkatesan, Tata-McGraw Pub., New Delhi, 1997.
- Quantum Mechanics: L. I. Schiff (Int. Student Ed.), McGraw Hill Co. Ltd.
- Modern Quantum Mechanics: J. J. Sakurai, Addison Wesley Pub., USA,1999, Ist ISE Rep.

Elective Paper Option (i)

PH-1.1.5: ELECTRONICS-I

Maximum Marks: 100 | **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) | **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) | **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: The course has been designed:

- To introduce fundamental principles of analog and digital electronics and distinguish between analog and digital systems.
- Learn and understand the basics of digital electronics, Boolean algebra, and able to design the simple logic circuits.

Section A

Semiconductor devices: PN Diode and Diode Equation, Bipolar Junction Transistors, Field effect devices, device structure, device characteristics and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs)

Two port network analysis: Active circuit model's equivalent circuit for BJT, Transconductance model: Common emitter, Common base and Common collector amplifiers.

Feedback in amplifiers: Stabilization of gain and reduction of non-linear distortion by negative feedback. Effect of feedback on input and output resistance. Voltage and current feedback.

Bias for transistor amplifier: Fixed bias circuit, Voltage feedback bias. Emitter feedback bias, Voltage divider bias method.

Multistage amplifier: Direct coupled CE two stage amplifier. RC coupling and its analysis in mid- high- and low-frequency range. Effect of cascading on bandwidth.

Oscillators: Feedback and circuit requirements for oscillator, Basic oscillator analysis, Hartley, Colpitts, RC-oscillators and crystal oscillator.

Section B

Number Systems: Binary, octal and hexadecimal number systems. Arithmetic operations: Binary fractions, Negative binary numbers, floating point representation, Binary codes: weighted and non-weighted binary codes, BCD codes, Excess-3 code, Gray codes, binary to Gray code and Gray to binary code conversion, error detecting and error correcting codes.

Logic Gates: AND, OR, NOT, EO operations, Realization using diode logic or resister transistor logic, Boolean identities, Demorgan's theorem: Simplification of Boolean functions. NAND, NOR gates, Universal property of NAND/NOR Gates, Converting AND-OR-INVERT logic to NAND/NOR logic.

Combinational logic: Minterms, Maxterms, K-map (up to 4 variables), POS, SOP forms. Decoders. Code converters, Full adder, multiple divider circuits.

Flip flops: Bistable multivibrator, RS-, JK-, D- and T-flip flops, setup and hold times, preset and clear operations.

Binary counters: Counters (Synchronous and asynchronous), Ring counters.

Registers: Series and parallel Shift Registers, Data in data out modes.

Course Outcomes: At the end of the course, the students will be able to:

- Apply Boolean laws and K-map to simplify the digital circuits.
- Have a understanding of the fundamental concepts and techniques used in digital electronics.
- To understand and examine the structure of various number systems and its application in digital design.

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- The ability to understand and analyze various combinational and sequential circuits

Text Books:

1. Electronic Fundamentals and Applications: J.D. Ryder, Prentice Hall of India (5th Ed.), New Delhi.
2. Digital Principles and Applications: A.P. Malvino & D.P. Leach, Tata McGraw-Hill, New Delhi
3. Electronic Devices and Circuits: J. B. Gupta, Kataria & Sons Publishers
4. An Introduction to Digital Electronics: M. Singh, Kalyani Publishers, New Delhi

Elective Paper Option (ii)

PH-1.1.5: REMOTE SENSING

Maximum Marks: 100
External Examination: 70 Marks (Pass Marks: 25)
Internal Assessment: 30 Marks (Pass Marks: 11)

Time Allowed: 3 Hours
Pass Marks: 35%
Teaching Hours: 60 (4 Credits)

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: The course has been designed to give basic knowledge of Remote Sensing and microwave communications. Further, also give knowledge of various applications associated with these systems.

Section A

History and scope of remote sensing: Milestones in the history of remote sensing, overview of the remote sensing process, A specific example, Key concepts of remote sensing, career preparation and professional development.

Introduction: Definition of remote sensing, Electromagnetic radiation, Electromagnetic Spectrum, interaction with atmosphere, Radiation-Target, Passive vs. Active Sensing, Characteristic of Images.

Sensors: On the Ground, In the Air& in Space, Satellite characteristics, Pixel Size and Scale, Spectral Resolution, Radiometric Resolution, Temporal Resolution, Cameras and Aerial photography, Multispectral Scanning, thermal Imaging, Geometric Distortion, Weather Satellites, Land Observation Satellites, Marine Observation Satellites, Other Sensors, Data Reception.

Section B

Microwaves: Introduction, Radar Basics, Viewing Geometry & Spatial Resolution, Image Distortion, Target Interaction, Image Properties, Advanced Applications, Polarimetry, Airborne vs. Spaceborne, Airborne & Spaceborne Systems.

Image Analysis: Visual Interpretation, Digital processing, Preprocessing, Enhancement, Transformations, Classification, Integration.

Applications: Agriculture-Crop Type Mapping and Crop Monitoring; Forestry-Clear Cut Mapping, Species identification and Burn Mapping; Geology-Structural Mapping & Geological Units; Hydrology-Food Delineation & Soil Moisture; Sea Ice-Type & Concentration, Ice Motion; Land Cover-Rural/Urban Change, Biomass Mapping; Mapping-Planimetry, DEMs, Topo Mapping; Oceans & Coastal-Ocean features, Ocean Colour, Oil Spill Detection.

Course Outcomes: At the end of the course, the students will be able to:

- Understand the Remote sensing and associated sensors
- Understand the microwave basics, image analysis and various applications

Text Books:

1. Introduction to Remote Sensing: James B. Cambell
2. Fundamentals of Remote Sensing: Natural Resources, Canada Centre of Remote Sensing

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Elective Paper Option (iii) **PH-1.1.5: MICROWAVE AND ITS PROPAGATION**

Maximum Marks: 100 **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: The course has been designed to give basic knowledge of Microwave tubes and related electronics. Further, give knowledge of microwave measurements and transmission lines.

Section A

Microwave linear beam tubes: Conventional vacuum tubes, Klystrons, resonant cavities, velocity modulation process, branching process, output power and beam loading; multi cavity klystron amplifiers, reflex klystrons, helix travelling wave tubes, slow wave structures.

Microwave crossed field tubes: Magnetron oscillators: cylindrical, linear and coaxial, forward wave crossed field amplifier, backward wave crossed field amplifier, backward wave crossed field oscillator, their principle of operation and characteristics.

Microwave transistor and tunnel diodes: Microwave bipolar transistors, physical structures, configurations, principles of operation, amplification phenomena, power-frequency limitations, heterojunction bipolar transistors, physical structures, operational mechanism and electronic applications, microwave tunnel diodes, principles of operation, microwave characteristics.

Microwave field effect transistors: Junction field effect transistors, metal semiconductor field effect transistors, high electron mobility transistors, metal oxide semiconductor field effect transistors, physical structures, principle of operation and their characteristics. MOS transistor and memory devices: NMOS, CMOS and memories. Charged coupled devices: Operational mechanism, surface channel CCD's dynamic characteristics.

Section B

Transferred electron devices: Gunn effect diodes, Ridley-Walkins-Hilsum theory, modes of operation, LSA diodes, InP diodes, CdTe diodes, microwave generation and amplification.

Avalanche transit time devices: Read diode, IMPATT diodes, TRAPATT diodes, BARITT diodes, their physical structure, principle of operation and characteristics.

Microwave measurements: Measurement of impedance, attenuation, insertion loss, coupling and directivity, frequency, power and wavelength at microwave frequencies.

Microwave transmission lines: Transmission line equations and solutions, reflection coefficient and transmission coefficient, standing wave and standing wave ratio, line impedance and admittance, Smith chart, impedance matching. Microwave cavities, microwave hybrid circuits, directional couplers, circulators and isolators.

Text Books:

1. Microwave Devices and Circuits, Sameul Y. Liao, Pearson Education
2. Microwaves: K.C. Gupta, Wiley Eastern Limited.

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Laboratory Practice: **PH- 1.1.6: (i) ELECTRONICS lab**
(ii) LASER and OPTICS lab

Maximum Marks: 100 **Time allowed: 3 Hours**
External Marks: 70 (Pass Marks: 28) **Credits: 6**
Internal Marks: 30 (Pass Marks: 12)

The final examination at the end of the semester carries 70 marks based on one full experiment requiring the student to setup the apparatus, take some data, analyze it and draw conclusion on the basis of 'Experimental Skills' as follows:

Experimental Skills: General Precautions for measurements and handling of equipment, Presentation of measurements, Fitting of given data to a graph, Results with proper significant figures and limits of error, Interpretation of results etc.
The 30 marks internal assessment is based on one seminar, viva-voce of each experiment report at the time of submission, total number of experiments performed, practical record file and attendance.

The laboratory comprises of experiments based on **Electronics** in one group and **Lasers and Optics** in the other group. Half of the students will perform the experiments of Group-I and other half will perform the experiments of Group-II during the entire semester.

GROUP I - ELECTRONICS experiments
Minimum 10 experiments are compulsory out of the followings:

1. Study the gain frequency response of a given RC coupled BJT, CE amplifier.
2. Study of Clipping & Clamping circuits.
3. Study of shunt capacitor filter, inductor filter, LC filter and π filter using Bridge Rectifier.
4. Find the energy gap of a given semiconductor by reverse bias junction method.
5. To calculate the temperature coefficient of Thermistor.
6. Verify De-Morgan's law and various combinations of gates using Logic gates circuit.
7. Study of various types of Flip-Flops.
8. To study various Oscillators (Hartley, Colpitt's, RC Phase shift etc.).
9. To study Amplitude Modulation and De-Modulation and calculate modulation index.
10. To study characteristics of FET and determine its various parameters.
11. Study the characteristics of Tunnel Diode.
12. To study 2 bit, 3 bit and 4 bit Adder & Subtractor.
13. Study the characteristics of basic Thyristors (SCR, MOSFET, UJT, TRIAC etc.).
14. Use of Transistor as a push pull amplifier (Class 'A', 'B' and 'AB').
15. Application of transistor as a series voltage regulator.
16. Study of biasing techniques of BJT.
17. To study Frequency Modulation and Demodulation.
18. Study of transistor as CE and CB amplifier.
19. Fourier series analysis of square, triangular and rectified wave signals.
20. To study half adder/subtractor and full adder circuit.
21. To study BCD to 7-segment decoder.
22. To study decade counter.
23. To study shift registers.
24. To study Astable multivibrator using transistor.
25. To study Astable Generators using IC555 timer.

GROUP II - LASERS AND OPTICS experiments

Minimum 10 experiments are compulsory out of the followings:

1. To study the optical bench model of microscope and to determine the numerical aperture of the microscope.
2. To study the optical bench model of telescope and to determine the angular field of view and magnifying power by entrance and exit pupil method.
3. To study the characteristics of solar cell.
4. To find the wavelength of light using Michelson interferometer and He-Ne Laser.
5. To find the wavelength of light using Michelson interferometer and sodium light source.
6. To study the optical thickness of mica sheet using channel spectrum interferometry.
7. To determine the Planck’s constant using photovoltaic cell.
8. To study the aberrations of a convex lens.
9. To study the electro-optic effect in LiNbO3 crystal using He-Ne laser.
10. To trace the B-H curve for ferromagnetic materials using CRO and to find the magnetic parameters from the B.H. Hysteresis loop.
11. To study the characteristics of optoelectronic devices (LED, Photodiode, Phototransistor, LDR).
12. To study the diffraction pattern by single slit, double slit and grating and to calculate the wavelength of He-Ne laser.
13. To study microwave optics system for reflection, refraction and polarization phenomena.
14. To calibrate the prism spectrometer using mercury lamp and to determine the refractive index of material of the prism for a given wavelength of light.
15. Measurement of Brewster angle and refractive index of materials like glass and fused silica (with He-Ne laser) with a specially designed spectrometer.
16. Particle size determination by diode Laser.
17. Calculate the numerical aperture and study the losses that occur in optical fiber cable.
18. To study losses at fiber junctions.
19. To measure losses in dB of two optical fiber patchcords and coefficient of attenuation.
20. To study the relationship between the LED forward current and the LED optical power output.
21. To study the relationship between the optical input power and resultant photo current.
22. To study the AC characteristics of a linear intensity modulation system.
23. To study external circuitry to transmit an audio signal through an optical fiber using the analogous transmitter and receiver.
24. To determine the wavelength of Balmer series in the visible region from hydrogen emission.
25. To determine the Rydberg constant.

