TECHNO INDIA UNIVERSITY
WESTBENGAL

EM 4, Sector V, Salt Lake, Kolkata-700091, West Bengal, India
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2-Year Master of Science (M.Sc.) Curriculum and Syllabus for Physics

Fourth Semester

Course Code	Course Title	Credit
TIU-PPH-S202	Career Advancement Skill Development	3
TIU-PPH-T202	Material Physics II (Special Paper – II*)	3
TIU-PPH-T204	Nuclear Physics II (Special Paper – II*)	3
TIU-PPH-T206	Superconducting Materials and Devices	3
TIU-PPH-E202	Advanced Condensed Matter Physics (Elective **)	3
TIU-PPH-E204	Introduction to Plasma Physics (Elective **)	3
TIU-PPH-E206	Advanced Optics and Holography (Elective **)	3
TIU-PPH-L202	Advanced Physics Lab	3
TIU-PPH-P298	Project II	6
TIU-PPH-G298	Comprehensive Viva	2
TIU-PES-S298	Entrepreneurship Skill Development	2
	Total	**25**

*Special Paper – II (Any One) –

[A] Material Physics II -
[B] Nuclear Physics II

**Elective (Any One) –

[A] Introduction to Plasma Physics
[B] Advanced Optics and Holography
[C] Advanced Condensed Matter Physics

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SEMESTER IV

TIU-PPH-T202: MATERIAL PHYSICS II (SPECIAL PAPER – II) L-T-P-C: 3-1-0-3]

Dielectric and Optical properties of materials: Theory of Electronic polarization and optical absorption, Ionic polarization, orientational polarization. Polarisation mechanism, Claussius-Mosotti equation for an isotropic linear dielectric, Temperature dependence of Dielectric Constants and Permanent Molecular dipole moment. Response of dielectrics to alternating fields.

Optical phonon mode in an ionic crystal: Interaction of electromagnetic waves with optical modes, Polariton, Dispersion curves of Transverse Optical (TO) phonon and optical photon in a diatomic ionic crystal, LST relation. Dielectric function of the electron gas: Plasmon. Exciton, Metal-Insulator transition.

Ferroelectric crystal: Theory of Ferroelectric transition- first order and second order phase transitions. Antiferroelectricity, Piezo electricity, Electrostriction.

Luminescence, Fluorescence, Phosphorescence, Raman scattering, Spectroscopic techniques.

Nanotechnology: Theoretical aspects of nanomaterials, preparation, characterisation and application of nanomaterials, electronic properties of low dimensional systems

Magnetism in Reduced Dimension: Techniques XMLD, XMCD, MFM, Spin-Glass systems,

Magnetism of nanoparticles, nano-wires, thin films, Magnetoresistance, GMR, TMR, CMR etc.,

Magnetic domain walls, domain wall dynamics.

Polymer Physics: Introduction to Polymer Physics, Different types of polymers, conjugate polymers and its different properties.

Text:

1. Solid State Physics – Ashcroft amd Mermin
2. Solid State Physics – Kittel
3. Electronics – Millman

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TIU-PPH-T204: NUCLEAR PHYSICS II (SPECIAL PAPER – II) [L-T-P-C: 3-1-0-3]

Heavy Ion collisions: Collisions near the Coulomb barrier: Semiclassical concepts, Elastic scattering, Coulomb excitation, Deep inelastic collisions, Fusion, Collisions near the Fermi velocity,

Nuclear Fission: Spontaneous fission, Mass energy distribution of fission fragments, Bohr-Wheeler theory, Fission isobars, Super-heavy nuclei.

Interaction of radiation with matter: Interaction of alpha, beta and gamma radiation with matter

Types of Radiation Detectors: Gas-filled detectors, Scintillation detectors, Semiconductor detectors

Particle Accelerators: Electrostatic accelerators, Cyclotrons, Synchrotrons, Linear accelerators

Radioactive Ion Beam (RIB): Details of RIB, Different methods to produce RIB, Existing facilities

Microscopic theory: Occupation number representation, Creation and annihilation operators, One and two-body operators, Matrix elements, Wick's theorem.

Hartree-Fock approximation and HF equations. BCS model.

