SEMESTER – II

UCPHB20 – THERMAL PHYSICS AND STATISTICAL MECHANICS

Year: I **Sem:** II	**Course Code:** UCPHB20	**Title of the Course:** Thermal Physics and Statistical Mechanics	**Course Type:** Theory	**Course Category:** Core	**H/W** 6	**Credits** 5	**Marks** 100

Course Objectives

1. To introduce the law of thermodynamics and their applications.
2. To acquire knowledge about classical and quantum theory of radiation.
3. To understand the basic of statistical mechanics.

Course Outcomes (CO)

The learners will be able to

1. Become familiar with various thermodynamic process and work done in each of these processes.
2. Have a clear understanding about Reversible and irreversible process
3. Learn the working of a Carnot engine, and knowledge of calculating change in entropy for various processes.
4. Realize the importance of Thermo dynamical functions and applications of Maxwell's relations.
5. Learn the relation between the entropy and probability.

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
CO1	L	H	H	H	M	L
CO2	M	L	L	M	M	H
CO3	H	H	H	M	M	H
CO4	M	H	H	H	L	M
CO5	H	M	H	M	L	H

CO	**PSO**					
	1	**2**	**3**	**4**	**5**	**6**
CO1	M	H	M	H	M	H
CO2	H	H	M	H	M	L
CO3	M	M	L	M	H	M
CO4	L	M	H	M	H	L
CO5	H	L	M	H	M	M

(Low - L, Medium – M, High - H)

Course Syllabus

Unit I: Thermal Conduction and Radiation (16 hours)

1.1 Coefficient of Thermal Conductivity - Thermal Diffusivity (K1, K2)
1.2 Rectilinear Flow of Heat along a Bar - Forbe's method - Lee's Disc Method (K3,K4)
1.3 Relation between Thermal and Electrical Conductivities - Wiedemann - Franz Law and Stefan's Law (K1,K2)
1.4 Derivation of Newton's Law of Cooling from Stefan's Law and Laboratory determination of Stefan's Constant (K3, K4)
1.5 Planck's Quantum Theory of Radiation-Deduction of Wien's Law and Raleigh-Jeans Law from Planck's Law (K1,K3,K4)
1.6 Solar Constants - Temperature of the Sun - Solar Spectrum (K2)

Unit II: Thermodynamics – I (14 hours)

2.1 Introduction – Thermodynamic system- Zeroth Law of Thermodynamics Quasistatic process (K1, K2)
2.2 Statement of First Law of Thermodynamics - Statement of Second Law (K1, K2)
2.3 Heat Engines and Ideal Heat Engine - Concept of Entropy-Entropy of an Ideal Gas Reversible and Irreversible Process and their entropy (K2,K3)
2.4 Carnot Theorem and Proof of Carnot Theorem (K2, K3,K4)
2.5 Construction and working of Internal Combustion Engine - Petrol and Diesel Engines(K3, K4)
2.6 First Latent Heat Equation – Clausis-Clapeyron equation and Second Latent Heat Equation (K4)

Unit III: Thermodynamics – II (15 hours)

3.1 Thermodynamic Scale of Temperature or Work Scale of Temperature and its Relation to Perfect Gas Scale (K4)
3.2 Entropy Temperature Diagram (K3)
3.3 Maxwell's Thermodynamic Equations and its Applications (K4)
3.4 Thermodynamic Potentials - Free Energy – Enthalpy - Internal energy – Helmholtz free energy – Significance of thermodynamic potentials (K1,K2)
3.5 Gibbs function - Gibb's Helmholtz Equation - Third Law of Thermodynamics (K1,K3)
3.6 Phase transition expression for the first orderand second order transition (K3, K4)

Unit IV: Low Temperature Physics (15 hours)

4.1 Introduction – Production of low temperature – Joule Thomson effect-Joule Kelvin Effect (Temperature of inversion) (K3)
4.2 Kammerling Onne's Method - Liquefaction of Hydrogen- Liquefaction of Helium(K3)

