Course Outcomes and Course Content

Semester	I
Paper Code	**PH 121**
Paper Title	**Mechanics, Heat and Thermodynamics**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

This paper introduces the students to the mathematical background needed for understanding concepts in Physics. This paper acts as the first step to gain insight about the basics of the classical mechanics. The students will be able to understand how matter and forces exist and interact in the macro world. Also, students gain knowledge about how matter and heat energy interact.

SEMESTER I
PH 121 – Mechanics, Heat and Thermodynamics

Total Hours: 60

Problems are mandatory from all chapters including self-study

UNIT I

1. **Coordinate system**:

Cartesian co-ordinate system - Vectors and scalars, addition of vectors, multiplication of vectors - dot product, cross product, resolution of vectors, unit vectors in plane polar co-ordinate system ($\hat{r}$, $\hat{\theta}$, $\frac{d\hat{r}}{d\theta}$, $\frac{d\hat{\theta}}{d\theta}$). Velocity ($\vec{v} = \vec{v}_r + \vec{v}_\theta$) and acceleration ($\vec{a} = \overrightarrow{a_r} + \overrightarrow{a_\theta}$) in polar coordinate system. Uniform circular motion-centripetal acceleration. Velocity and acceleration in Cartesian coordinate system. Spherical polar coordinate system, components of velocity in spherical polar coordinate system. **(7 Hours)**

Self-study: Geometrical interpretation of dot and cross product. **(1Hour)**

OBJECTIVE: Students should be able to have proper mathematical background needed for understanding concepts in Physics. Students will be capable of knowing when to apply cartesian / spherical co-ordinate system in each of the given situation.

2. **Mechanics: Laws of motion:**

Review of Newton's laws of motion. Frames of reference – Inertial & Non-inertial, Newtonian principle of relativity, Galilean transformation, Newton's laws of motion invariant under Galilean transformation, Non-inertial frame- linearly accelerated frame, uniformly rotating frame -fictitious forces, Coriolis force. **(5Hours)**

Self-study: Examples of Coriolis force - understanding cyclone, anticyclone in terms of Coriolis force - trade winds. **(1 Hour)**

OBJECTIVE: Students should be able to understand the fundamental concepts in Classical mechanics - Newtonian relativity.

3. **Conservation of momentum and mechanics of centre of mass:**

Homogeneity and isotropy of space, linear momentum, law of conservation of linear momentum, expression for impulse.

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, multistage.

Collision- elastic and inelastic. Perfectly inelastic collision in one dimension -expression for decrease in energy. **(5 hours)**

Self-study: Applications of the principle of conservation of angular momentum and Zero angular momentum eg: Falling of cat from heights. **(1 Hour)**

OBJECTIVE: Students should be able to apply Newton's laws of motion to understand physical phenomenon. Students can apply Newton's laws to variable mass system, two body problems.

4. Dynamics of rigid body:

Introduction – Inertia, moment of inertia and physical significance, angular momentum, torque on a rigid body, law of conservation of angular momentum, examples. Kinetic energy of rotating rigid body. Power delivered and work done by a torque. Similarity between translatory and rotatory motion, theorems of perpendicular and parallel axes. M.I of circular disc, thin rod and solid sphere. Kinetic energy of a body rolling on a horizontal plane. Acceleration of a body rolling down on an inclined plane. **(9 Hours)**

Self-study: Applications of parallel and perpendicular axis theorem – rectangular lamina.**(1Hour)**

OBJECTIVE: Should be able to differentiate between translatory and rotatory motion which helps to understand the dynamics of rigid body motion in nature.

UNIT- II

5. Kinetic theory of gases:

Assumptions of kinetic theory of gases, pressure of an ideal gas, Maxwell's speed distribution (graph & interpretation without derivation). Definitions & 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 and coefficient of diffusion. Expression for coefficient of thermal conductivity (no derivation). **(9 Hours)**

Self-study: Boyle's law, Charles's law, Avogadro's law from pressure expression and Dynamic nature of Maxwell's distribution-concept of evaporation. **(1 Hour)**

OBJECTIVE: Students should be able to relate macroscopic properties of a gas to its microscopic properties.

6. Thermodynamics:

Zeroth law, first law of thermodynamics, concept of internal energy, different types of thermodynamic processes – isothermal, adiabatic, isobaric & isochoric. Derivation of PV^{γ} = constant. Work done during isothermal & adiabatic changes. Carnot cycle, Carnot engine – efficiency. Clausius – Clapeyron's latent heat equation, Carnot's theorem (No proof only statement & explanation). Concept of absolute zero, entropy & second law of thermodynamics. Principle of increase in entropy in solving problems (No derivations), statement of Clausius inequality, T-S diagram & its use to find the efficiency of Carnot cycle. **(9 Hours)**

Self-study: reversibility of Carnot cycle – refrigerator, coefficient of performance. Third law of thermodynamics. Non attainability of absolute zero and IIIrd law of thermodynamics. **(1 Hour)**

OBJECTIVE: Students should be able to distinguish between different thermodynamic processes. They should be able to understand the concept of entropy and inter-convertibility of heat and mechanical work.

