

Asian Educational Institute, Patiala (PB)

(An Autonomous College)

School of Science and Mathematics



SYLLABUS

M.Sc. (Physics)-Part-2

Semester- III & IV

Session: 2026-2027

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**M.Sc. (Physics) Part-II
Semester-III
(2026-2027)**

PHY-3.1 –Condensed Matter Physics– I

**Max Marks: 100
External Marks: 70
Internal Marks: 30
Passing Marks: 35%**

**Credits: 04
Total Teaching Hours: 55 hrs**

Course Outcomes: After studying this course, the students will be able to:

CO1: Understand various structures of crystal and can draw crystal planes through the knowledge of Miller indices.

CO2: Explain the concept of diffraction and discuss various methods through which it can be observed.

CO3: Describe lattice vibrations through the concept of phonons and different models of specific heat i.e. Einstein model and Debye model of specific heat.

CO4: Analyze the Fermi surfaces and can explain different experimental methods.

CO5: List and explain the methods of synthesis and fabrication of nanomaterials and carbon nanotubes.

Instructions for the Paper Setter

The question paper will consist of three Sections: A, B and C. Section A will have four questions (from the respective section of syllabus) carrying 12 marks each, Section B will have also four questions (from the respective section of syllabus) carrying 12 marks each. Section C will consist of 11 short answer questions that will cover the entire syllabus and will be of 2 marks each.

Instructions for the Candidates

Candidates are required to attempt five questions selecting two questions from each of Section A & B and entire Section C.



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SECTION-A

Diffraction methods, Lattice vibrations, Free electrons: Diffraction methods, Scattered wave amplitude, Reciprocal lattice, Brillouin zones, Structure factor, Quasi Crystals, Form factor and Debye Waller factor, Lattice vibrations of mono-atomic and diatomic linear lattices, Free electron gas in 1-D and 3-D. Heat capacity of metals, Thermal effective mass, Drude model of electrical conductivity, Wiedman-Franz law, Hall effect, Quantized Hall effect.

Nanotechnology: 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 nanostructures and Energy bands in semiconductors: Carbon molecules, Carbon cluster, C_{60} (its crystals and superconductivity), Carbon nano tubes, their fabrication and properties, application of carbon nano tubes.

SECTION B

Optical processes: Optical reflectance, Kramers-Kronig relations, Electronic inter-band transitions, Excitons and its type, Raman Effect in crystals, Electron spectroscopy with X-rays, Energy loss of fast particles in solids.

Semiconductor Physics: 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.

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, Intrinsic carrier concentration, Intrinsic and extrinsic conductivity, 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.

Text Books:

1. Introduction to Solid State Physics; C. Kittel (7th Ed.), Wiley Eastern, N. Delhi, 1995
2. Introduction to Nano Technology: Charles P Poople, Jr. and Frank J. Owens, John Wiley & Sons Publications, 2003



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PHY-3.2 –Nuclear Physics

Max Marks: 100
External Marks: 70
Internal Marks: 30
Passing Marks: 35%

Credits: 04
Total Teaching Hours: 55 hrs

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

- CO1:** Identify basic nuclear properties and outline their theoretical descriptions.
- CO2:** Understand the nature of nuclear forces, forces between nucleons
- CO3:** Apply the semi-empirical mass formula to evaluate the binding energy of a nucleus and other binding energy related properties.
- CO4:** Describe the role of spin-orbit coupling in the shell structure of atomic nuclei and predict the properties of nuclear ground and excited states based on the shell model.
- CO5:** Understand the various nuclear reactions.
- CO6:** Explain various nuclear accelerators and analyze their role in nuclear physics experiments and other fields.

Instructions for the Paper Setter

The question paper will consist of three Sections: A, B and C. Section A will have four questions (from the respective section of syllabus) carrying 12 marks each, Section B will have also four questions (from the respective section of syllabus) carrying 12 marks each. Section C will consist of 11 short answer questions that will cover the entire syllabus and will be of 2 marks each.