Core Course-V

PH-1.2.1: MATHEMATICAL METHODS OF PHYSICS – II

Maximum Marks:	**100**	**Time Allowed:**	**3 Hours**
External Examination:	**70 Marks (Pass Marks: 25)**	**Pass Marks:**	**35%**
Internal Assessment:	**30 Marks (Pass Marks: 11)**	**Teaching Hours:**	**60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Section A

Laplace transforms: Definition, Conditions of existence, Functions of exponential orders, Laplace transform of elementary functions, Basic theorems of Laplace transforms, Laplace transform of special functions, Inverse Laplace transforms, its properties and related theorems, Convolution theorem, Use of Laplace transforms in the solution of differential equations with constant and variable coefficients.

Hermite Polynomials: Solution of Hermite differential equation. Hermite polynomials. Generating function and recurrence relations for Hermite polynomials. Rodrigues's formula and orthogonality.

Fourier series and transform: Dirichlet conditions, Expansion of periodic functions in Fourier series, Complex form of Fourier series, Sine and cosine series, The finite Fourier sine and cosine transforms, Fourier integral theorem and Fourier transform, Parseveall's identity for Fourier series and transforms. Convolutions theorem for Fourier transforms.

Section B

Laguerre Polynomials: Laguerre differential equation and its solution, Generating function, Rodrigues's formula orthogonality and recurrence relations for Laguerre polynomials. Associated Laguerre functions (Definition only).

Partial differential equations: one dimensional wave equation, the vibrating string fixed at both ends, D'Alembert and Fourier series solutions, Vibrations of a freely hanging chain, vibrations of rectangular membrane, Vibrations of a circular membrane. Heat distribution in rectangular and circular plate.

Group theory: Group postulates, Multiplication table, conjugate elements and classes, sub-group, Isomorphism and homomorphism, Discrete groups, Permutation groups, The group of symmetry of an equilateral triangle and square. Unitary Group, Point Group.

Text Books:

1. Laplace Transforms, M.R. Spiegel, Schaum Series, McGraw Hill Publication.
2. Fourier analysis, M.R. Spiegel, Schaum Series, McGraw Hill Publication.
3. Applied Mathematics, L.A. Pipes and Harwill, McGraw Hill Pub.
4. Mathematical Physics, Satya Prakash, Sultan Chand & Sons Educational Publishers
5. Mathematical Physics: B.S. Rajput, Pragati Parkashan, Meerut.

(BOS Chairman) (VC Nominee) (Academic Council Nominees) (Industry Expert) (Student Alumni) (Members)

Core Course-VI

PH-1.2.2: ADVANCED CLASSICAL MECHANICS AND ELECTRODYNAMICS

Maximum Marks: 100 **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objective: The purpose of the course is to train the students in the Hamilton- Jacobi and Special Theory of Relativity formalisms to an extent that they can use these in the modern branches of Physics.

Instructional delivery strategy/Pedagogy: The course will be taught using lectures followed up by homework assignments and periodic tests. Discussions of course topics during lectures are encouraged.

Section A

Hamilton-Jacoby theory: Hamilton-Jacobi equations for Hamilton principal and characteristic functions.

Problems: Harmonic oscillator using Hamilton-Jacobi formulation and through action-angle variables.

Special theory of relativity: Lorentz transformation in vector form and orthogonality of Lorentz transformation, Lorentz orthogonal transformation matrix, Equivalent rotation angle and Einstein addition law for parallel velocities, Intervals in four-space and Invariance of Space-time interval, covariant formulation of four space and representation of various vectors in four-space, covariant formulation of Force, momentum and energy equation in Minkowski space, Lagrangian formulation of relativistic mechanics.

Problems: Applications of relativistic formulation in the study of motion under constant force and relativistic one dimensional harmonic oscillator.

Small oscillations: Formulation of problem, Eigen value equation, Frequencies of free vibration and normal modes.

Problems: Normal mode frequencies and eigen vectors of diatomic and linear tri-atomic molecule.

Section B

Maxwell inhomogeneous equations and conservation laws: Poynting theorem and Maxwell stress tensor, Poynting theorem for harmonic fields. Fields and radiation of a localized oscillating source, Electric dipole fields and radiation, Magnetic dipole field, Centre fed linear antenna.

Electromagnetic waves and wave propagation: Plane waves in a non-conducting medium, Polarization and Stokes parameter, Energy flux in a plane wave, Reflection and refraction across a dielectric interface, Total internal reflection, Polarization by reflection, Waves in a conducting medium and skin depth.

Course learning outcome: On successful completion of this course, students will be able to:

- Solve Hamilton-Jacobi equations.
- Solve Lagrange's equations of motion for small oscillations.
- Understand the concept of Special Theory of Relativity and various Four vectors, concept of
- four-force and four-momentum etc.
- Explain the Covariant form of Maxwell's field Equations in term of Electromagnetic Field Tensor.

Text Books:

1. Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
2. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.

Reference Books:

- Classical Mechanics, J.C. Upadhyaya Revised Edition, Himalaya Publishing Company.
- Classical Mechanics, Gupta Kumar Sharma, Pragati Prakashan.
- Classical Electrodynamics by S.P. Puri , Revised edition 2017,Narosa Publications
- Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.

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Core Course-VII

PH-1.2.3: ADVANCED QUANTUM MECHANICS

Maximum Marks: 100 **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: To give exposure about the various tools employed to analyze the quantum mechanical problems.

Section A

Identical Particles: Indistinguishability principle, Symmetry and antisymmetry of wave functions, Exchange operators, Spin statistic theorem, Slater determinant, Scattering of identical particles.
Problem: Hydrogen molecule

Variational Method: Rayleigh Ritz variational method for ground & excited States, *Problem:* Ground state energy of hydrogen, helium and harmonic oscillator.

Time Independent Perturbation Theory: First order and second order perturbation theory for non-degenerate case; *Problems*: Anharmonic oscillator,
Degenerate perturbation theory; *Problem*: Stark effect

Time Dependent Perturbation Theory: Transition probability for constant and harmonic perturbation, Golden rule, Induced absorption and emission, Einstein coefficients; *Problem*: Radiative transitions

WKB Method in One Dimension: Classical limit, Principle of WKB, Connection formulae for penetration of a barrier; *Problem*: Alpha decay.

Section B

Collision Theory: Scattering amplitudes and cross section, Born approximation. Partial wave analysis: Scattering by central potential, short range interaction, Phase shifts, Optical theorem, s and p-wave scattering, scattering length, Effective range, Breit-Wigner formula.
Problem: Scattering by three dimensional square well potential

Relativistic Quantum Mechanics: Klein-Gordon equation: Probability and current densities, Continuity equation, Difficulties of K.G. equation, Plane wave solution. Dirac equation: Dirac algebra, Plane wave solutions, Positive and negative energy solutions of Dirac equation, positrons, Spin and magnetic moment (Qualitative), Properties of gamma matrices.

Course Outcomes:

1. Students will be able to apply the mathematical theories of quantum mechanics to real problems in Particle Physics and Classical Physics.
2. This course introduces the method of applying rules of quantum mechanics to understand the quantum properties of particles, radiations, atoms and their interaction.
3. Also this course introduces Application of approximation methods and scattering theories.

Text Books:

1. Advanced Quantum Mecahnics: Satya Prakash, Kedar Nath Ram Nath , Meerut U.P. India, 2010.
2. Quantum Mechanics Concepts and Applications: Nouredine Zettili, A John Wiley and Sons Ltd.

Reference Books:

- Quantum Mechanics: L.I. Schiff, Tata McGraw-Hill Publication.
- Quantum Mechanics: V.K. Thankappan, New Age International
- Quantum Mechanics: M.P. Khanna, Har-Anand Publication, Delhi
- Modern Quantum Mechanics by J. J. Sakurai (Principal text)-Pearson Education Pvt. Ltd.,

Core Course-VIII

PH-1.2.4: STATISTICAL MECHANICS

Maximum Marks: 100	**Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25)	**Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11)	**Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objective: To understand the properties of macroscopic systems using the knowledge of the properties of individual particles.

Instructional delivery strategy/Pedagogy: The course will be taught using lectures followed up by homework assignments and periodic tests. Discussions of course topics during lectures are encouraged.

Section A

Classical Statistical Mechanics Postulates, the macroscopic and microscopic states, contact between statistics and thermodynamics, connection between statistical and thermodynamic quantities, Entropy of an ideal gas, Gibb's paradox, Sackur Tetrode equation. Liouville's theorem and its consequences, Phase space, Ensemble, Micro canonical ensemble and its partition function, Gibb's micro canonical distribution, Ideal gas in micro canonical ensemble.

Canonical ensemble and its thermodynamics, Partition function, *Problems in canonical ensembles:* Classical ideal gas, System of independent harmonic oscillators, Dielectrics, Para magnetisms, Rotational partition function. Equipartition theorem and Virial theorem.

Grand canonical ensemble and its thermodynamics, Partition function, Energy and Density fluctuations: Correspondence with other ensembles. Classical ideal gas in grand canonical ensemble.

Section B

Postulates of Quantum Statistical Mechanics, Density matrix, Different ensembles in quantum statistical mechanics for different Ideal gases (Ideal Fermi Gas, Ideal Bose Gas and Boltzmann Gas), Distribution function for different ideal gases, density of states for an ideal gas, statistics of the occupation numbers.

Equation of state of an Ideal Fermi Gas, Degeneracy, Fermi energy at T=0 and at low temperatures. Thermodynamics of an ideal Fermi gas, free electron gas in metal.

Equation of state of an Ideal Bose gas, Bose-Einstein condensation, Thermodynamics of an Ideal Bose gas, Thermodynamics of Black body radiation (The photon gas)

Phase transition, Introduction to first and second order phase transition: The Clausius Claperyon equation, Ising model in zeroth approximation, random walk and Brownian motion, Fick’s diffusion formula, Fick law, Einstein relation.

Course Outcomes: On completion of this course, students will be able to:

- Identify and describe the statistical nature of concepts and laws in thermodynamics.
- Use the statistical physics methods such as Boltzmann distribution, Gibbs distribution,
- Fermi-Dirac and Bose-Einstein distribution. Body radiation to analyze radiation phenomenon.
- Apply the concepts and laws of thermodynamics to solve problems such as gases, heat engines

Text Book:

1. Statistical Mechanics: R.K. Patharia (2 nd Ed.), Butterworth Oxford
2. Classical Electrodynamics, S.P. Puri, Tata McGraw Hill, (1999)

Reference Books:

- Statistical Mechanics: Kerson Huang, (John Wiley & Sons, 2nd Ed.)
- Fundamental of Statistical and Thermal Physics Mechanics: by Frederick Reif

Elective Paper Option (iv) **PH-1.2.5: ELECTRONICS– II**

Maximum Marks: 100 **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.
Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.
Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**
Course Objective: The purpose of the course is to expose the students to the Power amplifiers, Tuned amplifiers, OPAMP and OPAMP based analog circuits and communication techniques.

