Semester VIII

Curriculum and Credit Framework for Undergraduate Programme of Physics Hons. (single Major) *w.e.f. 2024 (NEP 2020)*

Course	Course Code	Name of the Paper	Course Type/ Nature	Teaching Scheme in hour per week			Credit	Marks
				Th	Pr	T		
CC- 19	**PHSUMCC819**	Solid state physics	Theory	4	0	0	4	50 (ESE=40, IA-7,CA-3)
CC- 20	**PHSUMCC820**	Quantum Mechanics-II and its applications	Theory	4	0	0	4	50
CC-21	**PHSUMCC821**	Statistical Mechanics (Python Programming) and Solid State Physics Practical	Practical	0	8	0	4	50 CIA=30 (Gr.A-15, Gr.B-15) ESE=20 (Expt=15, Viva=5
DSE5	**PHSUDSE805**	Experimental Techniques **(Only Hons. Student)**	Theory	4	0	0	4	50
DSE6	**PHSUDSE806**	Project Work **(Only Hons. Student)**					4	50
		Dissertation Project Only Hons. With Research Students)					8	50
GE2D (MIC)	**PHSUMIC804**	Electricity and Magnetism (To be taken by the students from other discipline)	Practical	0	8	0	4	50 CIA=30 ESE=20 (Expt=15, Viva=5)

Th= Lecture, **T=** Tutorial, **Pr =** Practical, **CC -** Core Course, DSE=Discipline Specific Elective, IA= Internal Assessment, CA= Class attendance.
CIA=Continuous Internal assessment, ESE=End semester examination, Expt.=Experiment

CC19: SOLID STATE PHYSICS

(Credits: 04, Lectures 60)

This course is based on the fundamental ideas over the structures and properties of solid matters. Laboratory experiments are designed to understand the behaviours of solid materials and related things.

Crystal Structure: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice and Basis. Unit cell. Wigner-seitz cell. Crystal symmetry (External). Point group, Space group. Different types of lattices. Bravais lattice. Bravais lattices of cubic system. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor. Debye Waller effect. **(14Lectures)**

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law.

(10 Lectures).

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

(10 Lectures)

Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electro-strictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. **(5 lectures).**

Elementary band theory: Physical origin of the energy gap, Bloch function, Kronig Penny model. Band Gap. Extended, reduced and periodic zone schemes, effective mass, Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient. **(10 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation) **(6 Lectures)**

Dielectrics: Review of Dielectric in DC,Local field in liquids and solids, Clausius-Mosotti Relation, Complex dielectric constant and dielectric losses and relaxation. (**5 lectures**)

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
- Solid State Physics, Rita John, 2014, McGraw Hill
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

CC20: Quantum Mechanics-II and its applications

(Credits-4, Lectures-60)

The idea of this course in Quantum Mechanics is to revisit the foundational principles and mathematical tools to treat this subject.

Approximation methods for bound states: Stationary perturbation theory- non degenerate and degenerate cases, Fine structure, spin orbit coupling; simple problems **(5 Lectures**)

Variational method: Variational principle, Estimate ground state energy of harmonic oscillator, Hydrogen atom and Helium atom, simple problems. **(5 Lectures**)

WKB Approximation: WKB method, connection formulas, quantization rule for potential well with no rigid wall, with one rigid wall, with two rigid walls, Bound state energy for harmonic oscillator and coulomb potential, Tunnelling through potential barrier. **(5 Lectures)**

Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment.. Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Normal and Anomalous and Intermediate Zeeman Effect, Paschen Back effect and Stark Effect. (**10 Lectures**)

Many electron atom: Wave function for system of distinguishable particles, Identical particles, Exchange operator, Exchange degeneracy, Symmetrization postulate, symmetric and antisymmetric wavefunction, Slater determinant, Pauli Principle, Inclusion of spin, Spin wavefunction for two and three electrons, Ground and 1^{st} excited state of energy and wavefunction of helium atom, Ortho, Para Helium, Central field approximation, correction to central field approximation, L-S and j-j coupling, Fine structure terms for non-equivalent and equivalent electrons, Hund's rule, Spectra of Hydrogen and Alkali Atoms (Na etc.).D1 and D2 Lines. **(15 Lectures**)

Relativistic wave mechanics: Klein-Gordon equation for a free particle, solution of the KG equation, Probability density and probability current density, Drawbacks of KG equation, A spin zero particle in EM field, Coulomb field. fine structure, Dirac's equation for a free particle, Properties of γ matrices, Dirac Hamiltonian, Solution of the free particle Dirac equation, Dirac equation in covariant form, Invariance of Dirac equation under Lorentz Transformation, Form of matrix for an infinitesimal Lorentz Transformation, Spin of the Dirac particle, Continuity equation, Four vector current density, Dirac' hole theory, Anti commutation relations of the Dirac matrices, Helicity, Energy Projection Operator, Bilinear Invariants, Magnetic moment of the electron, spin orbit interaction in the Dirac equation, Dirac equation in EM field and Coulomb field. (**20 Lectures**)

Books Recommended:

1. 'Quantum Physics' by Robert Eisberg and Robert Resnick (John Wiley and sons).
2. Quantum Mechanics' by L. I. Schiff (McGraw-Hill Book, New York).
3. Quantum Field Theory by Ashok Das (World Scientific)
4. Quantum Mechanics' by F Schwabl (Narosa).
5. 'Quantum Theory' by D. Bohm (Prentice-Hall).
6. 'Quantum Mechanics: Theory and Applications' by A. K. Ghatak and S. Lokanathan (Macmillan India Ltd.).
7. 'Quantum Mechanics' by Cohen and Tanandji

CC21: Solid State Physics and Advanced Practical (Credit-4)

Group-A

(Solid State Physics)

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the refractive index of a dielectric layer using SPR
6. To study the PE Hysteresis loop of a Ferroelectric Crystal.
7. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
8. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.
9. To determine the Hall coefficient of a semiconductor sample.
10. Band gap measurement of a Semiconductor using P-N junction

Group-B

(Advanced Practical)

1. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
2. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
3. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Determination of Curie Temperature.
5. To Determine the speed of Ultrasonic waves in a liquid medium,
6. To study the diffraction pattern of a crossed grating with the help of a laser source.
7. Determination of separation of D1-D2 line.

DSE5: Experimental Techniques (Credit-4, Lecures-60)

In this course students will learn about the measurement procedures of hands-on experiments. They will learn to collect data, analysis of data and result finding in laboratory.

Measurements:

Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution.

(**10 Lectures**)

Signals and Systems:
Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise.

(**10 Lectures**)

Shielding and Grounding:
Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference. (**5 Lectures**)

Transducers &industrial instrumentation (working principle, efficiency, applications):
Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector.

(**15 Lectures**)

Digital Multimeter:
Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.

(**5 Lectures)**

Impedance Bridges and Q-meter:
Block diagram and working principles of RLC Bridge. Q - meter and its working operation. Digital LCR bridge.

(**5 Lectures**)

Vacuum Systems:
Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization).

(**10 Lectures**)

References:

1. Measurement, Instrumentation and Experiment Design in Physics and Engineering,
2. M. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
3. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
4. Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
5. Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
6. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
7. Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd. 8. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer.

GE2D (MIC): Electricity and Magnetism Practical

(Credit-4)

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.

6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanomete.
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's methodTo determine the mutual inductance of two coils by Absolute method.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, Vani Pub.

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