Instructions for the Candidates

Candidates are required to attempt five questions selecting two questions from each of Section A & B and entire Section C.

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 and Moments: Nuclear Spin, Nuclear Moments, Measuring Nuclear Moments



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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, Even-Z Even-N Nuclei and Collective Structure, Many-Particle Shell Model, Single Particle States in Deformed Nuclei

SECTION-B

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, Optical Model, Compound-Nucleus Reactions, Direct Reactions, Resonance Reactions, Heavy Ion Reactions, Fission and Fusion.

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

Text Books:

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

Reference Books:

1. Nuclear Physics: R. R. Roy and B. P. Nigam, New Age Pub., N. Delhi
2. Nuclear Physics: W.E. Burcham and M. Jobes (Ind. Ed.), Addison Wesley

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PHY-3.3 –Advanced Quantum Mechanics

Max Marks: 100
External Marks: 70
Internal Marks: 30
Passing Marks: 35%

Credits: 04
Total Teaching Hours: 55 hrs

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

CO1: Apply the time-independent (degenerate and non-degenerate) perturbation theory for calculating the change in energy (wave function) of a quantum system.

CO2: Understand transition probabilities among different energy eigen states

CO3: Calculate the ground-state energy of a quantum system (H-atom, He-atom, SHO etc.) by using a trial wave function as employed in the variational method.

CO4: Understand the scattering theory of quantum particles.

CO5: Appreciate the pioneer work of Dirac in the field of relativistic quantum mechanics.

CO6: Understand the concept of spin and its inclusion into the total wave function of the electron and the existence of anti-particles.

Instructions for the Paper Setter

The question paper will consist of three Sections: A, B and C. Section A will have four questions (from the respective section of syllabus) carrying 12 marks each, Section B will have also four questions (from the respective section of syllabus) carrying 12 marks each. Section C will consist of 11 short answer questions that will cover the entire syllabus and will be of 2 marks each.

Instructions for the Candidates

Candidates are required to attempt five questions selecting two questions from each of Section A & B and entire Section C.

SECTION-A

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

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



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Time Independent Perturbation Theory: First order and second order perturbation theory for nondegenerate case; *Problems:* Anharmonic oscillator, He-atom; Degenerate perturbation theory, *Problems:* Stark effect, Zeeman effect.

Time Dependent Perturbation Theory: Transition probability for constant and harmonic perturbation, Selection rules, Golden rule, Induced absorption and emission, Einstein coefficients; *Problems:* 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, Green function method, Integral equation of scattering amplitude, 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. *Problems:* Scattering by three dimensional square well potential, Elastic scattering of electrons by an atom.

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, Hole theory, Non-relativistic limit, Spin and magnetic moment, Zitterbewegung, Hydrogen atom. *Problem:* Fine structure, Lamb shift, Spin-orbit coupling, Covariant form of Dirac equation, Bilinear covariants

Text Books:

1. Quantum Mechanics: P.M. Mathews and K. Venkatesan, Tata McGraw-Hill Publication, N. Delhi
2. Quantum Mechanics: M.P. Khanna, Har-Anand Publication, Delhi

Reference Books :

1. Quantum Mechanics: L. I. Schiff, Tata McGraw-Hill Publication.
2. Quantum Mechanics: V. K. Thankappan, New Age International



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Elective Theory Papers

(Option- i) PHY-3.4 –LASER Physics

Max Marks: 100
External Marks: 70
Internal Marks: 30
Passing Marks: 35%

Credits: 04
Total Teaching Hours: 55 hrs

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

CO1: Understand absorption, spontaneous and stimulated emission in two level system and the effects of homogeneous and inhomogeneous line broadening, conditions for laser amplification.

CO2: Understand the various Pumping processes and laser equation.