Section A

Band-pass amplifiers: Parallel resonant circuit and its bandwidth. Single tuned and double tuned amplifiers.
Power amplifiers: Operating conditions, Power relations, nonlinear distortion, Class A power amplifier, Push-pull principle, Class B Push pull amplifier.
Fundamentals of modulation: Need for Modulation. Amplitude Modulation, Analysis and Frequency spectrum in amplitude modulation, Power relations in AM wave, SSB system, Generation and detection of amplitude modulation. Frequency modulation, Power relation and Analysis of FM waves. Transmission and Receiving systems.
Operational amplifiers: Schematic Symbol of Op-Amp, Ideal operational amplifier. Differential Amplifiers. Internal circuit of Operational amplifier. Open loop Op-Amp Configurations, Practical Op-Amp Parameters, Closed loop Op-Amp Configurations, Concept of Virtual ground. Operational amplifier characteristics: DC and AC characteristics.

Section B

Operational amplifier applications: Adder & Subtractor, Instrumentation amplifier, AC amplifier, Voltage to Current converter, Current to Voltage converter, Integrator and Differentiator. Precision Rectifiers (Half wave rectifier and full wave rectifier), Sample and Hold circuits, Log and antilog amplifiers.
Comparator and Waveform generators: Regenerative comparator (Schmitt Trigger), Square wave generator (Astable Multivibrator), Pulse generator (Monostable multivibrator), Triangular wave generator.
Voltage regulators: Series Op-Amp Voltage regulator, IC Voltage regulators and IC 723 general purpose regulator.
555 Timer: Functional Diagram, Monostable, Astable operations and their applications
Course learning outcome: On successful completion of this course, students will be familiar with the various Power amplifiers, Tuned amplifiers, OPAMP and OPAMP based analog circuits and communication techniques.

Text Books:

1. Electronic Devices and Circuits: Millman and Halkias (McGraw Hill).
2. Electronic Principles: A.P. Malvino (Tata McGraw, New Delhi), 7th edition, (2009).
3. Linear Integrated Circuit: D. Roy Choudury and Shail Jain, Wiley Eastern, New Delhi
4. OPAMPS and Linear Integrated circuits: Ramakant A Gayakwad (Prentice Hall), 1992.

Elective Paper Option (v)

PH-1.2.5: PHYSICS OF ELECTRONIC DEVICES AND FABRICATION OF INTEGRATED CIRCUITS AND SYSTEMS

Maximum Marks: 100 | **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) | **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) | **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Section A

Semiconductor Materials: Energy Bands, Intrinsic carrier concentration, Donors and Acceptors, Direct and Indirect band semiconductors. Degenerate and compensated semiconductors. Elemental (Si) and compound semiconductors (GaAs). Replacement of group III element and Group V elements to get tertiary alloys such as $Al_xGa_{(1-x)}$ As or $GaP_yAs_{(1-y)}$ and quaternary $In_xGa_{(1-x)}P_yAs_{(1-y)}$) alloys and their important properties such as band gap and refractive index changes with x and y. Doping of Si (Group III (n) and Group V (p) compounds and GaAs (group II (p), IV (n.p) and VI (n compounds). Diffusion of Impurities. Thermal Diffusion, Constant Surface Concentration, Constant Total Dopant Diffusion, Ion Implantation.

Carrier Transport in Semiconductors: Carrier Drift under low and high fields in (Si and GaAs), saturation of drift velocity. High field effects in two valley semiconductors. Carrier Diffusion, Carrier Injection, Generation Recombination Processes-Direct, Indirect bandgap semiconductors. Minority Carrier Life Time, Drift and Diffusion of Minority Carriers (Haynes-Shockley Experiment) Determination of: Conductivity (a) four probe and (b) Van der Paw techniques. Hall Coefficient, Minority Carrier Life Time. Junction Devices: (i) p-n Junction-Energy Band diagrams for homo and hetro junctions. Current flow mechanism in p-n junction, effect of indirect and surface recombination currents on the forward and reverse bias diffusion current, p-n junction diodes-rectifiers (high frequency limit) (ii) Metal-semiconductor (Schottky Junction): Energy band diagram, current flow mechanisms in forward and reverse bias, effect of interface states. Applications of Schottky diodes, iii) Metal-Oxide-Semiconductor (MOS) diodes. Energy band diagram, depletion and inversion layer. High and low frequency Capacitance Voltage (C-V) characteristics. Smearing of C-V curve, flat band shift. Applications of MOS Diode.

Microwave Devices: Tunnel diode, transfer electron devices (Gunn diode) Avalanche Transit time devices (Read, impatt diodes, and parametric devices)

Photonic Devices: Radiative and non-radiative transitions. Optional Absorption, Bulk and Thin film Photo-conductive devices (LDR), diode photodetectors, solar cell-(open circuit voltage and short circuit current, fill factor) LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), diode lasers (conditions for population inversion, in active region, light confinement factor. Optional gain and threshold current for lasing, Fabry-Perrot Cavity Length for lasing and the separation between modes).

Section B

Memory and other Electronic Devices: Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non-volatile-NMOS, magnetic, optical and ferroelectric memories, charge coupled devices (CCD).

Others Electronic Devices: Electro-Optic, Magneto-Optic and Acousto-Optic Effects. Material Properties related to get these effects. Important Ferroelectric, Liquid Crystal and Polymeric materials for these devices. Piezoelectric, Electrostrictive and magneto strictive Effects, Important materials exhibiting these properties, and their applications in sensors and actuator devices. Acoustic Delay lines, piezoelectric resonators and filters. High frequency piezoelectric devices-Surface Acoustic Wave Devices. Pyroelectric effect. Inorganic oxide and Polymer pyroelectric materials and their applications

Fabrication of integrated Devices: Thin film Deposition Techniques: Vacuum Pumps and gauges-pumping speed, throughout. Effective conductance control. Chemical Vapor Deposition (CVD), MOCVD, PEMOCVD (Plasma enhanced chemical vapor deposition). Physical Vapor deposition, Thermal Evaporation, Molecular Beam Epitaxy (MBE), Sputtering and Laser Ablation. Lithography, Etching and Micro-machining of Silicon, Fabrication of Integrated Circuits and Integrated Micro-Electro-Mechanical-Systems (MEMS).

Text Books:

1. The Physics of Semiconductor Devices by D.A. Eraser, Oxford Physics Series (1986)
2. Semiconductor Devices-Physics and Technology, S.M. Sze Wiley (1985)
3. Introduction to semiconductor devices, M.S. Tyagi, John Wiley & Sons

Reference Books:

- Measurement, Instrumentation and Experimental Design in Physics and Engineering, M. Sayer and A. Mansingh, Prentice Hall, India (2000)
- The material science of thin films, Milton S. Ohring
- Optical electronics by Ajoy ghatak and K. Thyagarajan, Cambridge Univ. Press
- Material Science for Engineers, James F. Shackelford, Prentice Hall
- Deposition techniques for films and coatings, R.F Bunshah (Noyes publications)

Elective Paper Option (vi)

PH-1.2.5: SCIENCE AND TECHNOLOGY OF SOLAR HYDROGEN AND OTHER RENEWABLE ENERGIES

Maximum Marks:	**100**	**Time Allowed:**	**3 Hours**
External Examination:	**70 Marks (Pass Marks: 25)**	**Pass Marks:**	**35%**
Internal Assessment:	**30 Marks (Pass Marks: 11)**	**Teaching Hours:**	**60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Section A

Solar Energy: Fundamentals of Photovoltaic Energy Conversion Physics and Material Properties Basic to Photovoltaic Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers. Type of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief descriptions of single crystal silicon and amorphous silicon solar cells, elementary ideas of advanced solar cells e.g. Tandem Solar Cells. Solid Liquid Junction Solar Cells, Nature of Semiconductor, Electrolyte Junction, Principles of Photo-electrochemical solar cells.

Hydrogen Energy: Relevance in relation to depletion of fossil fuels and environmental considerations

Section B

Hydrogen Production: Solar Hydrogen through Photo electrolysis and Photocatalytic process. Physics of material characteristic for production of Solar Hydrogen

Storage of Hydrogen: Brief discussion of various storage processes, special features of solid state hydrogen storage materials, structural and electronic characteristics of storage materials. New Storage Modes.

Safety and Utilization of Hydrogen: Various factors relevant to safety, use to Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Elementary concepts of other Hydrogen Based devices such as Air Conditioners and Hydride Batteries.

Other Renewable Clean Energies: Elements of Solar Thermal Energy Conversion.

Text Books:

1. Fonash: Solar Cell Devices Physics
2. Fahrenbruch & Bube: Fundamentals of Solar Cells Photovoltaic Solar Energy

Reference Books:

- Chandra: Photo electro chemical Solar Cells
- Winter & Nitch (Eds): Hydrogen as an Energy Carrier Technologies Systems Economy

Laboratory Practice: **PH- 1.2.6: (i) LASER and OPTICS lab**
(ii) ELECTRONICS lab

Maximum Marks: 100 **Time allowed: 3 Hours**
External Marks: 70 (Pass Marks: 28) **Credits: 6**
Internal Marks: 30 (Pass Marks: 12)

The final examination at the end of the semester carries 70 marks based on one full experiment requiring the student to setup the apparatus, take some data, analyze it and draw conclusion on the basis of 'Experimental Skills' as follows:
Experimental Skills: General Precautions for measurements and handling of equipment, Presentation of measurements, Fitting of given data to a graph, Results with proper significant figures and limits of error, Interpretation of results etc.
The 30 marks internal assessment is based on one seminar, viva-voce of each experiment report at the time of submission, total number of experiments performed, practical record file and attendance.

The laboratory comprises of experiments based on **Electronics** in one group and **Lasers and Optics** in the other group. The groups will get switched in this semester so that student of Group-I and Group-II can perform the experiments of other group than previous semester.

GROUP I - ELECTRONICS experiments
Minimum 10 experiments are compulsory out of the followings:

1. Study the gain frequency response of a given RC coupled BJT, CE amplifier.
2. Study of Clipping & Clamping circuits.
3. Study of shunt capacitor filter, inductor filter, LC filter and π filter using Bridge Rectifier.
4. Find the energy gap of a given semiconductor by reverse bias junction method.
5. To calculate the temperature coefficient of Thermistor.
6. Verify De-Morgan's law and various combinations of gates using Logic gates circuit.
7. Study of various types of Flip-Flops.
8. To study various Oscillators (Hartley, Colpitt's, RC Phase shift etc.).
9. To study Amplitude Modulation and De-Modulation and calculate modulation index.
10. To study characteristics of FET and determine its various parameters.
11. Study the characteristics of Tunnel Diode.
12. To study 2 bit, 3 bit and 4 bit Adder & Subtractor.
13. Study the characteristics of basic Thyristors (SCR, MOSFET, UJT, TRIAC etc.).
14. Use of Transistor as a push pull amplifier (Class 'A', 'B' and 'AB').
15. Application of transistor as a series voltage regulator.
16. Study of biasing techniques of BJT.
17. To study Frequency Modulation and Demodulation.
18. Study of transistor as CE and CB amplifier.
19. Fourier series analysis of square, triangular and rectified wave signals.
20. To study half adder/subtractor and full adder circuit.
21. To study BCD to 7-segment decoder.
22. To study decade counter.
23. To study shift registers.
24. To study Astable multivibrator using transistor.
25. To study Astable Generators using IC555 timer.