4.3 Helium I and II - Lambda Point, Viscosity- thermal conductivity- Rolling films (K3,K4)
4.4 Production of low temperature - adiabatic demagnetization
4.5 Practical applications of Low Temperature (K3)
4.6 Refrigerators - Air Conditioning Machines (K3, K4)

Unit V: Statistical Mechanics (15hours)

5.1 Definition of Phase-Space - Micro and Macro States (K1, K2)
5.2 Different types of Ensembles - Definition and relation between entropy and Probability (K1)
5.3 Expression for Maxwell Boltzmann Statistics (K4)
5.4 Maxwell's law of Distribution energy (K3)
5.5 Expression for Fermi Dirac Statistics (K3, K4)
5.6 Derivation for Bose Einstein Statistics - Comparison of Three Statistics (K3,K4)

Books for Study:

1. Brijilal and Subrahmanyam S. - Heat and Thermodynamics – Chand & Co., New Delhi, Reprint 1998.
2. D.S. Mathur - Heat and Thermodynamics - Sultan Chand & Sons, New Delhi, V Edition, 2005
3. Arora. C.L. – A Textbook of Heat and Thermodynamics - Chand & Co., New Delhi, Reprint 1998.
4. Dr. D. Jayaraman and Dr.K.Ilangovan – Thermal Physics and Statistical Mechanics- S. Viswanathan publishers 2016.

Books for Reference:

1. A.B.Gupta and H.Roy – Thermal Physics – Books and Allied Pvt. Ltd., Reprint 2005
2. D.Halliday, R.Resnick and J.Walker – Fundamental of Physics, 6^{th} Edition - Wiley N.Y., 2001
3. Roy - Thermal and Statistical Physics – S Chand & Co.,2001
4. R.Murugeshan – Thermal Physics – S.Chand& Co. Publication, Reprint 2004

SEMESTER – VI

UCPHK20 – Relativity and Quantum Mechanics

Year: III **Sem:** VI	**Course Code:** UCPHK20	**Title of the Course:** Relativity and Quantum Mechanics	**Course Type:** Theory	**Course Category:** Core	**H/W** 5	**Credits** 5	**Marks** 100

Course Objectives

1. Understand the concept of constant relative motion of different bodies in different frames of references
2. To introduce students to the concept of special relativity and its applications to Physical Sciences
3. To make the students understand the inadequacy of classical mechanics and the birth of quantum mechanics.
4. To study role of uncertainty in quantum physics.
5. To impart the knowledge about the postulates and the basic principles of quantum mechanics and operator formulation.
6. Students learn the concept of wave function and Schrodinger equation and their applications using spherically symmetric potentials.

Course Outcomes (CO)

The learners will be able to

1. Understand the concept of constant relative motion of different bodies in different frames of references
2. To introduce students to the concept of special relativity and its applications to Physical Sciences
3. To make the students understand the inadequacy of classical mechanics and the birth of quantum mechanics.
4. To study role of uncertainty in quantum physics.
5. To impart the knowledge about the postulates and the basic principles of quantum mechanics and operator formulation.

CO	**PO**					
	1	2	3	4	5	6
CO1	M	H	M	H	M	M
CO2	M	H	H	M	M	L
CO3	L	M	H	M	M	H
CO4	L	M	H	M	L	L
CO5	H	M	H	M	L	H

CO	PSO					
	1	2	3	4	5	6
CO1	H	H	M	L	H	M
CO2	L	H	M	L	H	M
CO3	H	H	M	L	H	M
CO4	M	L	H	M	H	M
CO5	H	H	M	L	H	M

(Low - L, Medium -M, High - H)

Course Syllabus

Unit I: Relativity **(15 hours)**

1.1 Postulates of special theory of relativity-Galilean transformation equation-Michelson-Morley Experiment (K1,K2,K3,K4)
1.2 Lorentz transformation equations(K3,K4)
1.3 Length contraction and Time dilation (K1,K2,K3)
1.4 Relativity of simultaneity and Addition of velocities (K1,K2,K3)
1.5 Variation of mass with velocity and Mass energy relation (K1,K2,K3,K4)
1.6 Minkowski's four dimensional space and Elementary ideas of general theory of relativity and its significance - Red Shift.(K3,K4)