CO3: Classify and explain the principle and operation of different type of lasers i.e. He-Ne, carbon dioxide, N_2 , Excimer, dye, chemical, semiconductor, ruby, colour center and free electron laser.

CO5: Learn about nonlinear optics, Q- switching and Mode locking.

CO6: Describe laser spectroscopy Stimulated Raman Effect, Coherent anti-stokes Raman spectroscopy, Photo acoustic Raman spectroscopy

Instructions for the Paper Setter

The question paper will consist of three Sections: A, B and C. Section A will have four questions (from the respective section of syllabus) carrying 12 marks each, Section B will have also four questions (from the respective section of syllabus) carrying 12 marks each. Section C will consist of 11 short answer questions that will cover the entire syllabus and will be of 2 marks each.

Instructions for the Candidates

Candidates are required to attempt five questions selecting two questions from each of Section A & B and entire Section C.

SECTION A

Introductory Concepts: Absorption, Spontaneous and stimulated emission, The laser idea, Properties of laser light.

Interaction of radiation with matter: Summary of black body radiation theory, Rates of absorption and stimulated emission, Allowed and forbidden transitions, Line broadening



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mechanisms, Transition cross-section, Absorption and gain coefficient, Non-radiative decay, Decay of many atom systems,

Pumping processes: Optical and electrical pumping, Passive optical resonators: Photon lifetime and cavity Q. Plane parallel resonator; Approximate treatment, Fox and Li treatment, Confocal resonator, Stability diagram.

Laser rate equation: Three level and four level lasers: Optimum output coupling, Laser spiking.

SECTION B

Transverse and longitudinal mode selection, Q switching, Mode locking.

Types of lasers: Ruby lasers, Nd: YAG laser, He-Ne laser, CO₂ laser, N₂ laser, Excimer laser, Dye lasers, Chemical lasers, Semiconductor lasers, Colour center and free electron lasers.

Nonlinear optics: Harmonic generation, Phase matching, Optical mixing, Parametric generation of light, Self focussing, Multiquantum photoelectric effect. Two photon process theory and experiment. Violation of the square law dependence. Doppler-free two photon spectroscopy. Multiphoton processes. Phase conjugation.

Laser spectroscopy: Stimulated Raman effect. Hyper Raman effect. Coherent anti-stokes Raman spectroscopy. Spin-flip Raman laser, Photo acoustic Raman spectroscopy.

Text Books:

1. Principles of Lasers; O. Svelto, (3rd Ed.), Plenum Press
2. Lasers and its applications: A.K. Ghatak and K. Thyagrajan
3. Lasers and Nonlinear Optics: B.B. Laud (2nd Ed.), Wiley Eastern
4. Laser Electronics: J.T. Verdeyen (2nd Ed.), PHI

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(Option- ii) PHY-3.4 –Material Science-I

Max Marks: 100

External Marks: 70

Internal Marks: 30

Passing Marks: 35%

Credits: 04

Total Teaching Hours: 55 hrs

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

CO1: Enhance their basic knowledge in the field of Material Science and Crystal imperfection.

CO2: Develop deep understanding of interrelationships of structure, processing and properties of their subject materials.

CO3: Classify and explain the mechanical, thermal, electrical, chemical and optical properties of engineering materials

CO4: Interpret Phase Diagrams: Draw, analyze, and interpret cooling curves and phase diagrams for pure metals and alloys.

CO5: Classify and explain the fabrication processes of composite materials, appreciate the significance and applications of various heat treatment processes,

CO6: Analyze the normal stresses and strains for axially loaded members using Hooke's law.

Instructions for the Paper Setter

The question paper will consist of three Sections: A, B and C. Section A will have four questions (from the respective section of syllabus) carrying 12 marks each, Section B will have also four questions (from the respective section of syllabus) carrying 12 marks each. Section C will consist of 11 short answer questions that will cover the entire syllabus and will be of 2 marks each.