Texts:

1. K. S. Krane, Introductory Nuclear Physics, John Wiley (1988).
2.Glenn F Knoll, Radiation Detection and Measurement, John Wiley & Sons, Inc.

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TIU-PPH-T206: SUPERCONDUCTING MATERIALS AND DEVICES [L-T-P-C: 3-1-0-3]

Basic properties of Superconductors; Zero resistance, Perfect Diamagnetism, Meissner effect, London's theory, Penetration depth, Concept of coherence length and origin of surface energy, Type I and Type II superconductors, Intermediate and mixed states, Critical currents and critical fields. Outlines of B-C-S theory, concept of energy gap.

Tunneling in superconductors: Gaiever tunneling and Josephson tunneling, Josephson junction in magnetic field; Fabrication of tunnel junction, Photolithography.

Flux Flow, Flux pinning, Pinning force, Magneto-thermal Instabilities in Type II superconductors, Flux Jumps, Stabilization Criterion: cryostatic, dynamic and enthalphic stabilization, Manufacture of long length superconducting multifilamentary wires. Design and fabrication of superconducting magnets, Persistent switches, superconducting magnet energization; Basic concepts of superconducting energy storage (SMES).

Superconducting Quantum Interference Devices (SQUIDS): DC and RF SQUIDs, SQUID's Fabrication, Applications of SQUIDs. Superconductive Switches and Infrared detectors.

Books Recommended:

1. Introduction to Superconductivity ………. Roseins & Rhodrih
2. Fundamentals of Superconductivity …….. Vladimir Z. Kresin & Stuart A. Wolf.
2. Applied Superconductivity, Vol I & II …….Newhouse
3. Applied Superconductivity…………………… Williams
4. Applied Superconductivity…………………… Barrone
5. Superconducting Magnet Design………….. Wilson
6. Superconducting Materials…………….. Fonner & Schowertz

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TIU-PPH-E202: ADVANCED CONDENSED MATTER (ELECTIVE) [L-T-P-C: 3-1-0-3]

Semiclassical Model of Electron Dynamics: Wave Packets of Bloch Electrons, Semiclassical Mechanics, General Features of the Semiclassical Model, Static Electric Fields, The General Theory of Holes, Uniform Static Magnetic Fields, Hall Effect and Magnetoresistance.

Semiclassical Theory of Conduction in Metals: The Relaxation-Time Approximation, General form of Nonequilibrium Distribution Function, DC Electrical Conductivity, AC Electrical Conductivity, Thermal Conductivity, Thermoelectric Effects, Conductivity in a Magnatic Field.

Fundamentals of many-electron system: Hartree-Fock theory: The basic Hamiltonian in a solid: electronic and ionic parts, the adiabatic approximation; Single- particle approximation of the many-electron system — single product and determinantal wave functions, matrix elements of one and two-particle operators; The Hartree-Fock (H-F) theory: the H-F equation, exchange interaction and exchange hole, Koopman's theorem; The occupation number representation: the many electron Hamiltonian in occupation number representation; the H-F ground state energy.

Superfluidity: Basic Phenomenology; Transition and Bose-Einstein condensation; Two fluid model; Roton spectrum and specific heat calculation, Critical velocity

Density Functional Theory: Basics of DFT, Comparison with conventional wave function approach, Hohenberg-Kohn Theorem; Kohn-Sham Equation; Thomas-Fermi approximation and beyond; Practical DFT in a many body calculation and its reliability.

Magnetic Resonance: Nuclear magnetic resonance, line width, hyperfine splitting, nuclear quadrupole resonance, ferromagnetic and antiferromagnatic resonance, electron paramagnetic resonance, principle of MASER action.

Non-crystalline solids: Diffraction pattern, Glasses, Amorphous ferromagnets and semiconductors, low energy excitations in amorphous solids, Fibre Optics.

Surface Effects: The work Function, Contanct Potentials, Low energy Electron Diffraction, Field Ion Microscopy, Electronic Surface levels.

Defects in Crystals: Thermodynamics of Point Defects, Schottky and Frenkel Defects, Annealing, Electrical Conductivity of Ionic Crystals, Color Centers, Polarons and Excitons, Dislocations, Strength of Crystals, Crystal Growth, Stacking Faults and Grain Boundaries.

