Semester – 1

BRANCH	Subject Title	Subject Code
B.Sc. (Physics – Major)	THERMODYNAMICS AND STATISTICAL PHYSICS	PYM1

Course Learning Outcomes (CLO)

1. The course would enable the students to understand the basic Physics of heat and temperature in relation to energy, work, radiation and matter.
2. The students are expected to learn that "how laws of thermodynamics are used in a heat engine to transform heat into work".
3. This course will also develop an understanding of the various concepts of statistics and the methods to apply them in thermodynamics.
4. Students will understand the importance of studying statistical mechanics with the behavior of particles under classical and quantum conditions.

CONTENT

Unit - 1

Historical background & Laws of thermodynamics

1. Historical background:

1.1.A brief historical background of thermodynamics and statistical Physics in the context of India and Indian culture, Contribution of S. N. Bose in statistical Physics.

2. Laws of thermodynamics:

2.1.Thermodynamical system and thermodynamical coordinates, Thermal equilibrium, Zeroth law of thermodynamics, The concept of path function and point function, Work done by and on the system.

2.2.First law of thermodynamics, Internal energy as a state function, Reversible and irreversible change, Heat engine and its efficiency, Carnot's cycle, Carnot's engine and its efficiency, Camot's theorem, Otto engine, Otto cycle, diesel engine.

2.3.Second law of thermodynamics, Statement of Kelvin- Plank and Clapeyron, Absolute scale of temperature: Zero of absolute scale, Size of degree, Identity of a perfect gas scale and absolute scale.

Unit - 2

Entropy

1. Concept of entropy, Clausius theorem, Entropy as a point function, Change in entropy in reversible and irreversible processes.

2. Change in entropy of an ideal gas, Change in entropy when two liquids at different temperatures are mixed (or two bodies at different temperatures are kept in contact).

3. Principle of increase of Entropy, Change in entropy of the universe in an irreversible process, Disorder and heat death of universe.

4. Physical significance of Entropy, Temperature - entropy (T-S) diagram, third law of thermodynamics.

Unit - 3

Thermodynamic potentials and kinetic theory of gases

1. Thermodynamic potential and its application:

1.1.Thermodynamic potentials, Thermal equilibrium, Internal energy, Helmholtz free energy, Enthalpy and Gibbs free energy.

1.2.Derivation of Maxwell's relations from thermodynamic potentials, Gibbs Helmholtz equation, Thermodynamic energy equation for ideal and van der Waal gas.

1.3.TdS equation, Derivation of expressions for Cp-Cy and their special cases for ideal and van der Waal gases, derivation of the expression Es/E Cp / Cv.

1.4.Clausius Clapeyron latent heat equation, Temperature change in adiabatic process, Principle of refrigeration, Joule Thomson effect, Cooling by adiabatic demagnetization, Production and measurement of very low temperatures.

2. Kinetic theory of gases:

2.1.Behavior of a real gas and its deviation from an ideal gas, Virial equation, Andrews experiment on CO2 gas.

2.2.Critical constant, continuity of the liquid and gaseous state, Vapour and gas state, Boyle temperature, van der Waals equation for real gas, Values of critical constants, Law of the corresponding state.

Unit - 4

Classical Statistics

1. Probability, Distribution of N particles in two identical boxes, Probability of occurrence of either event, probability of composite events, Weightage probability.

2. Probability distribution and its lnarrowing with the increase in number of particles, Expression for average properties, constraints, Accessible and non-accessible microstates.

3. Ensemble theory (Micro-canonical, Canonical and Grand- canonical), Macro and micro states with examples, Principle of equal a prior probability, Concept of phase space.

4. Boltzmann Canonical distribution law Application: average energy of one-dimensional harmonic oscillator,

5. Derivation of law of equipartition of energy from statistics, Equilibrium between two system in thermal contact and parameter, Statistical Interpretation of entropy and relation S=k logW.

6. Boltzmann partition function and derivation of expression for Internal energy, Helmholtz free energy, Enthalpy and Gibbs free energy.