7. 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. **(4 Hours)**

Self-study: Difference between the specific heat capacities for ideal gases & real gases. **(1 Hour)**

OBJECTIVE: Students should be able to relate thermodynamic potentials with thermodynamic variables. And should be able to apply Maxwell's relation to different thermodynamic processes.

8. Real gases:

Andrew's isothermal curves, Vander Waals' equation, critical constants (definition & derivation). Joule Thomson expansion with theory.

(4 Hours)

Self-Study: Difference between Joule Thomson expansion & adiabatic expansion, adiabatic de-magnetization. **(1 Hour)**

OBJECTIVE: Students should be able to differentiate between ideal and real gases.

Text Book:

1. Physics for degree students, B.Sc – I and II Year C.L . Arora, Dr. P. S. Hemne - S. Chand & Company 2nd Revised edition – 2013.

References:

1. University Physics – F.W. Sears & Zemansky & H.D. Young – Narosa Publications – New Delhi, 6th Edition.
2. Fundamentals of Physics – Resnick, Halliday & Walker – Asian Books Pvt. Ltd. – New Delhi, 5th Edition.
3. Feynman lectures on physics – Vol 1 – Narosa Publications – New Delhi.
4. Elements of Properties of Matter – D.S. Mathur – Shamlal Charitable Trust – New Delhi.
5. Mechanics – Berkley Physics Course Vol 1 – Mittal, Knight & Rudermann, TMH – Delhi, 1981.
6. Properties of Matter – Brijlal & Subramanyam, S Chand & Co.
7. Heat & Thermodynamics – J.B. Rajam.
8. Heat & Thermodynamics – D.S. Mathur – S Chand & Co – New Delhi, 5th Edition, 2004.
9. Teach Yourself Thermodynamics – Bharathibavan Publication.
10. Heat Thermodynamics & Statistical Physics –Brijlal, Subramanyam & P.S. Hemne, S Chand & Co.
11. Mechanics – J.C. Upadhaya, Ramprasad& Co – Agra.
12. Classical Mechanics – N.C. Rana and Joag, McGraw Hill Publication.
13. Mechanics & Thermodynamics –G.Basavaraju & Dipan Ghosh, TMH Publishing Ltd. – New Delhi.
14. Concepts of Physics Vol 1 & Vol II – H.C. Verma – Bharathibavan Publication – New Delhi.

BLUEPRINT

Code number: **PH 121**

Title of the paper: **Mechanics, Heat and Thermodynamics**

Chapter	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	30	**51**
Unit II	30	**51**
TOTAL	**60**	**102**
Maximum marks for the paper (Excluding bonus question) = 70		

Practical I

PH1P1 – Mechanics, Heat and Thermodynamics: (11 sessions 3hr/week)

List of experiments:

1. Measuring instruments – Vernier calipers, Screw Gauge & Travelling Microscope with error calculation.
2. Verification of principle of conservation of energy.
3. Determination of moment of inertia of an irregular body.
4. Verification of parallel & perpendicular axes theorem.
5. Determination of moment of inertia of a flywheel.
6. Coupled oscillators – Determination of period for normal modes & frequency of energy transfer.
7. Determination of Specific heat of a Liquid by Newton's law of cooling.
8. Determination of specific heat of water using Joule’s calorimeter.
9. Determination of thermal conductivity of rubber.
10. Determination of thermal conductivity of a bad conductor.

OR

Any other related experiments the department deems necessary.

Course Outcomes: At the end of the course, the student should

CO1	REMEMBER	1. Mathematical concepts as tools needed for understanding Physics. 2. Definitions, laws associated with mechanics, heat and thermodynamics.
CO2	UNDERSTAND	The underlying assumptions and hypothesis related to the laws of mechanics, heat and thermodynamics.
CO3	APPLY	1. The laws of mechanics to solve problems involving forces acting on a body in equilibrium and on an accelerating body. 2. The laws of heat and thermodynamics to relate microscopic properties of a gas with its macroscopic properties. 3. The above-mentioned laws to perform basic experiments and solve problems in mechanics, heat and thermodynamics in the laboratory.
CO4	ANALYSE	1. The experimental results with theoretical predictions. 2. The applicability of laws on various physical situations by solving problems in a logical and systematic method.
CO5	EVALUATE	1. The region of validity of laws or the limitations of physical laws. 2. Failure of mechanics in the case of bodies moving with very high velocities. 3. Different thermodynamic processes.
CO6	CREATE	1. With the knowledge of mechanics, model the trajectory of a particle or object. 2. Working models to demonstrate the concepts learnt. 3. Working models which benefit the society. With the knowledge of conservation of energy, one can predict the maximum utility of energy in day-to-day life.

