ST JOSEPH'S UNIVERSITY

BENGALURU – 560027

SEP SYLLABUS

followed during

2024-2027

School of Physical Sciences

DEPARTMENT OF PHYSICS

ST JOSEPH'S UNIVERSITY

BENGALURU-27

School of Physical Sciences

DEPARTMENT OF PHYSICS

Curriculum for B.Sc.

as per

SEP- 2024

UNDERGRADUATE PROGRAMME SYLLABUS FOR

I to II semester 2024

Onwards

Course Outcomes and Course Content

Semester	I
Paper Code	**PH 124**
Paper Title	**Mechanics and Properties of Matter**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objective of the Paper:

To make the students understand and learn the basic concepts of Mechanics and Properties of Matter in detail which makes a firm basis for the advanced topics taught in higher semesters. The paper gives a detailed overview of units and measurements, co-ordinate systems, relativity, basic mechanics of system of particles and gravitation which are the basic building blocks for understanding classical mechanics.

Semester- I

PH124: MECHANICS AND PROPERTIES OF MATTER

1. Units and measurements: dimensions of physical quantities, dimensional formulae.
Coordinate system: Cartesian co-ordinate system - Vectors and scalars, addition of vectors, multiplication of vectors - dot product, cross product, Geometrical interpretation of dot and cross product. resolution of vectors, unit vectors in plane polar co-ordinate system $\left(\hat{r},\hat{\theta},d\hat{r}/d\theta,d\hat{\theta}/d\theta\right)$,Velocity($\vec{V}=\vec{V}_r+\vec{V}_\theta$) and acceleration ($\vec{a}=\vec{a}_r+\vec{a}_\theta$) in polar coordinate system. Uniform circular motion-centripetal acceleration. Velocity and acceleration in Cartesian coordinate system.

2. Momentum and Energy:, Centre of mass, velocity and acceleration of centre of mass. Total linear momentum about the centre of mass, system of two particles, equation of motion of centre of mass, and rocket propulsion-single stage. (**8 Hours)**

Self study : System of units (CGS and SI), measurement of length, mass and time, Fictitious forces. Coriolis force. Work-Energy theorem, multistage rocket propulsion. **(2 hours)**

3. Dynamics of Rigid bodies: Rotational motion about an axis, moment of inertia and physical significance, angular momentum, torque on a rigid body, law of conservation of angular momentum, examples of conservation of angular momentum. Rotational energy. Theorems of perpendicular and parallel axes. M I of rectangular Lamina, circular disc, and solid cylinder. Flywheel. Theory of compound pendulum and determination of g. (**10 Hours)**

4. Central force and gravitation: Conservative force – central force, angular momentum in central force field, motion under central force, law of equal areas, nature of motion under central force. Kepler's laws (statements), law of time periods($T^2 \alpha A^3$). Newton's law of Gravitation, Gravitational potential energy, Gravitational field and potential, Calculations of gravitational potential and field – spherical shell & solid sphere, Physics of Oceanic tides, explanation of $1/r^3$ dependence. **(8 Hours)**

Self Study: Satellite in a circular orbit - Launching of artificial satellites, escape velocity, time period of a satellite. Geostationary, Geosynchronous satellites **(2 hours)**

5. Elasticity: Rigid bodies & elastic bodies, Concept of stress & strain, stress – strain diagram for metallic wire, elastic limit, Hooke's law, elastic moduli –Young's modulus, rigidity modulus & bulk modulus, Poisson's ratio, Mention the relation between them, limiting values of Poisson's ratio. Work done in stretching a wire(derivation), Bending of beams – concept of neutral surface and neutral axis, bending moment(derivation), theory of single cantilever. Torsion of a cylinder- Couple per unit twist.

6. **Surface tension:** Molecular forces in liquids & liquid surfaces – Adhesive & cohesive forces, Mention of sphere of influence, Molecular interpretation of surface tension. Surface energy – definition and derivation, angle of contact, lotus effect. Pressure difference across a curved surface (derivation), Excess of pressure inside a liquid drop and a bubble. Interfacial tension – drop weight method - balancing condition. (**13 Hours)**

Self study:

Viscosity: Streamline flow, turbulent flow, critical velocity, Reynold's number, equation of continuity and Stoke's method, life at low Rynold's number. **(2 hours)**

Course Outcomes

At the end of this course, students will be able to

- learn fixing units, tabulation of observations, analysis of data (graphical/analytical)
- learn about accuracy of measurement and sources of errors, importance of significant figures.
- Analyze the motion of particles under central forces.
- Analyze and apply the mechanics of orbital motion using Newton's law of gravitation.
- come to know how various elastic moduli can be determined.
- measure surface tension and viscosity and apply suitable method to the problem
- get hands-on experience of different equipment.