Unit - 5

Quantum Statistics

1. Indistinguishability of particles and its consequences, Maxwell Boltzmann statistics (Classical statistics): Maxwell- Boltzmann distribution law of velocity and speed, Maxwell - Boltzmann statistics and its distribution law.

2. Quantum statistics: Bose-Einstein statistics and distribution law, Derivation of Planck's radiation law from B-E statistics, Rayleigh -Jeans law, Wein's displacement law and Stefan's law.

3. Fermi Dirac statistics and its distribution law, Explanation of free electron theory, Fermi level and Fermi energy.

4. Comparison between the Maxwell Boltzmann, Bose- Einstein and Fermi - Dirac statistics.

Topic PRACTICAL

1. Determination of the mechanical equivalent of heat by Callendar & Barne's method

2. Determination of efficiency of electrical Kettle with variable voltages

3. Determination of temperature coefficient of a resistance using platinum resistance thermometer.

4. Determination of electromotive force of a thermocouple

5. Determination of thermal conductivity of a bad conductor by Lee's disc method.

6. Verification of Newton's law of cooling

7. Determination of the ratio of specific heat of air by Clement- Desorme's method.

8. Determination of specific heat of a liquid with the help of Newton's law of cooling

9. Determination of the coefficient of thermal conductivity of a metal by Searl's method.

10. Determination of thermal conductivity of the rubber using calorimeter.

11. Determination calorimeter. of mechanical equivalent of heat (J) using Joule calorimeter.

12. Determination of Stefan's constant using thermocouple.

13. Study of statistical distribution and determination of standard deviation with the help of black and white dice.

14. Determination of the temperature coefficient of a resistance with the help of Carey-Foster bridge.

15 Determination of the critical constant of a gas/vapour.

Semester 2

BRANCH	Subject Title	Subject Code
B.Sc. (Physics – Major)	MECHANICS AND GENERAL PROPERTIES OF MATTER	

Course Learning outcomes

1. The course would empower the students to develop the idea about the behavior of physical bodies.
2. It will provide the basic concepts related to the motion of all the objects around us in daily life.
3. The students would be able to build foundation to various applied field in science and technology especially in the field of mechanical engineering.
4. The students will acquire the knowledge of basic mathematical methods to solve the various problem in physics.
5. The students will be able the understand the relativistic effect and the relation between energy and mass.

CONTENT

Unit - 1

Historical background and Mathematical Physics

1. Historical background:

1.1. A brief historical background of mathematics and mechanics in the context of India and Indian culture.

1.2. A brief biography of Varahamihira and Vikram Sarabhai with their major contribution to science and society.

Mathematical Physics:

2.1. Scalar and vector fields, Gradient of a scalar field and Its physical significance.

2.2. Vector integral: line Integral, surface integral and volume integral, Divergence of a vector field and its physical significance, Gauss divergence theorem.

2.3. Curl of a vector field and its physical significance, Stokes and Green's theorem, Numerical problems based on the above topics.

Unit - 2

Mechanics of Rigid and deformable bodies

1.1. System of particles and concept of Rigid body, Torque, centre of mass: position of the centre of mass, Motion of the centre of mass, Conservation of linear & angular momentum with examples, Single stage and multistage rocket.

1.2. Rotatory motion and concept of moment of inertia, Theorems on moment of inertia: theorem of addition, theorem of perpendicular axis, theorem of parallel axis, Calculation of moment of inertia of rectangular lamina, disc, solid cylinder, solid sphere.

2. Mechanics of deformable bodies:

2.1. Hook's law, Young's modulus, Bulk modulus, Modulus of rigidity and Poisson's ratio, Relationship between various elastic moduli.

2.2. Possible values of Poisson's ratio, Finding Poisson's ratio of rubber in the laboratory, Torsion of a cylinder, Strain energy of twisted cylinder.

2.3. Finding the modulus of rigidity of the material of a wire by Barton's method, Torsional pendulum and Maxwell's needle, Searl's method to find Y, and or of the material of a wire, Bending of beam, Cantilever, Beam supported at its ends and loaded in the middle.