Unit II: Wave Nature of Matter **(15 hours)**

2.1 De Broglie wavelength - Phase velocity and group velocity of de Broglie waves – relationship between phase velocity and group velocity (K3,K4)
2.2 Experimental study of matter waves – Davisson and Germer's experiment – G. P. Thomson's experiment (K1,K2,K3,K4)
2.3 Wavelength of motion of particles like electron – Electron microscope (K1,K2,K3,K4)
2.4 Heisenberg's uncertainty principle –γ- ray microscope (K2,K3)
2.5 Application – Diffraction of electron beam by single slit and Non- existence of electrons inside the nucleus (K1,K2,K3,K4)
2.6 Explanation of Bohr radius - Minimum energy of Simple Harmonic Oscillator. (K3,K4)

Unit III: Schrodinger Equation **(15 hours)**

3.1 Failures of Classical mechanics - Wave function - Physical interpretation of wave function - Postulates of quantum mechanics (K1,K3,K4)
3.2 Operators for physical quantities (K2,K3,K4)
3.3 Eigen value equation - Eigen values and Eigen functions (K2,K3)
3.4 Schrodinger's equation -Time dependent and time independent equation (K1,K3,K4)
3.5 Expectation values – Expectation values of observables (K2,K3)
3.6 Ehrenfest's theorem (K4)

Unit IV: One dimensional Problem **(15 hours)**

4.1 Free particle solution of Schrodinger's equation (K3,K4)
4.2 Bound state problems: Particle in a box (K3,K4)
4.3 Wave equation and solution for the particle - Eigen values of energy (K2,K3,K4)
4.4 Normalization of the wave functions (K1, K3)
4.5 Simple harmonic oscillator– Square well potential of finite depth (K3,K4)
4.6 Rectangular potential barrier - Tunneling effect. (K4)

Unit V: Spherically Symmetric Potential Problems: **(15 Hours)**

5.1 Schroedinger equation in Spherical polar coordinates (K1,K3)
5.2 Reduction of two body problems in to one body problem (K3)
5.3 Hydrogen atom – Wave equations for the hydrogen atom - Separation of variables- Azimuthal, polar and Radial wave equations (K1,K2,K3,K4)
5.3 Solution for Azimuthal and polar wave equation (K1,K2,K3,K4)
5.5 Rigid Rotator- Moment of inertia of a rigid rotator (K1,K3,K4)
5.6 Wave equation for rigid rotator and its energy levels- wave functions for the rigid rotator. (K3,K4)

Books for Study:

1. R.Murugeshan – Modern Physics – S.Chand Publication – Reprint 2007 (Units I, III, V – Rigid Rotator)
2. Arthur Beiser – Concepts of Modern Physics – McGraw Hill Publication, 2003.
3. S.P.Singh, M.K.Badge& Kamal Singh – Quantum Mechanics – S.Chand & Co. Ltd., Reprint 2001(Unit – IV)
4. G.Aruldass – Introduction to quantum mechanics – Prentice Hall of India, Reprint 2005 (Unit – IV)
5. D.Devanathan, - Introduction to Quantum Mechanics – Narosa Publications, 2019.
6. Kamal Singh, S.P.Singh – Elements of Quantum Mechanics – S.Chand publications – Edition 2005 (Unit V)

Books for Reference:

1. Gupta Kumar Sharma – quantum Mechanics - Jai Prakash Nath Publications, 2017.
2. B.K.Agarwal – quantum Mechanics – Lokbharathi Publications, 2003
3. Sathyaprakash - Mathematical physics – S.Chand & Sons, Reprint 2006.
4. Sathyaprakash – Advanced quantum mechanics - S.Chand & Sons, Reprint 2006.