GROUP II - LASERS AND OPTICS experiments

Minimum 10 experiments are compulsory out of the followings:

1. To study the optical bench model of microscope and to determine the numerical aperture of the microscope.
2. To study the optical bench model of telescope and to determine the angular field of view and magnifying power by entrance and exit pupil method.
3. To study the characteristics of solar cell.
4. To find the wavelength of light using Michelson interferometer and He-Ne Laser.
5. To find the wavelength of light using Michelson interferometer and sodium light source.
6. To study the optical thickness of mica sheet using channel spectrum interferometry.
7. To determine the Planck's constant using photovoltaic cell.
8. To study the aberrations of a convex lens.
9. To study the electro-optic effect in LiNbO3 crystal using He-Ne laser.
10. To trace the B-H curve for ferromagnetic materials using CRO and to find the magnetic parameters from the B.H. Hysteresis loop.
11. To study the characteristics of optoelectronic devices (LED, Photodiode, Phototransistor, LDR).
12. To study the diffraction pattern by single slit, double slit and grating and to calculate the wavelength of He-Ne laser.
13. To study microwave optics system for reflection, refraction and polarization phenomena.
14. To calibrate the prism spectrometer using mercury lamp and to determine the refractive index of material of the prism for a given wavelength of light.
15. Measurement of Brewster angle and refractive index of materials like glass and fused silica (with He-Ne laser) with a specially designed spectrometer.
16. Particle size determination by diode Laser.
17. Calculate the numerical aperture and study the losses that occur in optical fiber cable.
18. To study losses at fiber junctions.
19. To measure losses in dB of two optical fiber patchcords and coefficient of attenuation.
20. To study the relationship between the LED forward current and the LED optical power output.
21. To study the relationship between the optical input power and resultant photo current.
22. To study the AC characteristics of a linear intensity modulation system.
23. To study external circuitry to transmit an audio signal through an optical fiber using the analogous transmitter and receiver.
24. To determine the wavelength of Balmer series in the visible region from hydrogen emission.
25. To determine the Rydberg constant.

PHYSICS DEPARTMENT

Syllabus

Master of Science Physics

Program Code: MSC-PH

Part-II
(Semester: III, IV)
2022-23, 2023-24

Sri Guru Teg Bahadur Khalsa College
Sri Anandpur Sahib-140118, Punjab

*An Autonomous College, Affiliated to Punjabi University Patiala
*NAAC Accredited 'A' Grade
*College with Potential for Excellence Status by UGC
*STAR College Status by Department of Biotechnology, Govt. of India
*Department of Science & Technology-FIST Scheme, Govt. of India

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APPROVED
Board of Studies Meeting held on 1st August, 2022

SCHEME OF STUDIES

M.SC. (PHYSICS) PART-II

Program Code: MSC-PH

SEMESTER-III

Paper Code	Paper Title	Credits	Hours per Week	Marks		
				External	Internal	Total
Core Papers						
PH-2.1.1	Condensed Matter Physics– I	4	4	70	30	100
PH-2.1.2	Nuclear Physics	4	4	70	30	100
PH-2.1.3	Atomic and Molecular Spectroscopy	4	4	70	30	100
Elective Papers* (Any One)						
PH-2.1.4*	(i) Laser and Fiber Optics	4	4	70	30	100
	(ii) Material Science	4	4	70	30	100
	(iii) Computational Methods and Simulation	4	4	70	30	100
Laboratory Practice						
PH-2.1.5	**Group I**: Nuclear Physics and Counter Electronics **Group II**: Condensed Matter Physics and Advanced Electronics	6	12	70	30	100
PH-2.1.6	Computer Lab	2	4	35	15	50
	Total	**24**	**32**			**550**

*Each student will choose only one paper of their choice. Different options will be offered depending upon the availability of teachers.

SEMESTER IV

Paper Code	Paper Title	Credits	Hours per Week	Marks		
				External	Internal	Total
Core Papers						
PH-2.2.1	Condensed Matter Physics– II	4	4	70	30	100
PH-2.2.2	Nuclear and Particle Physics	4	4	70	30	100
Elective Papers (Any Two)**						
PH-2.2.3** & PH-2.2.4**	(iv) Radiation Physics	4	4	70	30	100
	(v) Advanced Electronics	4	4	70	30	100
	(vi) Theoretical Nuclear Physics	4	4	70	30	100
	(vii) Plasma Physics	4	4	70	30	100
	(viii) Experimental Techniques in Physics	4	4	70	30	100
	(ix) Project Work	4	4	-	100	100
Laboratory Practice						
PH-2.2.5	**Group I:** Condensed Matter Physics and Advanced Electronics **Group II:** Nuclear Physics and Counter Electronics Lab	6	12	70	30	100
PH-2.2.6	Computer Lab	2	4	35	15	50
	Total	**24**	**32**			**550**

** Each student will choose any two papers of their choice. Different options will be offered depending upon the availability of teachers.

Monika Sharma

(BOS Chairman) (VC Nominee) (Academic Council Nominees) (Industry Expert) (Student Alumni) (Members)

PROGRAM OVERVIEW

Program Code: MSC-PH

Duration: 2 Years

Master of Science (M.Sc.) in Physics program is designed to prepare students for a research career in academia or industry by introducing advanced ideas and techniques that are applicable in a wide range of research areas while emphasizing the underlying concepts of Physics. This course provides in-depth understanding of principles and concept of Physics, proficiency in experimentation to understand the theoretical and experimental dimensions of Physics.

Program Educational Objectives

5. The post graduates will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications.
6. The post graduates will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.
7. The post graduates will become effective researcher who will be able to provide lucid summation of the scientific literature on a given topic of study.
8. The post graduates will develop the skill to plan, execute and report the results of an extended experimental or theoretical Physics based project in a research environment.

Program Outcomes

At the end of the program the students will be able to:

- Apply theoretical knowledge of principles and concepts of Physics to practical problems.
- Use mathematical techniques and interpret mathematical models of physical behavior.
- Demonstrate the ability to plan, undertake, and report on a program of original work; including the planning and execution of experiments, the analysis and interpretation of experimental results.
- Assess the errors involved in an experimental work and make recommendations based on the results in an effective manner.
- Develop communication skills, both written and oral, for specialized and non-specialized audiences.

Core Paper-IX

PH-2.1.1: CONDENSED MATTER PHYSICS-I

Maximum Marks: 100 | **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) | **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) | **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: To study some of the basic properties of the condensed phase of matter especially solids. This paper enables the students to understand about crystal structure, Lattice vibration, Free electron theory, Band theory, electrical properties, semiconductors, Fermi surface in metals, Nanotechnology and carbon nanostructures.

Section A

Crystal Structure: Bravais lattice, Reciprocal lattice, Brillouin zones, Diffraction methods, scattered wave amplitude, Structure factor, Form factor, Quasi Crystals and Bonding of Solids

Lattice vibration and Free Electron Theory: Lattice vibrations of mono-atomic and diatomic linear lattices, Concept of Phonons, Heat capacity of metals, Free electron gas in 1-D and 3-D, Drude model of electrical and thermal conductivity, Wiedmann-Franz law, Hall effect.

Band Theory: Nearly free electron model, Bloch functions, Kronig-penny model, Wave equation of electrons in a periodic potential, Solution of the central equation, Solutions near a zone boundary, Number of Orbitals in a band, Metals and insulators.

Section B

Semiconductors and Fermi-surfaces in Metals: Band gap, Equation of motion, properties of holes, Effective mass of electrons (m*), m* in semiconductors, Band structure of Si Ge and GaAs, Thermoelectric Effects, Semimetals, Different zone schemes, Constructions of Fermi surfaces, Experimental methods in Fermi surface studies, Quantization of orbits in a magnetic field, De Haas-Van Alphen effect, Extremal orbits, Fermi surfaces for Cu and Au, Magnetic breakdown.

Nanotechnology and Carbon nanostructures: Introduction to nanoparticles, Metal nano clusters (various types), Properties of semi conducting nanoparticles, Methods of synthesis, Quantum well, Quantum wire and Quantum dots (in brief) and their fabrication. Carbon molecules, Carbon cluster, C_{60} (its crystals and superconductivity), Carbon nano tubes, their fabrication and properties, application of carbon nano tubes.

Course Learning Outcomes: After the completion of the course, students will be able to

- Understand the physics behind structural and electrical behaviour of the solids.
- Tailor the properties of the solids with proper understanding.
- Understand the physical process underlying many solid state devices.
- Understand the concept of Nanotechnology and Carbon Nanotubes.
- Pursue the research work in the field of material science and nanotechnology

Text Books:

1. Introduction to Solid State Physics; C. Kittel (7^{th} Ed.) , Wiley Eastern, N. Delhi, 1995
2. Solid State Physics: A.J. Dekker, Mc. Millan India Ltd.
3. Introduction to Nano Technology: Charles P Poople, Jr. and Frank J. Owens, John Wiley & Sons Publications, 2003

Reference Book

- Solid State Physics; Ashroft and Mermin, Thomson learning International.
- Elements of Solid State Physics; J.P. Srivastava, 4^{th} Edition, 2015, Prentice-Hall of India Private Limited, N. Delhi.

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Core Paper-X

PH-2.1.2: NUCLEAR PHYSICS

Maximum Marks:	**100**	**Time Allowed:**	**3 Hours**
External Examination:	**70 Marks (Pass Marks: 25)**	**Pass Marks:**	**35%**
Internal Assessment:	**30 Marks (Pass Marks: 11)**	**Teaching Hours:**	**60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: To impart knowledge about basic nuclear physics properties and nuclear models for understanding of related reaction dynamics.

Section A

Nuclear Properties: Nuclear Radius, Mass and Abundance of Nuclides, Nuclear Binding Energy, Semi-empirical Mass Formula, Nuclear Angular Momentum and Parity, Nuclear Electromagnetic Moments, Nuclear Excited States, Nuclear spin.

Forces between Nucleons: Deuteron problem, Nucleon-Nucleon scattering, Proton- Proton and Neutron-Neutron interactions, Properties of Nuclear Forces, Exchange Force Model.

Nuclear Models: Shell Model (Single and many particle), Even-Z Even-N Nuclei and Collective Structure, Single Particle States in Deformed Nuclei, Rotational spectra.

Section B

Alpha Decay: Why alpha decay occurs? Basic alpha decay processes, Alpha decay systematic. Theory of alpha emission. Angular momentum and Parity in Alpha Decay.

Beta Decay: Energy Released in Beta Decay. Fermi Theory of Beta Decay. Angular Momentum and Parity Selection Rules. Comparative Half Lives and Forbidden Decays. Neutrino Physics. Non-conservation of Parity.

Gamma Decay: Energetic of gamma decay, Angular momentum and Parity selection rules, internal conversion.

Course learning outcomes: Students will have achieved the ability to:

- Explain the ground state properties of the nucleus for study of the nuclear structure behavior.
- Explain the deuteron behavior at ground and excited states.
- Apply deuteron physics and the Nucleon-Nucleon scattering for explaining the nuclear forces.
- Demonstration of the shell model and collective model descriptions.
- Apply various aspects of nuclear reactions in view of compound nuclear dynamics.

Text Books:

1. Introductory Nuclear Physics: K.S. Krane, John Wiley & Sons, New York

Reference Books:

- Nuclear Physics: D. C. Tayal, Himalaya Publishing House.
- Nuclear Physics: R.R. Roy and B.P. Nigam, New Age Pub.
- Nuclear Physics: W.E. Burcham and M. Jobes (Ind. Ed.), Addison Wesley
- Basic Ideas and Concepts in Nuclear Physics: K. Heyde

Core Paper-XI

PH-2.1.3: ATOMIC AND MOLECULAR SPECTROSCOPY

Maximum Marks: 100 (4 Credits) **Time Allowed: 3 Hours**
External Examination: 70 **Pass Marks: 35%**
Internal Assessment: 30 **Teaching Hours: 60**

30 marks internal assessment will be based on two mid-semester tests, class tests, written assignments/project work and lecture attendance. Final examination at the end of semester will carry 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed**.

Section A

Spectra of one and two valance electron systems:

Brief Review of early atomic Models of Bohr and Sommerfeld Theory, Quantum States Of one electron atom, Relativistic Corrections for energy levels of Hydrogen atom; Magnetic dipole moments; Larmor's theorem; Space quantization of orbital, spin and total angular momenta; Vector model for one and two valance electron atoms; Electron spin, Spin-orbit interaction and fine structure of hydrogen, Lamb shift, Spectrum of Helium, Spectroscopic terminology; Spectroscopic notations for L-S and J-J couplings; Spectra of alkali and alkaline earth metals; Selection and Intensity rules for doublets and triplets

Breadth of spectral line and effects of external fields:

The Doppler effect; Natural breadth, External effects like collision damping, asymmetry and pressure shift and stark broadening; The Zeeman Effect for two electron systems; Intensity rules for the Zeeman effect; Lande-g factor; The calculations of Zeeman patterns; Paschen-Back effect; Stark effect.