Instructions for the Candidates

Candidates are required to attempt five questions selecting two questions from each of Section A & B and entire Section C.

SECTION A

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.



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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 Jominy 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.

Text Books:

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



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PHY-3.5 PHYSICS LABORATORY-III

Maximum Marks: 100

Internal Marks: 30

External Marks: 70

Credits: 04

Time allowed: 3 Hours

Pass Marks: 35%

Instructions for Practical Examination:

Out of 100 Marks, internal assessment (based on seminar, viva-voice of experimental reports, number of experiments performed and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

List of Experiments: (Perform Minimum 10 experiments)

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. Determine the coercivity, retentivity and saturation value of magnetic induction of the given sample by studying the B-H loop.
10. Determine the Hall coefficient of the given sample and hence find the carrier concentration and mobility.
11. Study of solar cell and characteristics
12. Measurement of Photo-peak (full energy peak) efficiency of Scintillation detector.
13. To verify the given Boolean identities on the ALU system.
14. Programming with Microprocessor training kit (8085 processor).



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PHY-3.6 COMPUTER LAB

Maximum Marks: 100

Internal Marks: 30

External Marks: 70

Credits: 03

Time allowed: 3 Hours

Pass Marks: 35%

Out of 100 Marks, internal assessment (based on seminar, viva-voce of experimental reports, number of experiments performed and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Course Outcomes: Students will be able to write programs for solving physics problems and gain expertise in simplification of calculations, etc.

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.



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Semester-IV

M.Sc. (Physics) Part-II Semester-IV (2026-2027)

PHY-4.1 –Condensed Matter Physics– II

Max Marks: 100
External Marks: 70
Internal Marks: 30
Passing Marks: 35%

Credits: 04
Total Teaching Hours: 55 hrs

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

CO1: Differentiate between diamagnetic, paramagnetic, and ferromagnetic materials, and explain macroscopic quantum phenomena like the Meissner effect and BCS theory.

CO2: Develop understanding of phenomenon of superconductivity.

CO3: Learn about magnetic resonance and dielectric absorption of ferroelectric materials.

CO4: Understand the concept of polaritons and Polarons, Details of Plasma frequency, plasmons and anomalous skin effect.

Instructions for the Paper Setter

The question paper will consist of three Sections: A, B and C. Section A will have four questions (from the respective section of syllabus) carrying 12 marks each, Section B will have also four questions (from the respective section of syllabus) carrying 12 marks each. Section C will consist of 11 short answer questions that will cover the entire syllabus and will be of 2 marks each.

Instructions for the Candidates

Candidates are required to attempt five questions selecting two questions from each of Section A & B and entire Section C.

SECTION A

Magnetic properties of materials: Diamagnetism, Langevin diamagnetism equation, Quantum theory of diamagnetism of mononuclear system, 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,



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ferromagnetic magnons, Ferromagnetic domains, Bloch wall, Origin of domains, Application of soft and hard magnetic materials.

Magnetic resonance and dielectric absorption of ferroelectric materials: Magnetic resonance, Equations of motion, Line width and motional narrowing, Hyperfine splitting, Complex dielectric constant, Debye equations, Optical absorption, Ferro-electric materials and their classification, Dipole theory of ferroelectricity, Objections against dipole theory, Ferroelectricity in BaTiO₃, Landau theory of phase transition.

SECTION B

Superconductivity: Survey of traditional and high T_c 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, Estimation of H_{C1} and H_{C2}, Single particle Tunneling, DC and AC Josephson effects. Macroscopic quantum interference, SQUIDS and its applications.

Plasmons, polaritons, polarons and Lattice defects: Dielectric function of the electron gas, Plasmons, Electrostatic screening, Mott transition, polaritons and LST relation, polarons, Point defects, diffusion, Ionic conductivity, Photoconductivity, Concepts of traps, Colour centers, Shear strength in single crystals, 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.