Text Book:

1. Physics for Degree Students, B.Sc First Year, C.L. Arora and P.S. Hemne, II edition, 2013, S. Chand and Company Ltd.

Reference Books:

1. University Physics with modern physics, Sears and Zemansky, 12th Edition, 2009, Pearson Education.

2. Mechanics, D.S. Mathur, S. Chand and Company Ltd. 2000.

3. Mechanics Berkeley Physics Course, Vol.1, Charles Kittel, 7th edition, Tata McGraw- Hill, 2007.

4. Properties of Matter, Brijlal & Subramanyam, S. Chand and Company Ltd. 2002.

5. Rotation, Scientific America, compilation of scientific paper. (Reference for conservation of angular momentum)

6. Life at lower Reynolds number, E.M. Purcell, American Journal of Physics 45, 3 (1977); https://doi.org/10.1119/1.10903.

7. Fundamentals of Physics, Resnick, Halliday & Walter, Wiley, 2002.

8. Newtonian Mechanics, A.P. French, WW Norton & Co.

9. Classical Mechanics, Rana and Jog, Tata Mc-Graw-Hill, 24th Edition, 1991

Practical I

PH 1P1: Practical

List of experiments.

Introduction to measuring devices (significant digits) and error analysis.

1. Determination of moment of inertia of a Fly Wheel.
2. Verification of parallel and perpendicular axis theorems.
3. Determine the Young's Modulus by bar bending method (single cantilever)
4. Viscosity by Stoke’s method
5. Surface tension and interfacial tension by drop weight method.
6. Moment of inertia of irregular body.
7. Rigidity modulus by dynamic method
8. Searle’s double bar
9. Bulk modulus of rubber
10. Verification of conservation of energy

Course Outcomes and Course Content

Semester	II
Paper Code	**PH 224**
Paper Title	**Thermal and Statistical Physics**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objective of the Paper:

To make the students understand and learn the basic concepts of Thermodynamics and Statistical mechanics in detail which makes a firm basis for the advanced topics taught in higher semesters. The paper gives a detailed overview of Thermodynamics and Statistical mechanics with real time applications.

Semester- II

PH224 -THERMAL AND STATISTICAL PHYSICS

1. **Kinetic theory of gases:**

Kinetic theory of gases: Assumptions of kinetic theory of gasses, Deduction of the pressure of an ideal gas, Deduction of Boyle's law, Maxwell's velocity distribution (Graph & interpretation without derivation), Definition & expressions for rms, mean & most-probable velocity. Degrees of freedom, Principle of equipartition of energy, ratio of specific heat capacity for mono-atomic, di-atomic & tri-atomic gas. Mean free path (Derivation). Transport phenomenon – derivation of coefficient of viscosity. (**9 hours)**

Self Study: Charles's law & Avogadro's law from kinetic theory. **(1 hour)**

2. **Real gases:**

Andrew's isothermal curves for real gases, Van-der-Waals' equation, critical constants. Joule Thomson expansion- porous plug experiment with theory. **(5 Hours)**

3. **Thermodynamics:**

Zeroth law, First law of thermodynamics, Concept of internal energy, Concept of absolute zero, Entropy & second law of thermodynamics. Different types of thermodynamic processes: isothermal, adiabatic, isobaric & isochoric. Derivation of PV^{γ} = constant. Expressions for change of entropy- for phase transition and change in temperature. Statement of Clausius inequality, T-S diagram & its use to find the efficiency of Carnot cycle. Third law of thermodynamics. **(7 Hours)**

Self Study: Work done during isothermal & adiabatic changes. Carnot cycle, Carnot engine – efficiency. Carnot's theorem (Statement & explanation), thermodynamics of rubber band. **(3 hours)**