Section B

Microwave and Infra-Red Spectroscopy:

Types of molecules, Rotational spectra of diatomic molecules as a rigid and non-rigid rotator, Intensity of rotational lines, The vibrating diatomic molecule as a simple harmonic and a harmonic oscillator, Isotope effect on Rotational and Vibrational spectra; Diatomic molecule as a vibrating rotator, The interaction of rotation and vibrations

Raman and Electronic Spectroscopy:

Quantum and classical theories of Raman Effect, Pure rotational Raman spectra for linear and polyatomic molecules, Vibrational Raman spectra, Structure determination from Raman and infra-red spectroscopy, Electronic structure of diatomic molecule, Electronic spectra of diatomic molecules, Born Oppenheimer approximation- The Franck Condon principle, Dissociation and pre-dissociation energy, Nuclear Magnetic Resonance Spectra; Electron Spin Resonance Spectra

Text Books:

1. Introduction to Atomic Spectra: H.E. White-Auckland Mc Graw Hill, 1934.
2. Fundamentals of Molecular Spectroscopy: C.B. Banwell-Tata Mc Graw Hill, 1986.
3. Introduction to Molecular Spectroscopy: G.M. Barrow-Tokyo Mc Graw Hill, 1962.
4. Spectra of Diatomic Molecules: Herzberg-New York, 1944.
5. Molecular Spectroscopy: Jeanne L McHale.

Elective Paper Option (i)

PH-2.1.4: LASER AND FIBER OPTICS

Maximum Marks:	**100**	**Time Allowed:**	**3 Hours**
External Examination:	**70 Marks (Pass Marks: 25)**	**Pass Marks:**	**35%**
Internal Assessment:	**30 Marks (Pass Marks: 11)**	**Teaching Hours:**	**60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: The course aims to present various aspects of the foundations, design, operation and application of lasers and Fiber optics.

Section A

Introductory Concepts: Absorption, Spontaneous and stimulated emission, The laser idea, Rates of absorption and stimulated emission, Einstein Coefficient's, Pumping & Pumping Schemes (Basic Idea), Light amplification, Threshold condition, Line broadening mechanisms, Natural broadening, Collision broadening and Doppler broadening, Laser Properties.

Laser rate equation: Introduction, Two level laser system, Three level laser system, and four level laser system, Variation of laser power around threshold, Optimum output coupling, Laser spiking.

Optical Resonator: Modes of a Rectangular Cavity & the Open Planar Resonator, the Quality factor, Mode Selection, Q-Switching, Techniques of Q-Switching, Mode Locking (Qualitative), Techniques of Mode Locking.

Types of lasers: Ruby lasers, Nd: YAG laser, He-Ne laser, Co_2 laser, N_2 laser, Excimer laser, Dye lasers, Chemical lasers, Semiconductor lasers.

Section B

Optical Fiber Waveguides: Introduction, Ray Theory Transmission, Total Internal Reflection, Acceptance Angle, Numerical Aperture, Skew Rays, Electromagnetic mode theory for optical propagation, Electromagnetic Waves, Modes in a Planar Guide, Evanescent Field (definition only), Goos-Haenchen Shift. Step Index Fibers, Single Mode Fibers, Cutoff Wavelength.

Transmission characteristics of Optical Fiber: Introduction, Attenuation, Intrinsic and Extrinsic absorption loses, Linear Scattering losses, Rayleigh Scattering, Mie Scattering, Non-Linear Scattering Losses, Stimulated Brillouin Scattering, Stimulated Raman Scattering, Bending losses, Dispersion.

Optical Fiber Connection: Introduction, Fiber alignment and joint loss, Multimode Fiber Joints, Single Mode Fiber Joints, Fiber splices, Fusion Splices, Mechanical Splices, Multiple Splices, Fiber connectors, Cylindrical Ferrule Connectors, Biconical Ferrule Connectors, Double Eccentric Connector.

Course Learning Outcomes: Within the course structure offered, students will gain a good understanding of the building blocks of lasers and fiber optics. In particular, they will be able to:

- Predict fundamental (and ultimate) characteristics of laser systems based on specific laser materials, such as output power and lasing threshold
- Assess and design the optical cavities for different laser systems
- Determine the laser behaviour depending on the line broadening mechanism
- Solve the rate equations in steady state for a laser
- Find the interrelations between Einstein coefficients
- Quantitatively describe the key characteristics of pulsed lasers and their interrelation
- Describe concrete major example laser systems in detail and understand their technological challenges Students should therefore gain a significantly enhanced understanding of how lasers work and which types of lasers are most relevant for specific performance specifications and subsequent applications.

- Understand the basic optical fibre communication
- Explain the loss mechanisms, transmission characteristics and in optical fibre
- Able to understand different type of fibre splices and joints

Text Books:

1. Principles of Lasers: O. Svelto,(3rd Ed.), Plenum Press
2. Optical Electronics A.K. Ghatak and K. Thyagrajan, Cambridge Univ Press
3. Optical Fiber Communications: principles and practice by John M. Senior, 2nd Edition, Prentice-Hall of India.

Reference Books

- Lasers and its applications: A.K. Ghatak and K. Thyagrajan, TMH
- Laser Fundamentals by Silvfast, Cambridge University Press
- Optical Fiber Communications, 3rd Edition.by Gerd Keiser Mc Graw-Hill.
- Introduction to Fiber Optics by Ghatak, Cambridge University Press
- Fibre optics through experiments, M. R. Shenoy, S. K. Khijwania, et.al. 2009, Viva Books

Elective Paper Option (ii) **PH-2.1.4: MATERIAL SCIENCE**

Maximum Marks: 100 **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: The course aims to present various aspects of the crystals, its imperfections and its mechanical properties. Further, discuss the phase diagrams and various engineering materials.

Section A

Crystal Imperfections:

Classification of imperfections: Point imperfections, Line imperfections; mixed dislocations. Characteristics of dislocations; Sources of dislocations, their effects and remedies; Phenomena related to behavior of dislocations, Surface imperfections, Volumes imperfections, Whiskers.

Diffusion in solids: Diffusion controlled applications, Types of diffusion, Diffusion processes, Laws of diffusion, Solution to Fick's second law, Applications based on second law, Experimental determination of diffusivity, Factors affecting diffusivity.

Mechanical Properties:

Basic properties: Strain, Stress, Young's modulus, Elastic constants, Isotropy, Anisotropy, Orthotropy, Homogeneity and heterogeneity; Stress-strain diagrams, Stress-strain diagram of structural steel, Elastic properties; Other mechanical properties: Strength, Stiffness, Elasticity, Plasticity, Resilience, Proof resilience, Toughness, Ductility, Brittleness and malleability, True stress-strain diagrams, Fatigue and Creep.

Mechanical Tests: Destructive tests, Tensile test, Compression tests, Shear and bending (on Flexure) tests, Torsion test, Hardness tests, Impact tests, Fatigue test and Creep test.

Section B

Phases and Phase diagrams

Solid phases in alloys, Solid solution, Inter-metallic compounds and intermediate compounds, Phases, Phase diagrams, Binary phase diagram, typical phase diagrams, Application of phase diagrams, Ternary phase diagram.

Phase Transformations and Heat Treatment

Rate of cooling and crystallization, Strengthening mechanisms; Cold and hot working; Precipitation (or Age) hardening, Dispersion hardening, Solid solution hardening, Recovery and re-crystallization, Grain growth and preferred orientation.

Purpose of heat treatment, Microstructure of steel and iron, Iron-Carbon phase diagram, Transformation in steel and critical cooling curve, Heating temperature range in various heat treatment processes, Hardening, Tempering, Annealing, Normalizing, Case hardening or carburizing, Cyaniding, Nitriding, Flame hardening, Induction hardening and Jaminy End-quenched test.

Engineering Materials (Ferrous)

Production of iron and steel, Casting of ingots, Refining, Continuous casting, Steels, Plain carbon steels and applications, Alloy steels, Heat treatment of stainless-steels, Tool-steels and Cast iron.

Engineering Materials (Non-ferrous)

Aluminium, Properties of aluminium alloys, Age-hardening of aluminium alloys, Copper and its production, Copper alloys, Magnesium and its alloys, Titanium alloys, Bearing materials, Alloys for cutting tools, Creep resistant materials.

Course Learning Outcomes:

- Describe how and why defects (point, line and interfacial) in materials greatly affect properties of materials
- Calculate stress, strain and the elastic modulus from data and applications.
- Describe the fundamental mechanical properties of materials covered in the course (stress, strain, elastic constant, creep, fatigue, wear, hardness, Poisson's ratio, toughness, ductility, flexural strength, impact strength, elongation)
- Use binary phase diagrams to predict microstructures and also to understand precipitation hardening. Understand how thermal treatments affect the microstructure and, thus, properties of materials.
- Describe the production and application of ferrous and non-ferrous engineering materials.

Text Books:

1. Material Science and Engineering: K.M. Gupta (Ist Ed.), Umesh Pub., Delhi
2. Material Science: Abdul Mubeen and Farhat Mubeen (2nd Ed.), Khanna Pub., Delhi

Elective Paper Option (iii) **PH-2.1.4: COMPUTATIONAL METHODS AND SIMULATION**

Maximum Marks: 100 **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: The aim of this course is to give basic information of FORTRAN language and its application in solving physical and scientific problems.

Section A

FORTRAN: Review of fundamental FORTRAN commands and programming structures (sequential, repetitive and selective), data types, subscripted variables: Arrays, DIMENSION statement, PARAMETER statement, format directed input and output statements, handling of data files, Subprograms: Function and Subroutines, DATA, SAVE and COMMON statements.

Fortran 77 programs of the following problems:

1. Convert the Cartesian coordinates to spherical coordinates
2. Finding Mean and Standard deviation of data
3. Conversion of Decimal Integer to Binary
4. Conversion of Binary to Decimal Integer
5. Inverse of 2 × 2 Matrix
6. Fitting straight line through given data points
7. Roots of an equation by Bisection method
8. Solution of First order differential equation by Euler's method

Section B

Solution of Ordinary Differential Equations: Eulers method, Taylor series method, Runge-Kutta methods, Predictor corrector methods, Solution of coupled differential equations, and second order differential equations, Monte Carlo technique: Pseudo random numbers, their generation and properties, Monte Carlo method.

Algorithmic development for simulation of the following physics problems: -

1. Motion in one dimension in viscous medium
2. Motion of satellite
3. Simple harmonic oscillator
4. Damped oscillator
5. Electric field and potential due to assemble of charges
6. Application of Kirchhoff's laws for simple electric circuits
7. Monte Carlo method to find value of pi
8. Monte Carlo technique for simulation of nuclear radioactivity

Course Learning Outcomes:

- Knowledge of the fundamentals of linear algebra, ordinary and partial differential equations, optimization, and statistical uncertainty quantification using FORTRAN.
- Overview of various commands used in Fortran language with available software.
- Application of fundamental and advanced algorithms to various physical problems.

Text Books:

1. V.K. Mittal, R.C. Verma and S.C. Gupta, FORTRAN for Computational Physics, Ane Books Ltd.
2. V. Rajaraman, Computer Oriented Numerical Methods, PHI Publications
3. R.C. Verma, Computer Simulation in Physics (using FORTRAN), Anamaya Pub
4. J.H. Mathews, Numerical Methods, Prentice Hall of India, New Delhi

PH-2.1.5: LABORATORY PRACTICE

(i) Nuclear Physics and Counter Electronics
(ii) Condensed Matter Physics and Advanced Electronics

Maximum Marks: 100 | **Time allowed: 3 Hours**
External Marks: 70 (Pass Marks: 28) | **Credits: 6**
Internal Marks: 30 (Pass Marks: 12)

The final examination at the end of the semester carries 70 marks based on one full experiment requiring the student to setup the apparatus, take some data, analyze it and draw conclusion on the basis of 'Experimental Skills' as follows:
Experimental Skills: General Precautions for measurements and handling of equipment, Presentation of measurements, Fitting of given data to a graph, Results with proper significant figures and limits of error, Interpretation of results etc.
The 30 marks internal assessment is based on one seminar, viva-voce of each experiment report at the time of submission, total number of experiments performed, practical record file and attendance.
The laboratory comprises of experiments based on **NUCLEAR PHYSICS AND COUNTER ELECTRONICS** in one group and **CONDENSED MATTER PHYSICS AND ADVANCED ELECTRONICS** in the other group. Half of the students will perform the experiments of Group-I and other half will perform the experiments of Group-II during the entire semester.