Text Books:

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



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PHY-4.2 –Atomic and Molecular Physics

Max Marks: 100
External Marks: 70
Internal Marks: 30
Passing Marks: 35%

Credits: 04
Total Teaching Hours: 55 hrs

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

CO1: Understand the concept of spectrum of hydrogen, coupling scheme, lamb shift.

CO2: Explain Larmor's theorem, Zeeman effect and anomalous g-value.

CO3: Understand the spectroscopy terms like rotational levels, infrared spectroscopy.

CO4: Know about Raman spectra.

CO5: Learn about electronic spectra, Deslandre's table, symmetry properties of electronic eigen-functions.

Out of 100 Marks, internal assessment (based on two mid-semesters tests/ internal examination, written assignment/project work etc. and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks

Instructions for the Paper Setter

The question paper will consist of three Sections: A, B and C. Section A will have four questions (from the respective section of syllabus) carrying 12 marks each, Section B will have also four questions (from the respective section of syllabus) carrying 12 marks each. Section C will consist of 11 short answer questions that will cover the entire syllabus and will be of 2 marks each.

Instructions for the Candidates

Candidates are required to attempt five questions selecting two questions from each of Section A & B and entire Section C.

SECTION A

Hydrogen and Hydrogen-like ions: Series in hydrogen, circular motion, nuclear mass effect, elliptical orbits, energy levels. **Fine structure:** basic facts and Sommerfeld theory, electron spin and spin-orbit coupling, relativistic correction and Lamb shift (qualitative).

Alkali-like Spectra: General features, doublet structure, Larmor's theorem and magnetic levels, elementary theory of weak and strong magnetic fields, **Zeeman Effect in doublet spectra:** anomalous Zeeman effect and the anomalous g-value. Pauli's principle and shell structure: Systems with several electrons and spin functions.

Complex Spectra: LS-Coupling scheme, normal triplets, basic assumptions of the theory, identification of terms, selection rules, jj- coupling (Qualitative)



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SECTION - B

Infrared and Raman Spectra: Rigid rotator, energy levels, spectrum (no derivation of selection rules), Harmonic oscillator: energy levels, eigenfunctions, spectrum, comparison with observed spectrum, Raman effect, Quantum theory of Raman effect, Rotational and Vibrational Raman spectrum.

Anharmonic oscillator: energy levels, Infrared and Raman Spectrum, Vibrational frequency and force constants. Non-rigid rotator: energy levels, spectrum, Vibrating-rotator energy levels, Infrared and Raman spectrum (no derivation of Dunham coefficients), Symmetry properties of rotational levels, influence of nuclear spin. Electronic Spectra: Electronic energy and potential curves, resolution of total energy, Vibrational Structure of Electronic transitions. General formulae, Deslandre's table, absorption sequences (qualitative) and Vibrational analysis, **Rotational Structure of Electronic bands:** General relations, branches of a band, band-head formation, Intensity distribution in a vibrational band system. Franck Condon Principle and its wave mechanical formulation. **Classification of electronic states:** Orbital angular momentum, Spin, total angular momentum of electrons, Symmetry properties of electronic eigen functions.

Text Books:

1. Atomic Spectra: H. Kuhn (Longman Green) 1969.
2. Molecular Spectra and Molecular Structure I: G. Herzberg (Van-Nostrand Rein-hold), 1950.
3. Atomic Spectra: H.E. White (McGraw Hill) 1934.
4. Fundamentals of Molecular spectroscopy: Banwell and McCash (Tata McGraw Hill), 1994.
5. Molecular Spectroscopy: S. Chandra (Narosa), 2009.
6. Atomic, Molecular and Photons, Wolfgang Damtrodes (Springer), 2010.