Text:

1. Solid State Physics – Ashcroft and Mermin
2. Solid State Physics – Kittel

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TIU-PPH-E204: INTRODUCTION TO PLASMA PHYSICS (ELECTIVE) [L-T-P-C: 3-1-0-3]

Introduction: Development, Temperature, Density, Quasineutrality, Debye Shielding, Plasma Oscillation

Orbit Theory: Particle motion in uniform Electric, Magnetic and Gravitational field, Plasma Drifts

Fluid Model: Continuity, Magnetic Pressure, Frozen in Magnetic field

Plasma Waves: Electron Plasma waves, Ion acoustic waves, MHD waves

Kinetic Theory of Plasma: Boltzmann equation, Fluid equation, Vlasov equation, Landau damping

Transport Process: Conductivity on diffusion

Stability: Instability – classification

Non-linear effects: Ponderomotive force, Non-linear Schrodinger equation, KdV equation Confinement and Diagnostics

Text:

1. Introduction to Plasma Physics and Controlled Fusion by F F Chen
2. Basic Plasma Physics by Basudev Ghosh

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TIU-PPH-E206: ADVANCED OPTICS AND HOLOGRAPHY (ELECTIVE) [L-T-P-C: 3-1-0-3]

Physics of Laser and Laser applications: Coherence and Monochromaticity. Line shape function; Line broadening mechanisms: Natural broadening, Collision Broadening and Doppler broadening. Principles of light amplification: Interaction of atoms with radiation, Lasing action, Population inversion, Role of feedback (Cavity), Threshold condition for population inversion.

Laser rate equations; Two, three and four level systems.
Modes of Laser oscillation: Mode selection process: Transverse mode selection and Longitudinal mode selection. Production of giant pulse: Q switching technique.
Different laser systems: Gas lasers, Solid state and liquid state lasers, excimer lasers: Operation principles, design (construction) and output characteristics.

Optical fibers & characteristics:
Transmission characteristics of fibers- Modal analysis of a step index fiber, single mode fibers- spot sizes, attenuation - absorption & scattering losses, bending loss, splice losses. Dispersion - inter & intra modal dispersion, material dispersion and wave-guide dispersion, design consideration of various fibers.
Preparation of fibers: Liquid Phase techniques, vapor phase depositions, OVPO, VAD, MCVO, PCVD and design of optical fiber cables.

Magneto-Optics and Electro-Optics: Zeeman effect – normal and anamolous, Inverse Zeeman effect, Faraday effect, Kerr magneto optic effect, Kerr electro optic effect, Stark effect, Inverse Stark effect.

Basics of holography: in-line and off-axis holography; Reflection, white light, rainbow and wave guide holograms; Theory of plane holograms, magnification, aberrations, effects of non-linearity, band-width and source size;

Volume holograms: coupled wave theory, wavelength and angular selectivity, diffraction efficiency; Recording medium for holograms: silver halides, dichromatic gelatin, photoresist, photoconductor, photorefractive crystals, etc.

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Applications: microscopy; interferometry, NDT of engineering objects, particle sizing; holographic particle image velocimetry; imaging through aberrated media, phase amplification by holography; optical testing; HOEs: multifunction, polarizing, diffusers, interconnects, couplers, scanners; Optical data processing, holographic solar concentrators; antireflection coatings; holo-photoelasticity;

Colour holography: recording with multiple wavelength; white light colour holograms; Electron holography, acoustic and microwave holography and some typical applications, computer holography, digital holography.

Text:

1. Laser and is Application – A. Ghatak
2. Fibre Optics – A. Ghatak
3. Basics of Holography

<u>TIU-PPH-L202: ADVANCED PHYSICS LAB</u> [L - T - P - C - 0 - 0 - 6 - 3]

List of experiments:

Experiment 1: Study of I-V characteristic of nano-material

Experiment 2: Study of Faraday effect by He – Ne Laser

Experiment 3: Study of thermal conductivity of solids

Experiment 4: Fibre optics Experiments

Experiment 5: Study of electrical transport properties of nanofibre

Experiment 6: Study of p-E loop and measurement of piezoelectric coefficients of piezoelectric material

Experiment 7: Study of Thermoelectric power of Thin films

Experiment 8: Energy calibration of charge particle

Experiment 9: Thickness measurement of thin foil