GROUP-I: NUCLEAR PHYSICS AND COUNTER ELECTRONICS experiments
Minimum 10 experiments are compulsory out of the followings:

1. Study of standard deviation using G-M counter
2. Half-life of ^{40}K using G-M Counter
3. Measurement of mass absorption coefficient of beta rays in given materials
4. To find range and energy of β- particles
5. To find Dead time of a GM Tube
6. Study of energy calibration of NaI(Tl) scintillation detector
7. Study and analysis of spectrum of ^{137}Cs
8. Verify inverse square law (in case of gamma rays) using scintillation spectrometer.
9. Study of Compton scattering law for energy of scattered photons
10. To determine the source strength of a given radioactive gamma source
11. Study and analysis of the spectrum of ^{60}Co
12. Measurement of Photo-peak (full energy peak) efficiency of Scintillation detector.
13. To verify the given Boolean identities on the ALU system.
14. To study various Encoders and Decoders, and Random Access Memory (RAM) circuit.
15. To study the various counters.
16. To study the left and right shift registers and ring counters.
17. To study the operation of multiplexer and demultiplexer circuits.

GROUP-II: CONDENSED MATTER PHYSICS AND ADVANCED ELECTRONICS experiments
Minimum 10 experiments are compulsory out of the followings:

1. Find the value of the 'g' factor in a DPPH sample by using ESR technique.
2. To determine the Curie temperature of a given PZT sample.
3. Determine the coercivity, retentivity and saturation value of magnetic induction of the given sample by studying the B-H loop.
4. Determine the Hall coefficient of the given sample and hence find the carrier concentrationand mobility.
5. Find the band gap energy of the given semi-conductor sample by four probe method.
6. Measurement of susceptibility of paramagnetic solutions by Quinck's Tube Method.
7. Measurement of magneto-resistance of a semi-conducting sample.
8. Study of Dispersion relation for Mono-atomic and Diatomic lattices using Lattice dynamic kit.
9. Study of solar cell and characteristics
10. Determination of velocity of ultrasonic wave in liquids hence to find the compressibility.
11. Frank Hertz experiment for Quantization of Bohr's model of atom.

12. To study Digital to Analog Converter and Analog to Digital Converter.
13. To study multivibrators (astable, monostable and bistable) using discrete components.
14. To study the multivibrators (BMV, AMV and MMV) using IC-555.
15. To study Timer Integrated circuit IC-555.
16. To study the basic operational amplifier (Model 741).
17. To study the applications of operational amplifier (Model 741).
18. To study the voltage controlled oscillator (VCO)
19. To study the voltage regulator using IC 317.
20. Programming with Microprocessor training kit (8085 processor)

Course Learning Outcomes: On satisfying the requirements of this course, students will have the knowledge and skills to:

1. design a complete experimental apparatus able to implement Nuclear Physics, advanced condensed matter physics and electronics experiments.
2. acquire basic skills to critically elaborate and interpret experimental data.
3. apply key analysis techniques to typical problems encountered in the field
4. have hands-on laboratory training allows the student to achieve advanced capabilities in equipment handling and experimental problem solving.
5. gain and apply discipline-specific knowledge, including self-directed research into the scientific literature.

PH-2.1.6: COMPUTER LAB

Maximum Marks: 50 | **Time Allowed: 3 Hours**
External Examination: 35 (Pass Marks: 12) | **Pass Percentage: 35%**
Internal Assessment: 15 (Pass Marks: 05) | **Teaching Hours: 60 (2 Credits)**

Out of 50 Marks, internal assessment (based on performance of the candidate in the computer lab and attendance) carries 15 marks, and the final examination at the end of the semester carries 35 marks.

This laboratory comprises of any ten of the following Physics problems to be solved using computer.

1. To print even and odd numbers between given limit
2. To generate prime numbers between given limit.
3. To construct Fibonacci series.
4. To find maximum and minimum number among a given data.
5. To find area of a triangle.
6. To find factorial of a number.
7. To find roots of a quadratic equation.
8. To construct AP and GP series.
9. To construct Sine and Cosine series.
10. Conversion of temperature scale.
11. Addition of two matrices.
12. Motion of horizontally thrown projectile.
13. Finding mean and standard deviation of a given data.
14. To find perfect numbers.

Text Books:

1. V.K. Mittal, R.C. Verma and S.C. Gupta, FORTRAN for Computational Physics, Ane Books Ltd.
2. V. Rajaraman, Computer Oriented Numerical Methods, PHI Publications
3. R.C. Verma, Computer Simulation in Physics (using FORTRAN), Anamaya Pub.
4. J.H. Mathews, Numerical Methods, Prentice Hall of India, New Delhi

Core Paper-XII

PH-2.2.1: CONDENSED MATTER PHYSICS-II

Maximum Marks: 100 | **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) | **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) | **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: This paper enables the students to understand about magnetic and Dielectric properties of matter, Ferroelectric materials, superconductivity phenomenon, defects and disorders in solids so that they are prepared with the techniques used in investigating these aspects of matter in condensed phase.

Section A

Magnetic properties: Langevin diamagnetism equation, Paramagnetism, Quantum theory of para-magnetism, magnetism of rare earth and iron group ions, Crystal field splitting, Quenching of orbital angular momentum, Conduction electron magnetization, Cooling by adiabatic demagnetization, Ferromagnetism, Magnetization at absolute zero and its temperature dependence, Spin waves and magnons in ferromagnetics, Neutron magnetic scattering, Ferrimagnetic order and iron garnets, Anti ferromagnetic order and susceptibility, Anti ferromagnetic magnons, Ferromagnetic domains, Bloch wall, Origin of domains, Application of soft and hard magnetic materials.

Dielectric absorption of ferroelectric materials: Complex dielectric constant, Debye equations, Optical absorption, Ferro-electric materials and their classification, Dipole theory of ferroelectricity, Objections against dipole theory, Ferroelectricity in BaTi03, Landau theory of phase transition.

Section B

Superconductivity: Survey of traditional and high Tc superconductors, Meissner effect, Heat capacity, Energy gap, Isotope effect, Stabilization energy density, London equations, Coherence length, Some basic ideas of BCS theory, Flux quantization in superconducting ring, Duration of persistent currents, Type II Superconductors, Single particle Tunneling, DC and AC Josephson effects. Macroscopic quantum interference, SQUIDS and its applications.

Plasmons, polaritons, polarons: Dielectric function of the electron gas, Plasmons, Electrostatic screening, Mott transition, polaritons and LST relation, polarons.

Defects and disorders: Point imperfections, Dislocations and its types, Burger's vector, Stress field of dislocations. Low angle and large angle grain boundaries. Dislocation multiplication by Frank-Read source and strength of alloys.

Course Learning Outcomes: After the completion of the course, students will be able to:

- Understand the magnetic behaviour of the solids and be able to distinguish types of magnetism.
- Understand the concept of Dielectric and Ferroelectric materials.
- Understand the concept of superconductivity.
- Tailor the properties of the solids with proper understanding.
- Describe how and why defects and disorders in materials affect properties and limit their use.

Text Books:

1. Introduction to Solid State Physics; C. Kittel (7^{th} Ed.), Wiley Eastern Ltd.,1995
2. Solid State Physics; A.J. Dekker (2^{nd} Ed.), Mc Millan India Ltd.

Reference Book:

- Solid State Physics; Ashroft and Mermin, Thomson learning International.
- Elements of Solid State Physics; J.P. Srivastava, 4^{th} Edition, 2015, Prentice-Hall of India Private Limited, N. Delhi.
- Elementary Solid State Physics, M. Ali Omar, 1999, Pearson India

Core Paper-XIII

PH-2.2.2: NUCLEAR AND PARTICLE PHYSICS

Maximum Marks:	**100**	**Time Allowed:**	**3 Hours**
External Examination:	**70 Marks (Pass Marks: 25)**	**Pass Marks:**	**35%**
Internal Assessment:	**30 Marks (Pass Marks: 11)**	**Teaching Hours:**	**60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: Student gets acquainted with basic laws of nuclear and particle physics. Acquired competence: Knowledge of basic decay processes. Capability of elementary problem solving in nuclear and particle physics, and relating theoretical predictions and measurement results.

Section A

Nuclear Reactions-I: Types of Nuclear Reactions and Conservation Laws, Energetics of Nuclear Reactions, Isospin, Reaction cross-sections.

Neutron Physics: Neutron Sources, Absorption and Moderation of Neutrons, Neutron Detectors

Nuclear Reactions-II: Experimental Techniques, Coulomb Scattering, Nuclear Scattering, Compound-Nucleus Reactions, Direct Reactions, Heavy Ion Reactions, Fission and Fusion.

Accelerators: Cyclotron, Van de Graaff & Pelletron Accelerators, Synchrotrons, Colliding Beam Accelerator.

Section B

Particles and Forces: Classification and Properties of Hadron and Leptons and Fundamental Forces.

Conservation Laws: Parity and Isospin strangeness, Operations and transformations, Baryons and Leptons Conservation, C, P and CP Violation in Weak Interactions, K-decays, CPT invariance (Statement and consequences).

Meson Physics: Yukawa's Hypothesis, Discovery and properties of pions and muons and Tau Lepton Spin, parity and isospin of π mesons.

Strange Particles: Mass and lifetime for K-meson. Relativistic kinematics**,** Gellmann- Nishijima Scheme, Baryons and Meson Multiplets

Quark Model: Development, Meson Baryon construction, Colour Quantum Number. Magnetic Moments, Nucleon Structure from Scattering and Evidence of Quark Structure. Application of symmetry arguments to particle reactions.

Course learning outcomes: Students will have achieved the ability to:

- Basic knowledge nuclear and particle physics. Knowledge and understanding of the elementary particle interactions. Capability of relating the theory predictions and measurements.
- Understanding of various particle interactions and their interrelation. Relation of basic laws of particle physics and macroscopic physics phenomena. Usage of basic laws in determination of particle properties and properties of processes in the subatomic world.

Text Book:

1. Introductory Nuclear Physics: K.S. Krane, John Wiley & Sons, New York

Reference Books:

- Elementary Particle Physics: I.S. Hughes, Cambridge Univ. Press
- Introduction to Elementary Particles: D.J. Griffiths, John Wiley & Sons.
- Introduction to Particle Physics: M. P. Khanna, Prentice Hall of India (2004)

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Elective Paper Option (iv) **PH-2.2.3 or PH-2.2.4: RADIATION PHYSICS**

Maximum Marks:	**100**	**Time Allowed:**	**3 Hours**
External Examination:	**70 Marks (Pass Marks: 25)**	**Pass Marks:**	**35%**
Internal Assessment:	**30 Marks (Pass Marks: 11)**	**Teaching Hours:**	**60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objective: The aim and objective of the course on Radiation Physics is to expose the students of M.Sc. Physics class to reactor physics, analysis of nuclear spectroscopy data and details of various experimental techniques.

Section A

Thermal Neutrons: Prompt and delayed neutrons, Neutron yield and neutron production ratio, Energy distribution of thermal neutrons, Effective cross section of thermal neutron Slowing down of reactor neutrons, Transport mean free path and scattering cross-section, Average logarithmic energy decrement, slowing down power and moderating ratio, Resonance escape probability.

Nuclear Chain Reaction: Neutron cycle and multiplication factor Neutron leakage and critical size, Nuclear reactors and their classification.