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Elective Theory Papers

Option (i) **PHY- 4.3 & 4.4 EXPERIMENTAL TECHNIQUES IN PHYSICS**

Max Marks: 100
External Marks: 70
Internal Marks: 30
Passing Marks: 35%

Credits: 04
Total Teaching Hours: 55 hrs

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

CO1: Classify transducers and explain analytical techniques used in experimental physics.

CO2: Describe the principles of thermal evaporation, cathodic sputtering, glow discharge sputtering.

CO3: Explain the working principles of Scanning Electron Microscope, Transmission Electron Microscope, Scanning Tunneling Microscope, Atomic Force Microscope and differentiate between their resolution and applications.

CO4: Describe the basic concept of spectroscopic techniques and discuss their applications in material characterization.

CO5: Explain the concept, working and applications of Magnetometers, Vibrating sample magnetometer and SQUID magnetometer.

Instructions for the Paper Setter

The question paper will consist of three Sections: A, B and C. Section A will have four questions (from the respective section of syllabus) carrying 12 marks each, Section B will have also four questions (from the respective section of syllabus) carrying 12 marks each. Section C will consist of 11 short answer questions that will cover the entire syllabus and will be of 2 marks each.

Instructions for the Candidates

Candidates are required to attempt five questions selecting two questions from each of Section A & B and entire Section C.

SECTION A

Transducers: Transducers as input elements to instrumentation systems, classification of transducers, selecting a transducer, strain gauges, displacement transducers, temperature measurements, photosensitive devices.



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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, Analytical Techniques and Transducers 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

Diffraction techniques: Principal, Instrumentation, working and applications of X-ray diffraction, Neutron diffraction, Electron diffraction

Confocal Scanning Optical Microscopy: Basic concepts, Instrumentation & working, Applications

Electron microscopy: 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

Magnetometers: Vibrating sample magnetometer: Basic concepts, Instrumentation & working, Applications; SQUID magnetometer: Basic concepts, Instrumentation & working, Applications

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 Gauglitz and T Vo-Dinh, Published by WILEY VCH Verlag GmbH & Co.



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Option (ii) PHY- 4.3 & 4.4 Advanced Electronics

Max Marks: 100
External Marks: 70
Internal Marks: 30
Passing Marks: 35%

Credits: 04
Total Teaching Hours: 55 hrs

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

CO1: Understand the principles, operation, and performance characteristics of DACs and ADCs used in digital measurement and instrumentation systems.

CO2: Explain the architecture, operation, memory organization, and I/O interfacing of the 8085 microprocessor.

CO3: Apply memory interfacing, memory mapping, and I/O interfacing concepts to microprocessor-based data acquisition and control systems used in physics laboratories.

CO4: Develop and test 8085 assembly language programs for solving basic computational and instrumentation-related problems.

CO5: Describe the fundamentals of microcontrollers and contemporary processor architectures, and recognize their applications in scientific instrumentation and automation.

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).

Microcomputer: Example of an 8085 based single Board microcomputer.



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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.

Text Books:

1. An Introduction to Digital Electronics: M. Singh, 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:

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

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Option(iii) PHY-4.3 Material Science-II

Max Marks: 100
External Marks: 70
Internal Marks: 30
Passing Marks: 35%

Credits: 04
Total Teaching Hours: 55 hrs

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

CO1: Develop comprehensive understanding of structure, processing, properties and applications of polymeric, ceramic, composite, metallic and alloy materials used in engineering and advanced technologies.

CO2: Explain the structure-property relationships governing the mechanical, thermal, electrical and magnetic behavior of engineering materials and their role in material selection.

CO3: Understand the concept of superconductivity and acquire the indepth knowledge of conducting, semiconducting, dielectric and magnetic materials.

CO4: Appreciate the importance of advanced materials in science, engineering and emerging technologies.

SECTION A

Polymeric Materials: Monomers of polymers, Degree of polymerization, Mechanism of polymerization, Additives in polymers, strengthening mechanisms of polymers, Deformation of polymers, Stereo-tactic synthesis, Plastics. Fibers and filaments. Rubber, Elastomer, Thermal behaviour of polymers. Glass transition temp. Special purpose plastics.