Course Outcomes and Course Content

Semester	II
Paper Code	**PH 221**
Paper Title	**Properties of Matter, Waves and Radiation**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

This paper enables the students to have a deeper understanding of the various properties of matter and appreciate it. It helps them to differentiate between the central forces and non-central forces in nature and their consequences. Students can interpret and use mathematical expressions for sinusoidal periodic waves. They understand the failure of classical mechanics in explaining the complete black body spectrum which paved the way for quantum mechanics.

Semester – II

PH 221 – Properties of Matter, Waves & Radiation

Total Hours: 60

Problems are mandatory from all chapters including self-study

UNIT I:

1. 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 required to twist a uniform solid cylinder. **(8 Hours)**

Self-study: I-section girders and its applications. **(1 Hour)**

OBJECTIVE: Students should be able to distinguish between rigid bodies and elastic bodies. To analyze conditions in which a body is deformed by tension, compression, pressure or shear.

2. 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. Capillarity and expression for capillary rise. Pressure difference across a curved surface (derivation), Excess of pressure inside a liquid drop and a bubble. Vanishing of surface tension at the critical point.

Interfacial tension – drop weight method - balancing condition. **(5 Hours)**

Self-study: Minimization of surface energy under constraint condition, soap films and soap bubbles. **(1 Hour)**

OBJECTIVE: The chapter gives a wider aspect of static property of fluids. To understand surface tension in terms of intermolecular forces, and application of surface tension.

3. Viscosity:

Streamline & turbulent flow, critical velocity, Reynold's number, derivation of Poiseuille's formula for steady flow of liquid through a narrow tube. Equation of continuity, Stokes law – co-efficient of viscosity, derivation of Stokes's formula using dimensional analysis. Expression for terminal velocity. **(4 Hours)**

Self-study: Bernoulli's equation and its applications, *Life at lower Reynolds number (Reading project) **(1 Hour)**

OBJECTIVE: The chapter gives a wider aspect of dynamic property of fluids. Application of Bernoulli's principle.

4. Central force and Gravitation:

Introduction to fundamental forces. Conservative force – central force – different types, angular momentum in central force field, motion under central force, law of equal areas, nature of motion under central force.

Newton's laws of Gravitation, Gravitational potential energy, Gravitational field and potential, Calculations of gravitational potential and field – spherical shell & solid sphere, gravitational self-energy of a uniform solid sphere.

(8 Hours)

Self-Study: Kepler's laws of planetary motion, Launching of artificial satellites, escape velocity, time period of a satellite, Geostationary, Geosynchronous satellites (qualitative). **(2 Hour)**

OBJECTIVE: Students should be able to differentiate between central and non-central forces, understanding of motion of bodies under central force (gravitational force), which is a foundation to study Astrophysics.

UNIT II:

5. Simple Harmonic Motion:

Simple harmonic motion – projection of circular motion as SHM, equation of motion of SHM, energy conservation in SHM, simple pendulum as a linear harmonic oscillator. Coupled oscillator – normal mode, n-coupled oscillator, angular SHM, torsional pendulum, compound pendulum – expression for time period & concept of equivalent length of a bar pendulum, spring mass oscillator-effective mass of the spring and acceleration due to gravity. Composition of two SHM's (conditions for maxima & minima), Lissajous' figures. Equation of motion of damped harmonic oscillation, solution of differential equation (no derivation) – critical damping, oscillatory and over damping. **(12 Hours)**

Self-study: Forced oscillation – concept of resonance. **(1 Hour)**

OBJECTIVE: Students should be able to identify whether the motion is simple harmonic or not. They should be able to understand the consequences of superposition of SHM. Damped harmonic oscillation.

6. Wave Motion:

Progressive wave equation, sine wave travelling on a string, wave pulse on a string, velocity of wave on a string. Energy transmitted by a wave, intensity and power transmitted by a sine wave, concept of phase velocity, group velocity (derivation of Vg= dw/dk) and the relation between them. Qualitative study of reflection and

refraction of waves across the interface. Fourier theorem, Fourier series, evaluation of the Fourier coefficients, Fourier analysis of a square wave. **(9 Hours)**

Self-study: Superposition of waves- interference, beats, standing waves, Fourier analysis of triangular wave and saw-tooth wave. **(2Hours)**

OBJECTIVE: Students should be able to distinguish between particle motion and wave motion. They will be able to understand how a complex wave can be generated from sine/cosine wave.