Interaction of Nuclear Radiation with Matter: Introduction, Interaction of light charged particles with matter, Interaction of Heavy charged particles with matter, Interaction of gamma ray with matter, Absorption coefficient of gamma ray, Photoelectric effect, Compton effect, Pair production.

Section B

Nuclear Radiation Detectors: Brief Overview: Introduction, Gas filled detectors, Ionization chamber, Proportional counter, Geiger Muller counter, Scintillation detectors, Semiconductor radiation detectors, Construction of a semiconductor radiation detector, Neutron counters, Brief survey of nuclear electronic systems.

General Properties of Radiation Detectors: Sensitivity, Detector response, Energy resolution, Response function (Qualitative Only), Response time, Detector efficiency, Dead time and its measurement.

Biological Effects of Radiation: Types and sources of ionizing radiation, random nature of radiation, fluence & its rate (qualitative only), Kerma its components & its relation to energy fluence (qualitative only). Dosimetric units: Roentgen, Absorbed dose, rad, Gray, Relative biological effectiveness and quality factor, Dose equivalent, rem, Sievert, Effective dose, Typical doses from sources in the environment, Biological effects: high dose received in a short time, Low-level doses, Dose limits, Shielding.

Irradiation Techniques for Elemental Analysis: Principles, instrumentation and spectrum analysis of XRF, PIXE and neutron activation analysis techniques, Rutherford backscattering.

Course Learning Outcomes: On completion of this course, student will be able to understand the:

- Basics of thermal neutrons physics
- Concept of nuclear chain reaction.
- Different types of Nuclear reactors.
- General properties of radiation detectors
- Analysis of nuclear spectrometric data
- Principle, instrumentation and spectrum analysis of XRF, PIXE and neutron activation analysis techniques.
- Background and detector shielding

Text Books:

1. S.E. Liverhant: Elementary Introduction to Nuclear Reactor Physics

2. R.M. Singru: Introduction to experimental nuclear physics, Wiley Eastern Pub., N. Delh
3. W R Leo: Techniques for Nuclear and Particle Physics Experiments by, Springer-Verlag, Berlin Heidelberg
4. H.R.Verma: Atomic and Nuclear Analytical Methods, Springer Berlin Heidelberg, New York
5. F.H. Attix: Introduction to Radiological Physics and Radiation Dosimetry-Wiley-VCH, 1986

Reference Books

- K.S. Krane: Introductory Nuclear Physics, John Wiley & Sons, New York
- G.F. Knoll: Radiation Detection and Measurement, Wiley, New York, 2010
- Konrad Kleinknecht: Detectors for particle radiation, Cambridge University Press, 1999
- James E. Martin(auth.) - Physics for Radiation Protection, Wiley-VCH, Third Edition, 2013

Elective Paper Option (v) **PH-2.2.3 or PH-2.2.4: ADVANCED ELECTRONICS**

Maximum Marks:	**100**	**Time Allowed:**	**3 Hours**
External Examination:	**70 Marks (Pass Marks: 25)**	**Pass Marks:**	**35%**
Internal Assessment:	**30 Marks (Pass Marks: 11)**	**Teaching Hours:**	**60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.
Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.
Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**
Course Objective: The objective of the course is to provide knowledge of advanced digital systems, the working of digital to analog & analog to digital converters, 8085 microprocessor basics, microprocessor operations and the programming model, Introduction to 8085 assembly languages, programming techniques.

Section A

Digital to analog and analog to digital converters: Binary equivalents of analog signals. Weighted register and binary ladder networks. Digital to analog converter, Performance criteria for digital to analog converters. Resolution and accuracy. Analog to digital converters. Performance criteria for analog to digital converters; counter; up down, Successive approximation; Dual slope analog to digital converters.
General introduction of Microprocessors, assembly and computer languages.
Microprocessor Architecture: Registers, ALU, timing and control section and their arrangement in 8085 microprocessor. Microprocessor operations and its bus organization.
Memory: ROM; Bipolar and MOS ROMs. RAM; Bipolar and Static/Dynamic MOS RAMs, Addressing of a RAM and Applications of RAM. Memory Mapping, addressing and interfacing with microprocessor.
I/O Devices and their interfacing: Input/output devices, Basic interfacing concepts; Interfacing output displays, interfacing of input devices, Memory-Mapped I/O (8085 based).

Section B

Introduction to 8085 assembly language programming: The 8085 programming model, Instruction classification, Instruction and data format.
Introduction to 8085 instructions: Data transfer (copy) operations. Arithmetic operations. Logic operations. Branch operations. Writing assembly language programs.
Programming techniques with additional instructions: Programming techniques; Looping; Counting; and indexing. Additional data transfer and 16 bit arithmetic instructions. Logic operations: Rotate, Compare.
Stack and Subroutines: Stack, Subroutine, conditional Call and Return Instructions. Introduction to Single Chip Microcontrollers, 16, 32 and 64 bits processors.

Course Learning Outcomes: Upon completion of this course, the students shall be able to:

- Learn the basics of Digital to Analog and Analog to Digital Conversion circuits and their working principles.
- Learn importance of Microprocessors in designing real time applications
- Describe the 8085 Microprocessors architectures and its feature.
- Develop interfacing to real world devices.
- Learn 8085 assembly language programmes.
- Learn programming techniques.
- Learn use of hardware & software tools.

Text Books:

1. M. Singh, An Introduction to Digital Electronics, Kalyani Publishers, N.Delhi

2. Ajit Paul, Microprocessors Principles and Applications, Tata McGraw-Hill.
3. R. S. Gaonkar, Microprocessor Architecture Programming and Applications, Willey Eastern.

Reference Books:

- Millman and Grabel: Microelectronics, 2nd Ed., MHB.
- Millman: Microelectronics, Digital and Analog Circuits and Systems, MHB.
- R. L. Tekheim: Microprocessor Fundamentals, MHB.

Elective Paper Option (vi) **PH-2.2.3 or PH-2.2.4: THEORETICAL NUCLEAR PHYSICS**

Maximum Marks: 100 **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: Student gets acquainted with basic theoretical of nuclear physics. Acquired competence: Knowledge of basics of angular momentum, nuclear models and scattering theory.

Section A

Angular momentum theory: Angular momentum operators and their matrix representations. Vector addition of two angular momenta. Clebsch-Gordan coefficients and their properties. Rotation operators, Rotation D-matrices and their properties.

Problems: Matrix representation of angular momentum operators for j =1 case, Evaluation of C-G Coefficient For j_1=1/2 and j_2 = ½ case. Evaluation of Rotation matrices for simple cases.

Spherical tensors. Wigner-Eckart theorem and its applications, Wigner 3-j symbols. Addition of three angular momenta. Definition of Racah coefficients and their properties.

Problems: Matrix representation of angular momentum operators

Nuclear force and two nucleon systems: Symmetries of nucleon-nucleon force. Isospin of two nuclear systems. Solution of Deuteron problem, Deuteron magnetic dipole moment. Evaluation of Deuteron electric quadrupole moment. Tensor force and Deuteron D-state.

Problems: Evaluation of nuclear magnetic moments in the Schmidt limit. Symmetry properties of two nucleon spin and isospin wave functions.

Section B

Nuclear models: Deformable liquid drop and nuclear fission. Single particle shell model, spin and parity of ground state of nuclei. Extended single particle shell model, seniority scheme and reduced isospin, configuration mixing, Simple description of two particle shell model spectroscopy.

Problems: Calculation of nuclear ground state spin and parity of odd-A nuclei using shell model (with examples), Spin-orbit coupling in shell model. Description of two particle shell model spectroscopy (with examples);

Vibrational model. Rotational model, nuclear rotational wave functions and energy spectra from deformed even-even and odd-A nuclei. Nilsson model. Nilsson diagrams. Statistical model, evaporation spectra and nuclear temperature. Interacting Boson Model.

Problems: Calculation of nuclear spin and parity for deformed nuclei using Nilsson diagrams.

Scattering Theory: Elastic scattering of spin zero projectile from a spin zero target, total cross section for elastic scattering and optical theorem. Integral equation for the scattering wave function and Born approximation. Low energy scattering parameters. Scattering from a complex potential.

Problems: Discussion of low energy scattering parameters.

Text Books:

1. Introductory Nuclear Physics by S. S. M. Wong, Prentice Hall of India Pub., New Delhi
2. Nuclear Physics by R. R. Roy and B. P. Nigam, New Age Publication, New. Delhi
3. Nuclear and Particle Physics by W. E. Burcham and M. Jobes, Addison Wesley Pub. (Ind. Ed.)

Reference Books:

- Nuclear reactions by D. F. Jackson
- Nuclear Structure by M. K. Pal, Affiliated East-West Press
- Physics of the Nucleus by M.A. Preston

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Elective Paper Option (vii) **PH-2.2.3 or PH-2.2.4: PLASMA PHYSICS**

Maximum Marks: 100
External Examination: 70 Marks (Pass Marks: 25)
Internal Assessment: 30 Marks (Pass Marks: 11)

Time Allowed: 3 Hours
Pass Marks: 35%
Teaching Hours: 60 (4 Credits)

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: To understand the concept of plasma and its occurrence. To introspect the plasma parameters and various phenomena associated with its applications. To familiarize with various waves and instabilities in plasma.

Section A

Basics of Plasmas: Plasma as a fourth state of matter, Occurrence of plasma in nature, Definition of plasma, Concept of temperature, Debye shielding, The Plasma Parameter: Criteria for Plasma, Applications of Plasma Physics: Gas discharges, Controlled Thermonuclear Fusion, Space Physics, Modern Astrophysics, MHD Energy Conversion and Ion Propulsion, Solid State Plasmas, Gas Lasers.

Plasma Production and measurements: DC Conductivity and Negative Differential Conductivity, Plasma response to constant amplitude radio frequency field, Ponderomotive Force, Cyclotron Motion. Plasma response to Uniform RF Electric field, Conductivity Tensor, Cowling Effect and Cyclotron Resonance Heating.

Waves and Instabilities: Electromagnetic wave Propagation in Plasma: Effective Plasma Permittivity, Dispersion relation. Electromagnetic wave Propagation in Inhomogeneous, Electrostatic waves in Plasma: Electron and Ion Susceptibility, Langmuir Wave, Ion Acoustic Wave, Surface Plasma Wave.

Classification of Instabilities: Two stream instability, Weibel Instability and Rayleigh Taylor Instability.

Section B

Plasma confinement: Motion of Charged particles in a constant uniform magnetic field, Motion in Constant and Uniform Electric and Magnetic fields, Motion in Inhomogeneous and Curved Magnetic Field. Magnetic Moment Invariance, Magnetic Mirrors, Motion in Non-Uniform E Field, Tokamak: Its schematic and operation.

Waves in Magnetized Plasma: Electromagnetic Waves in Magnetized Plasma, Longitudinal Electromagnetic Wave Propagation: cut-offs, resonances and Faraday rotation, Electromagnetic Waves propagation at oblique angles to magnetic field in a plasma, Ion Acoustic, Ion Cyclotron and Magnetosonic Waves in Magnetised Plasma.

Applications: Plasma Processing of Materials, Laser driven Electron Acceleration, Laser driven Proton Acceleration, Laser Ablation of Materials, Laser Driven Fusion.

Course Learning Outcomes: After completion of the course, student will be able to:

- Interpret the basics of the plasma parameters.
- Analyze the behavior of electromagnetic waves and instabilities with plasma.
- Introspect the applications in plasma processing of materials, magnetic fusion etc.
- Apply knowledge of physics to become successful in national level examinations like NET, SLAT, GATE etc. And engage in research in the field of physics.

Text Books:

1. Introduction to Plasma Physics and Controlled Fusion: F F Chen-Springer, 1984.
2. Propagation of Electromagnetic Waves in Plasma, V.L. Ginzburg, Gordan and Breach, Inc.
3. Fundamental of Plasma Physics: S R Seshadri-American Elsevier Pub. Co. 1973.