Unit - 3

Fluid mechanics

1. Surface Tension:

1.1. Inter-molecular forces and potential energy curve, force of cohesion and adhesion.

1.2. Surface tension, Explanation of surface tension on the basis of intermolecular forces, Surface energy, Effect of temperature and impurities on surface tension, Daily life application of surface tension.

1.3. Angle of contact, The pressure difference between the two sides of a curved liquid surface, Excess pressure inside a soap bubble, Capillarity, determination of surface tension of a liquid capillary rise method, Jaeger's

2. Viscosity:

2.1. Ideal and viscous fluid, Streamline and turbulent flow, Equation of continuity, Rotational and Irrotational flow, Energy of a flowing fluid, Euler's equation of motion of a non-viscous fluid and its physical significance

2.2. Bernoulli's theorem and its applications (Velocity of efflux, shapes of wings of airplane, Magnus effect, Filter pump, Bunsen's burner).

2.3. Viscous flow of a fluid, Flow of liquid through a capillary tube, Derivation of Poiseuille's formula and limitations, Stocks formula, Motion of a spherical body falling in a viscous fluid.

Unit - 4

Gravitational potential and Central forces

1. Gravitational potential:

1.1.Conservative and non-conservative force field, Conservation of energy in motion under the conservative and non-conservative forces, Potential energy.

1.2. Conservative force, Conservation of energy, Gravitational potential and gravitational potential energy, Gravitational potential and intensity of gravitational field due to a uniform spherical shell and a uniform solid sphere.

1.3.Gravitational self-energy, Gravitational self-energy of a uniform spherical shell and a uniform solid sphere.

2. Central forces:

2.1.Motion under Central forces, Conservative characteristics of central forces.

2.2.The motion of a two particles system in Central force, Concept of reduced mass, Reduced mass of positronium and hydrogen. 2.3.Motion of particles in an inverse-square central force, Motion of celestial bodies and derivation of Kepler's laws,

2.4.Elastic and inelastic scattering (elementary idea).

Unit - 5

Relativistic Mechanics and Astrophysics

1. Relativistic Mechanics:

1.1.Frame of references, Galilean transformation, Michelson -Morley experiment.

1.2.Postulates of special theory of relativity, Lorentz, Transformation, Simultaneity and order of events, Length contraction, Time dilation, Relativistic transformation of velocities, Variation of mass with velocity.1.3. Mass-energy equivalence and its experimental verification.

2. Astrophysics:

2.1.Introduction to the Universe, Properties of the Sun, Concept of Astronomical Distance

2.2. Life cycle of a stars, Chandrasekhar Limit, H-R diagram, Red giant star, White dwarf star, Neutron star, Black hole,

2.3.Big Bang Theory (elementary Idea).

PRACTICAL

1.Determination of Young's modulus, modulus of rigidity and Poisson's ratio of material of a wire using Searle's method.

2. Determination of Young's modulus of material of a metallic bar by bending of beam method.

3. Determination of acceleration due to gravity (g) using Bar pendulum.

4. Determination of acceleration due to gravity (g) using Kater's reversible pendulum.

5. Determination of modulus of rigidity of a rod with the help of Barton's apparatus

6. Determination of coefficient of viscosity of liquid using Poiseuille's method.

7. Determination of the moment of inertia of a flywheel about its axis of rotation.

8. Determination of the moment of inertia of a given body (Irregular body) with the help of inertia table.

9. Verification of laws of the parallel/perpendicular axes of moment of inertia

10. Determination of modulus of rigidity of material of a wire with the help of Maxwell's needle.

11. Determination of Young's Modulus of a material of a rod using the cantilever method

12. Determination of modulus of rigidity of material of a wire with the help of torsional pendulum.

13. Determination of force constant of a spring.

14. Determination of Poisson's ratio of rubber.

15. Determination of surface tension of a liquid by Jaeger's method.