Ceramic Materials: Refractories, Silica and silicates, Glasses, Glass-forming constituents, Types of glasses, Perovskite structures of mixed oxides, Lime, Cement, Cement concrete, Reinforced cement concrete (RCC), Pre-stressed concrete, Rocks and stones, Clay and clay-based ceramics, chemically bonded ceramics.

Composite Materials: Agglomerated composites, Cermets, Laminates, Reinforced composite materials, Classification of reinforced composite materials. Particulate materials, Flake composites, Whisker reinforced composites, Hybrid composites, Sandwich composites, Fiber-reinforced glass and glass ceramic composites, Polymer concrete, Fiber reinforced concrete



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(pRC), MMC and wood composites, Advantages and limitations of composites, Fibers, Forms of reinforcing fibers. Mechanics of composite laminates, Generalized Hook's law and elastic constants, Applications and mechanical properties.

Materials and Alloys: Alloys; Alloys in different applications: Heat resisting alloys, Cryogenic alloys, Bearing metals (Babbitts), Metals and alloys for nuclear industry, Common ferrous and non-ferrous alloys, Tool and die steels, Fusible alloys; Materials for rocket and missile, Materials in robots, Materials for special cases.

SECTION B

Conductors and Semiconductors: Conductivity; Charge carriers, Mean free path, Conductors and resistors, Factors affecting resistivity; Semiconductors, Intrinsic and extrinsic semiconductors, Compound semiconductors and semiconductor devices, Photoelectric effect and its applications, Hall effect, Fabrication of integrated circuits, Semiconductor lasers, Materials for advanced electronic devices and fiber optics

Dielectric Materials: Classification of dielectrics, Polarization; Basic properties of dielectrics: Electrical susceptibility, Power loss, Electric- breakdown; Effect of temperature and frequency on permittivity, Insulating materials, Ferro-electrics, Piezo-electrics, Electrets, Pyro-electrics and Electrostriction.

Magnetic Materials: Classification of magnetic materials – Diamagnetic, Paramagnetic, Ferromagnetic, Anti-ferromagnetic and Ferrites, Curie temperature, Laws of magnetic materials, Magnetization curve, Magnetic hysteresis loop, Hysteresis losses, Domain theory, Magnetic materials: Soft and hard magnetic materials, Magnetostriction, Magnetic tapes and films, Metallic glasses and magnetic bubbles.

Superconductors: Properties of superconductors, types of superconductors, Critical magnetic field and critical temperature, Mechanism of super-conduction, Ideal and hard superconductors, Current applications and limitations, Milestones in research and development of superconductors, Present scenario of high temperature superconductors.

Text Books: 1.

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



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PHY-4.5 PHYSICS LABORATORY-IV

Maximum Marks: 100
Internal Marks: 30
External Marks: 70

Credits: 04
Time allowed: 3 Hours
Pass Marks: 35%

Instructions for Practical Examination:

Out of 100 Marks, internal assessment (based on seminar, viva-voice of experimental reports, number of experiments performed and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

List of Experiments: (Perform Minimum 10 experiments)

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. Measurement of wavelength, frequency, VSWR and Reflection coefficients of microwaves.
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 voltage controlled oscillator (VCO).
15. Programming with Microprocessor training kit (8085 processor)



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COMPUTER LAB

Maximum Marks: 100

Internal Marks: 30

External Marks: 70

Pass Marks: 35%
Time allowed: 3 Hours

Instructions for Practical Examination:

Out of 100 Marks, internal assessment (based on seminar, viva-voce of experimental reports, number of experiments performed and attendance) carries 30 marks, and the final examination at the end of the semester carries 70 marks.

Course Outcomes: Students will be able to write programs for solving physics problems and gain expertise in simplification of calculations, etc.

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.



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