Reference Books:

- Plasma Physics: R.O. Dendy-Cambridge University Press, 1995.
- Ideal Magnetohydrodynamics: J P Friedberg-Springer, Edition, 1987.
- Plasma Dynamics: Boyd, T.J.M. and Sanderson, J.J., Nelson, 1969.

Elective Paper Option (viii) **PH-2.2.3 or PH-2.2.4: EXPERIMENTAL TECHNIQUES IN PHYSICS**

Maximum Marks: 100 **Time Allowed: 3 Hours**
External Examination: 70 Marks (Pass Marks: 25) **Pass Marks: 35%**
Internal Assessment: 30 Marks (Pass Marks: 11) **Teaching Hours: 60 (4 Credits)**

Internal assessment, based on two mid-semester tests/internal examinations, class tests, written assignments/project work and lecture attendance, carries 30 marks and the final examination at the end of semester carries 70 marks.

Instructions for the Paper Setter: The question paper will consist of three sections A, B and C. Each section, A and B will have four questions from respective sections of the syllabus. Section C will have 10 short answer type questions, which will be set from the entire syllabus uniformly. Each question of sections A and B will carry 10 marks and section C will carry 30 marks.

Instructions for the candidates: The candidates are required to attempt any two questions out of four from each section A and B and the entire section C of the question paper. Each question of sections A and B carries 10 marks and section C carries 30 marks. **Use of scientific calculator is allowed.**

Course Objectives: This course has been formulated to introduce students to some important techniques for the fabrication and characterization of different types of materials including thin films. This course also provides a detailed account of some common experimental techniques in physics research. It introduces the basic working principles, the operational knowledge, the strength and limitations of the techniques.

Section A

Thin Film Deposition Technology: Thermal evaporation – general considerations and evaporation methods. Cathodic sputtering – sputtering process, glow discharge sputtering, sputtering variants and low pressure sputtering. Chemical methods – electrodeposition and chemical vapour deposition. Vacuum deposition apparatus – vacuum systems and surface deposition technology.

Thickness Measurements and Analytical Techniques: Thickness measurement – electrical methods, microbalance monitors, mechanical method, radiation absorption and radiation emission methods, optical interference methods. Analytical techniques – chemical analysis and structural analysis.

Section B

Methods of Surface and Structural Analysis: X-ray diffraction: Principal, Instrumentation, working and Applications; Neutron diffraction, Electron diffraction, Confocal Scanning Optical Microscopy: Basic concepts, Instrumentation, working and Applications; Scanning Electron Microscope: Basic concepts, Instrumentation & working, Applications; Transmission Electron Microscope: Basic concepts, Instrumentation & working, Applications; Scanning probe microscopy: Scanning Tunneling Microscope: Principal, Construction & working, Applications; Atomic Force Microscope: Principal, Construction & working, Applications.

Spectroscopic Techniques (Basic concepts, Instrumentation & working, Applications): UV-Visible absorption spectroscopy, X-ray photoelectron spectroscopy, Raman spectroscopy, Infrared spectroscopy, Luminescence spectroscopy, Atomic absorption spectroscopy, Mass spectroscopy, Mossbauer spectroscopy.

Course Learning Outcomes:

- After completing this course, students would be able to deal with the fabrication and characterization of materials including thin films.
- The student is able to describe and explain the working principles of the various techniques.
- The student is able to know the operational details and interpret the data obtained by these techniques.
- The course is made to understand the need of nanotechnology also. Various fabrication and characterization techniques for nanomaterial will help the students for seeking jobs in future industry.

Text Books:

1. Thin Film Phenomena: K.L. Chopra, McGraw Hill Book Company
2. Electronic Instrumentation and Measurement Techniques: W.D. Cooper and A.D. Helfrick (3rd Ed.), Prentice Hall of India Pvt. Ltd.

3. Springer Handbook of Nanotechnology Edited by Bharat Bhushan, Published by Springer.
4. Handbook of Spectroscopy Edited by G Gaugliz an T Vo-Dinh,Published by WILEY VCH Verlag GmbH & Co.

Reference Book

- Concise Encyclopedia of Materials Characterization Edited by R Cahn, Published by Elsevier.
- Dekker Encyclopedia of Nanoscience and Nanotechnology. Edited by J A Schwarz, C I Contescu and K Putyera, Published by Marcel Dekker Inc.
- Handbook of Microscopy for Nanotechnology Edited by N Yao and Z L Wang, Published by Kluwer Academic Publishers.

Elective Paper Option (ix) **PH-2.2.3 or PH-2.2.4: PROJECT WORK**

Maximum Marks: 100
Pass Percentage: 35% **Research Hours: 60 (4 Credits)**

Project allotment
M.Sc. Project to students of M.Sc. final year with a ratio of 1:2 only with respect to number of regular faculty members in the Department of Physics will be offered on ***Merit (in the 1st year of M.Sc.)/Option of the student/ Selection Process*** before the end of the 3rd semester.

Aim of Project
The aim of project work in M.Sc. 4th semesters is to expose the students to some of the preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc.

Project Guidelines
- Project work can be in Experimental Physics or Theoretical Physics in the thrust as well as non-thrust research areas of the regular faculty of the department and facilities available.
- A brief synopsis on the research project to be carried out by the student has to be submitted to the Departmental Research Committee (DRC) within first week at start of the academic session of the 4th semester.
- Finally, a report/thesis of about 60-80 pages on the work done in the project (typed on single side of the page properly hard bound) will be submitted by a date to be announced by the DRC.
- Assessment of the work done under the project will be carried out by a committee on the basis of efforts put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc. as per guidelines prepared by the DRC.
- Marks distribution is as following:

Thesis	:	40 marks
Final Seminar	:	20 marks
Monthly Reports/Seminar	:	20 marks
Viva-voce	:	20 marks

Seminar
- Students pursuing M.Sc. Projects in the 4th Semester have to give regular seminars along with the final seminar on the project duly supported by the use of multimedia. Evaluation will be carried out by DRC.

Departmental Research Committee (DRC)
All regular teaching staff and head of the Physics Department are members and Chairman of DRC respectively.

PH-2.2.5: LABORATORY PRACTICE

(i) Condensed Matter Physics and Advanced Electronics
(ii) Nuclear Physics and Counter Electronics

Maximum Marks: 100 **Time allowed: 3 Hours**
External Marks: 70 (Pass Marks: 28) **Credits: 6**
Internal Marks: 30 (Pass Marks: 12)

The final examination at the end of the semester carries 70 marks based on one full experiment requiring the student to setup the apparatus, take some data, analyze it and draw conclusion on the basis of 'Experimental Skills' as follows:

Experimental Skills: General Precautions for measurements and handling of equipment, Presentation of measurements, Fitting of given data to a graph, Results with proper significant figures and limits of error, Interpretation of results etc.

The 30 marks internal assessment is based on one seminar, viva-voce of each experiment report at the time of submission, total number of experiments performed, practical record file and attendance.

The laboratory comprises of experiments based on **NUCLEAR PHYSICS AND COUNTER ELECTRONICS** in one group and **CONDENSED MATTER PHYSICS AND ADVANCED ELECTRONICS** in the other group. The groups will get switched in this semester so that student of Group-I and Group-II can perform the experiments of other group than previous semester.

GROUP-I: CONDENSED MATTER PHYSICS AND ADVANCED ELECTRONICS experiments
Minimum 10 experiments are compulsory out of the followings:

1. Find the value of the 'g' factor in a DPPH sample by using ESR technique.
2. To determine the Curie temperature of a given PZT sample.
3. Determine the coercivity, retentivity and saturation value of magnetic induction of the given sample by studying the B-H loop.
4. Determine the Hall coefficient of the given sample and hence find the carrier concentration and mobility.
5. Find the band gap energy of the given semi-conductor sample by four probe method.
6. Measurement of susceptibility of paramagnetic solutions by Quinck's Tube Method.
7. Measurement of magneto-resistance of a semi-conducting sample.
8. Study of Dispersion relation for Mono-atomic and Diatomic lattices using Lattice dynamic kit.
9. Study of solar cell and characteristics
10. Determination of velocity of ultrasonic wave in liquids hence to find the compressibility.
11. Frank Hertz experiment for Quantization of Bohr's model of atom.
12. To study Digital to Analog Converter and Analog to Digital Converter.
13. To study multivibrators (astable, monostable and bistable) using discrete components.
14. To study the multivibrators (BMV, AMV and MMV) using IC-555.
15. To study Timer Integrated circuit IC-555.
16. To study the basic operational amplifier (Model 741).
17. To study the applications of operational amplifier (Model 741).
18. To study the voltage controlled oscillator (VCO)
19. To study the voltage regulator using IC 317.
20. Programming with Microprocessor training kit (8085 processor)

GROUP-II: NUCLEAR PHYSICS AND COUNTER ELECTRONICS experiments
Minimum 10 experiments are compulsory out of the followings:

1. Study of standard deviation using G-M counter
2. Half-life of ^{40}Kusing G-M Counter
3. Measurement of mass absorption coefficient of beta rays in given materials
4. To find range and energy of β- particles
5. To find Dead time of a GM Tube
6. Study of energy calibration of NaI(Tl) scintillation detector
7. Study and analysis of spectrum of ^{137}Cs

8. Verify inverse square law (in case of gamma rays) using scintillation spectrometer.
9. Study of Compton scattering law for energy of scattered photons
10. To determine the source strength of a given radioactive gamma source
11. Study and analysis of the spectrum of ^{60}Co
12. Measurement of Photo-peak (full energy peak) efficiency of Scintillation detector.
13. To verify the given Boolean identities on the ALU system.
14. To study various Encoders and Decoders, and Random Access Memory (RAM) circuit.
15. To study the various counters.
16. To study the left and right shift registers and ring counters.
17. To study the operation of multiplexer and demultiplexer circuits.

Course Outcomes: On satisfying the requirements of this course, students will have the knowledge and skills to:

1. Design a complete experimental apparatus able to implement Nuclear Physics, advanced condensed matter physics and electronics experiments.
2. Acquire basic skills to critically elaborate and interpret experimental data.
3. apply key analysis techniques to typical problems encountered in the field
4. Have hands-on laboratory training allows the student to achieve advanced capabilities in equipment handling and experimental problem solving.
5. Gain and apply discipline-specific knowledge, including self-directed research into the scientific literature.

Monika Sharma

(BOS Chairman) (VC Nominee) (Academic Council Nominees) (Industry Expert) (Student Alumni) (Members)

PH-2.2.6: COMPUTER LAB

Maximum Marks: 50
External Examination: 35 (Pass Marks: 12)
Internal Assessment: 15 (Pass Marks: 05)

Time Allowed: 3 Hours
Pass Percentage: 35%
Teaching Hours: 60 (2 Credits)

Out of 50 Marks, internal assessment (based on performance of the candidate in the computer lab and attendance) carries 15 marks, and the final examination at the end of the semester carries 35 marks.

This laboratory comprises of any ten of the following physics problems to be solved using computer.

1. To generate Frequency Distribution Table.
2. Solution of a differential equation by RK2 method.
3. To find area under a curve by Trapezoidal Rule and Simpson's Rule
4. Gauss elimination method.
5. Multiplication of Two Matrices.
6. Motion of Projectile thrown at an Angle.
7. Numerical Solution of Equation of Motion.
8. Simulation of planetary motion.
9. Root of an equation by Newton- Raphson method.
10. Sorting numbers by selection sort.
11. Solution of a differential equation by RK4 method.
12. Fitting straight line through given data points.
13. Roots of an equation by secant method.
14. Newton interpolation.

Text Books:

1. V.K. Mittal, R.C. Verma and S.C. Gupta, FORTRAN for Computational Physics, Ane Books Ltd.
2. V. Rajaraman, Computer Oriented Numerical Methods, PHI Publications.
3. R.C. Verma, Computer Simulation in Physics (using FORTRAN), Anamaya Pub.
4. J.H. Mathews, Numerical Methods, Prentice Hall of India, New Delhi.