Department of Physics

Government Degree College (Autonomous), Baramulla

SEMESTER 5th COURSE **MAJOR / MINOR**

Subject: Physics

Course Title: Modern Physics **Course Code: BPH22C501**

Credits: Theory: 04; Practical: 02 **Contact Hours: Th 64 Hr, Pr 64Hr**

Learning Objectives:

1. **Understand Quantum Mechanics:** Learn about wave-particle duality, the Schrödinger equation, quantum states, and phenomena like tunneling and entanglement.
2. **Explore Atomic and Molecular Physics:** Investigate atomic structure, electron configurations, spectra, and molecular bonding.
3. **Utilize Mathematical Techniques:** Apply advanced mathematical methods essential for modern physics, such as differential equations and linear algebra.

Learning Outcomes:

1. Understand the inadequacies of classical physics in explaining phenomena like Blackbody Radiation, the Photoelectric Effect, and the Compton Effect.
2. Explain Heisenberg's Uncertainty Principle and its significance in quantum mechanics.
3. Understand Schrödinger's wave equation in its time-independent form.
4. Explain the linearity and superposition principles in quantum mechanics.
5. Calculate expectation values and work with operators in quantum mechanics.
6. Understand the concept of tunneling and its effects in quantum mechanics.
7. Understand the concept of electron spin and its experimental verification through the Stern-Gerlach experiment.
8. Describe the concept of symmetric and anti-symmetric wave functions in the context of quantum mechanics.
9. Understand atomic structures, including electron shells and sub-shells.
10. Calculate the total angular momentum J and understand the normal and anomalous Zeeman Effect.
11. Quantized rotational energies and describe rotational energy levels.

Unit-I Dual nature of light:- **16 Contact Hours**

Inadequacy of classical physics, Brief Review of Black body Radiation, Photoelectric effect, Compton Effect, Pair Production.

Atomic Model and Spectra: Line spectra of hydrogen atom, Alpha Particle Scattering, Rutherford Model of atom and its limitations. Atomic Model: Bohr’s Model of Hydrogen atom, explanation of atomic spectra, limitations of Bohr model, Summerfield’s modification of Bohr’s Theory.

UNIT- II Dual nature of Matter and radiation: **16 Contact Hours**

Wave Packet: superposition of two waves, phase velocity and group velocity, wave packets, Gaussian Wave Packet, Wave-Particle Duality and Complementarity, de Broglie principle, velocity of de Broglie wave.

Uncertainty Principle and its application: Heisenberg Uncertainty Principle: Illustration of the Principle through thought Experiments of γ-ray Microscope
and electron diffraction through a slit, non-existence of electron in the nucleus.

Schrodinger equation and Wave Mechanics: Time dependent Schrodinger equation, Properties of Wave Function, Well behaved Wave function, Interpretation of wave function, Probability and probability current densities in three dimensions, Normalization, Double-slit experiment with photons and electrons, Linearity and Superposition Principles. Wave function of a free particle

Unit III Principles of Wave Mechanics: **16 Contact Hours**

Operators, Hermitian Operators, Expectation values of position and momentum, Ehrenfest Theorem, Bohr's Corresponding principle, Eigenvalues and Eigen functions of Hermitian Operator, Degeneracy, Linear Dependence. Time Independent Schrodinger equation in one dimension, Hamiltonian: stationary states and energy Eigen values

Application of Time Independent Schrodinger's equation: Particle in an box, finite Square well potential, Tunnel Effect, Boundary condition and emergence of discrete energy levels, discrete energy spectra of one dimensional harmonic oscillator (no derivation):- ground state, zero point energy and uncertainty principle.

UNIT-IV Electron Angular Momentum, Spin and Atomic spectra: 16 Contact Hours

Electron angular momentum—its components and algebra, Stern-Gerlach Experiment, Spin Magnetic Moment, Electron Spin and Spin Angular Momentum, Pauli's Exclusion Principle, Symmetric and anti-symmetric wave functions, Properties of Quantum numbers (n,l,m,s) and atomic structure (Shells and sub-shells), Spin-Orbit coupling, Vector Atom Model, L-S and J-J coupling. Normal and Anomalous Zeeman Effect, Lande g-factor, Paschen back and Stark Effect (qualitative Discussion only).

Molecular Spectra:- Pure Rotational Spectra, Rotational energy levels and their quantization, Pure Vibrational energy, Vibrational energy levels and their quantization, Rotational-Vibrational spectra of diatomic molecules.

PRACTICALS (2 CREDITS)

1. Study of e/m by Helical Method.
2. Determination of e/m by Thomson Method.
3. Determination of Planck's constant.
4. Study of Zeeman Effect.