4. **Thermodynamic potentials:**

Internal energy, enthalpy, Helmholtz free energy, Gibbs free energy & their significance, Maxwell's thermodynamic relations from thermodynamic potentials & their significance. Application of Maxwell's thermodynamic relation – nature of variation of internal energy with volume, Clausius – Clayperon's equation. **(5 Hours)**

5. **Radiation:**

Black body radiation, Characteristics of black body spectrum, Planck's law with derivation, Deduction of Wien's displacement law & Rayleigh – Jean's law from Planck's law, Stefan's law, Stefan – Boltzmann law. Solar constant, Surface temperature of sun - derivation. **(5 Hours)**

Self Study: Bolometer and Bolometric measurements.

6. Statistical physics:

Fundamental Postulates of Statistical Mechanics- phase space, microstate, macrostate, thermodynamic probability. Maxwell Boltzmann statistics- basic postulates, distribution function. Bose Einstein statistics – postulates, distribution function, Fermi-Dirac statistics, and Fermi distribution function, Comparison of three statistics, Partition function, mention about the gas laws from partition function (no derivation). **(8 hours)**

Self study: Gas laws from partition function, width of spectral line (Collision broadening), Maxwell distribution of molecular velocities. (**2 hours)**

Course Outcomes:

Students will be able to

- Comprehend the assumptions of kinetic theory of gases and derive pressure of an ideal gas and deduce the gas laws.
- Interpret the Maxwell's velocity distribution and calculate RMS, Mean and Most probable velocity.
- Apply the principle of equipartition of energy to determine specific heat capacities, mean free path and coefficient of viscosity.
- understand Andrew's isotherms for real gases, their behavior under Van-der-Waals' conditions, and the calculation and interpretation of critical constants.
- learn an in-depth explanation of the Joule-Thomson expansion process and analyze its effects on real gases.
- Understand the Zeroth and First laws of thermodynamics and internal energy, analyze various processes, and derive the relationship between constants (P, V, γ).
- Know the foundation and application of the ideas of thermodynamic cycles to understand Carnot cycle, entropy, and the Third Law of Thermodynamics.
- Appreciate the relation between thermodynamic potentials and thermodynamic variables through Maxwell's thermodynamic relations.
- Grasp a fundamental understanding of the black body spectrum and the laws that regulate it to compare the behavior of any hot object, including the sun.
- learn about phase-space, concept of ensemble, ergodicity and various distribution functions based on the distinguishability of particles.

Text book:

1. Physics for Degree Students, B. Sc second year – C.L. Arora and P.S. Hemne, II revised edition 2013.

Reference:

1. Heat & Thermodynamics – J.B.Rajam.
2. Heat & Thermodynamics – D.S.Mathur – S Chand & Co – New Delhi, 5th Edition, 2004.
3. Teach Yourself Thermodynamics – Bharathibavan Publication.
4. Heat Thermodynamics & Statistical Physics – Brijlal, Subramanyam & P.S. Hemne, S Chand & Co.
5. Thermodynamics and Statistical Physics - Singhal, Agarwal.
6. Statistical and Thermal Physics: An Introduction, S. Lokanathan and R.S. Ghambir, I Edition, Prentice Hall India Learning Private Limited, 1991.
7. Fundamentals of Statistical and Thermal Physics, VI edition, Waveland Press, 2010.
8. Statistical Mechanics - M. Eisner B K Agarwal, New age international Pvt Ltd, 2020.
9. PSSC Physics, Gardner Robert, Kendall Hunt Pub Co, 1991.
10. Bose and his statistics, G. Venkatraman, Sangam Books Lte, 1993.

PH2P1 Practical

List of experiments:

1.Determination of Specific heat of water using Joule's calorimeter.
2. Determination of Thermal conductivity of rubber.
3. Determination of Thermal conductivity of a bad conductor.
4. Determination of Emissivity of a surface by Lee's disc method.
5. Verification o of Stefan's constant by Emissivity method.
6. Newton's Law of cooling.
7. Black body radiator- determination of Stefan's constant.
8. Gaussian distribution – using radioactive source.
9. Entropy of latex rubber band (ref: Thermodynamics of a rubber band, American Journal of Physics)
10. Galton Board experiment- to demonstrate statistical distribution.