7. Radiation:

Emissive power, emissivity, absorptive power, Kirchoff's law, Black body radiation, characteristics of black body spectrum, Planck's law with derivation, deduction of Wien's law & Rayleigh – Jean's law from Planck's law, Stefan's law, Stefan – Boltzmann law. Radiation pressure (qualitative).

(5 Hours)

Self-study: Solar constant, Surface temperature of sun. **(1hour)**

OBJECTIVE: Students should be able to understand the characteristics of blackbody, limitations of classical physics and emergence of quantum physics.

Text Book:

1. Physics for degree students, B.Sc – I and II Year C.L . Arora, Dr. P. S. Hemne - S. Chand & Company 2nd Revised edition – 2013.

References:

1. University Physics –F.W. Sears and Zemansky & H.D. Young – Narosa Publications – New Delhi.
2. Fundamentals of Physics, 6th Edition – Resnick, Halliday & Walker – Asian Books Pvt Ltd – New Delhi, 5thEdition.
3. Ferman lectures on physics – Vol 1 – Narosa Publications – New Delhi.
4. Elements of Properties of Matter – D.S. Mathur – Shamlal Charitable Trust – New Delhi.
5. Mechanics – Berkley Physics Course Vol 1 – Mittal, Knight & Rudermann, TMH – Delhi,1981.
6. Oscillation & waves – D.P.K. Hadelwal, Himalaya publishing house.
7. Properties of Matter – Brijlal & Subramanyam, S Chand & Co.
8. Oscillation & waves –Brijlal & Subramanyam, S Chand & Co.
9. Heat & Thermodynamics –D.S. Mathur–S Chand & Co – New Delhi, 5th Edition, 2004.
10. Teach Yourself Thermodynamics –Bharathibavan Publication.
11. Heat Thermodynamics & Statistical Physics –BrijlalSubramanyam & P.S. Hemne, S Chand & Co.
12. Mechanics – J.O. Upadhyaya, Ramprasad& Co – Agra.
13. Mechanics & Thermodynamics –G Basavaraju & Dipan Ghosh, TMH Publishing Ltd – New Delhi.
14. Concepts of Physics Vol 1 &VoI II – H.C. Verma. Bharathibavan Publication – New Delhi.
15. Waves - (Berkely Physics Vol.3) - Frank S Crawford Jr.
16. *Life at lower Reynolds number, E.M.Purcell, Americal Journal of Physics 45, 3 (1977); https://doi.org/10.1119/1.10903.

BLUEPRINT

Code number: **PH 221**

Title of the paper: **Properties of Matter, Waves and Radiation**

Chapter	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	30	**51**
Unit II	30	**51**
TOTAL	**60**	**102**
Maximum marks for the paper (Excluding bonus question) = 70		

Practical II

PH2P1: Properties of Matter, Waves and Radiation (11 sessions 3hr/week)

List of experiments:

1. Determination of Young's modulus – by single cantilever.
2. Determination of modulii of elasticity using Searle's double bar.
3. Determination of acceleration due to gravity using Spring– mass oscillator.
4. Determination of rigidity modulus by dynamic method.
5. Determination of acceleration due to gravity using bar pendulum.
6. Determination of Viscosity of a liquid by Stoke's method.
7. Determination of Surface tension of a liquid & Interfacial tension between two liquids.
8. Determination of Emissivity of a surface by Lee's disc method.
9. Determination of Stefan's constant by Emissivity method.

OR

Any other related experiments the department deems necessary.

Course Outcomes: At the end of the course, the student should

CO1	REMEMBER	1. Remember the definitions and recall the laws associated with Properties of matter, wave motion and radiation.
CO2	UNDERSTAND	1. The difference between rigid bodies and elastic bodies. 2. Various types of harmonic oscillation. 3. Discrete nature of energy. 4. Significance of wave motion
CO3	APPLY	1. Solving problems related to properties of matter, waves and radiation. 2. Perform experiments of properties of matter, waves, and radiation.
CO4	ANALYSE	1. Nature of bodies, fluids, wave motion. 2. Practical application of materials. 3. Relate the concepts of black body to study stars.
CO5	EVALUATE	1. Behavior of materials in various states in nature deviating from ideal conditions. 2. The failure of classical mechanics in interpreting the blackbody. spectrum and the need for new mechanics.
CO6	CREATE	1. Working models to demonstrate the concepts learnt. 2. Develop working models which benefit the society. 3. New techniques for detergents, paints, emulsions, and pain-relieving oils etc. 4. Developing streamlined bodies