5. Determination of Bohr Magneton using normal Zeeman effect.
6. To setup Millikan Oil drop experiment for determination of charge.
7. Characteristics of Tunnel Diode

TEXT BOOKS:

1. Concepts of Modern Physics by Arther Beiser , Shobhit Mahajan , S. Rai Choudhury , McGraw Hills.
2. Modern Physics, R Murugeshan and Kiruthiga Sivaprasath ,S. Chand & Co.
3. Modern Physics, Raymond A. Serway, Clement J. Moses and Curt A. Moyer, Pearson.
4. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
5. B.Sc. Practical Physics by C.L. Arora
6. A Textbook of Advanced Practical Physics by S. Ghosh: New Central Book Agency.

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SEMESTER 5th **MAJOR COURSE**

Subject: Physics

Course Title: Electronics-I **Course Code: BPH22C502**

Credits: Theory: 04; Practical: 02 **Contact Hours: Th 64 Hr, Pr 64Hr**

Course Learning Objectives:

1. Understand the fundamental principles of semiconductor physics and their applications in electronic devices.
2. Analyze the characteristics and operation of various electronic devices, including diodes, transistors, and operational amplifiers.
3. Design and analyze basic electronic circuits for amplification, signal processing, and power supply applications.
4. Understand the principles of electronic communication systems, including modulation and demodulation techniques.
5. Apply their knowledge to analyze and design simple communication systems.

Course Learning Outcomes:

1. Explain the energy band theory and its application to semiconductors.
2. Differentiate between intrinsic and extrinsic semiconductors.
3. Analyze the behaviour of PN junctions and their applications in rectifier circuits.
4. Understand the operation of Zener diodes and their use in voltage regulation.
5. Describe the structure and operation of bipolar junction transistors (BJTs) and field-effect transistors (FETs).
6. Analyze the DC and AC characteristics of BJTs in different configurations.
7. Understand the biasing techniques for transistors.
8. Compare and contrast different types of FETs (JFET, MOSFET).
9. Analyze the performance of transistor amplifiers using h-parameters.
10. Design and analyze basic transistor amplifier circuits.
11. Understand the operation of operational amplifiers and their applications in linear circuits.
12. Explain the operation of photodetectors, LEDs, phototransistors, and solar cells.
13. Understand the basics of signal and noise concepts in communication systems.
14. Analyze the principles of amplitude modulation and demodulation.
15. Describe the concept of pulse code modulation and its significance.

Unit – I **16 hours**

Energy band theory of Solids, Semiconductor Materials: Intrinsic & Extrinsic semiconductors, Charge carrier concentration in intrinsic & extrinsic semiconductors, Law of Mass action (Statement only) PN junction: Construction, operation & its VI characteristics, Concept of drift and diffusion currents, Ideal and practical diode characteristics, Static and dynamic resistance, Load Line analysis of Diode, Zener diode characteristics and its application as voltage regulator.

Unit – II **16 hours**

Bipolar Junction Transistor: Construction, working of NPN and PNP transistor. Characteristics under CB, CE & CC configurations: active, cut-off and saturation regions, DC biasing and operating point: Fixed bias, Emitter bias & Voltage divider bias, Stability of operating point.
JFET: Basic structure and operation of JFET, its V-I characteristics & pinch off point, MOSFET: construction, working and V-I characteristics of Depletion and Enhancement type MOSFET.

Unit – III **16 hours**

Transistor modeling using h-parameters, Common-Emitter transistor amplifier Analysis, Transistor α, β parameters and relation between them, calculation of current and voltage gain.

Differential amplifier circuit, Block diagram of an operational amplifier, Ideal and practical characteristics, Voltage gain, Open and closed loop configuration. Applications of OP-Amp: Inverting and non-inverting amplifiers, Voltage follower, summing amplifier, difference amplifier, Differentiator & Integrator.

Unit – IV **16 hours**

Electronics devices for communication: Photo-detector, LED, Phototransistors and photo resistors, solar cell.
Introduction to Signals and its classification (analog, digital), Brief review to *em* waves, Noise and interference, Need for Modulation, Amplitude modulation and demodulation, Introduction to Angle modulation: relation between phase and frequency modulation, Narrow and wide band FM, Frequency spectrum. Pulse code Modulation, sampling and Nyquist theorem (statement only).

PRACTICALS (2 CREDITS) **64 Hours**

1. To study characteristics of a PN Junction diode.
2. To study characteristics of a transistor
3. Characteristics of a Tunnel Diode.
4. Characteristics of a Solar Cell.
5. To study the Characteristics of an LED.
6. To study Zener Diode as a Voltage Regulator.
7. To study logic Gates.
8. To study OP-Amps as Adder and a subtracter circuit.
9. To study a Full wave rectifier.
10. To study transistor as a switch.

TEXT BOOKS:

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1. Semiconductor Devices Physics and Technology, S M Sze, (2007), John Wiley and Sons Inc. Asia.
2. Solid State Electronic Devices, Ben G Streetman, Sanjay Banerjee, (Fifth edition, 2000), Pearson Education, Asia.
3. Semiconductor Optoelectronic Devices, Pallab Bhattacharya, (Second Edition, 1997), Pearson education, Asia.
4. The art of electronics, Paul Horowitz and Winfield Hill, (Second Edition, 1992), Foundation Books, New Delhi.
5. Electronic Principles, A P Malvino, (Sixth Edition, 1999), Tata McGraw Hill, New Delhi.
6. Op-Amps and Linear Integrated Circuits, Ramakant A Gayakwad, (Third Edition, 2004), Eastern Economy Edition.
7. Electronic Devices and Circuit Theory by Robert L. Boylestad and Louis Nashelsky
8. Communication Systems by Simon Haykin

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SEMESTER 5th **MAJOR COURSE**

Subject: Physics

Course Title: Statistical Mechanics **Course Code: BPH22C502**

Credits: Theory: 04 **Contact Hours: Th 64 hr,**

Course Objectives

The primary objective of this course is to equip students with a solid foundation in classical and quantum statistical mechanics. Upon completion, students will be able to:

- Understand the fundamental principles of probability and statistical mechanics.
- Apply statistical mechanics to describe macroscopic systems in terms of microscopic properties.
- Analyze and interpret the behavior of ideal and real gases using statistical mechanics.
- Explore the quantum nature of particles and their impact on statistical properties.
- Understand the concept of blackbody radiation and its implications.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Define and explain key terms and concepts in statistical mechanics, such as probability, microstates, macrostates, ensembles, entropy, partition function, distribution functions, and blackbody radiation.
- Differentiate between classical and quantum statistics and their applications.
- Understand the relationship between statistical mechanics and thermodynamics.
- Apply probability theory and counting techniques to calculate statistical properties of systems.
- Calculate thermodynamic functions using statistical mechanics.
- Analyze the behaviour of ideal and real gases based on statistical models.
- Apply statistical mechanics to analyze physical systems and interpret results.
- Critically evaluate different statistical models and their limitations.
- Solve complex problems involving statistical mechanics using appropriate methods.
- Analyze experimental data using statistical mechanics concepts.

UNIT- I **16 hours**

Introduction and Mathematical Methods in Statistical Mechanics: Probability Distributions (PD), Mean, Variance, Standard deviation of a PD, Random Variables and distribution functions, Stirling's approximation, Discrete distribution (Poisson); Continuous distribution (Gaussian distribution), Delta function, Binomial and Multinomial distribution, Binomial distribution for large numbers; Maximum term method; Lagrange Multipliers.

Introduction to Statistical Mechanics and its importance: Microstate and Macrostate; Thermodynamic Probability and frequency; Distinguishability and indistinguishability of particles in a system, Brief overview of classical and quantum statistical physics, Basic postulates of Statistical Mechanics.

UNIT- II 16 hours

Classical Statistical Mechanics: Concept of Ensemble: Types of ensembles, Micro canonical, Canonical and Grand Canonical ensemble, Partition Function—Definition and importance in statistical mechanics, Micro-canonical ensemble: Entropy as the thermodynamic variable—its thermodynamic properties, concept of temperature.

Study of ideal gas and expression for Entropy (using Micro-canonical ensemble), Gibbs Paradox--- the inconsistency of classical entropy for identical particles, Law of equipartition of Energy (with proof)

Principle of equal a Priori Probability, phase Space, Liouville's theorem and its significance, Maxwell-Boltzmann Distribution Law.

UNIT-III 16 hours

Quantum Statistical Mechanics: Identical particles, Indistinguishability of particles—Fermions and Bosons, macrostates and microstates, Bose Einstein distribution. Brief overview of Bose- Einstein Condensation (BEC), Conditions for BEC.

Fermi-Dirac distribution function, Effect of temperature on Fermi-Dirac distribution function, degenerate Fermi gas, Density of States, Concept of Fermi energy.

UNIT-IV 16 hours

Radiation: Properties of Thermal Radiation, Blackbody Radiation and its Temperature dependence, Kirchhoff's law.

Stefan-Boltzmann law: Thermodynamic proof, Radiation Pressure, Wien's Displacement law, Wien's distribution Law, Rayleigh Jeans Law, Ultraviolet catastrophe.

Planck's Law of Black body Radiation: Experimental verification, Deduction of Rayleigh-Jeans Law, Stefan-Boltzmann Law, and Wien's Displacement Law from Planck's Law.

REFERENCE BOOKS:

1. Introduction to Statistical Physics by Kerson Huang (Wiley).

2. Statistical Physics, Berkeley Physics Course, F.Reif (Tata Mc Graw-Hill)

3. Statistical Mechanics, B.K. Agarwal and Melvin Eisner (New Age International)

4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics: Francis W. Sears and Gerhard L.Salinger (Narosa)

5. Statistical Mechanics: R. K. Pathria and Paul D. Beale (Academic Press)

6. Thermodynamics and Statistical Physics by Keith Stowe. (Cambridge)

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