attractive force field; define gravitational potential energy of a mass m in the earth's field; expression for gravitational potential energy $U(r) = W_{\infty p} = m.V(r) = -G\,M\,m/r$; show that $\Delta U = mgh$, for $h << R$. Relation between intensity and acceleration due to gravity.

(iv) *Derive expression for the escape velocity of earth using energy consideration; v_e depends on mass of the earth; for moon v_e is less as mass of moon is less; consequence - no atmosphere on the moon.*

(v) *Satellites (both natural (moon) and artificial) in uniform circular motion around the earth; Derive the expression for orbital velocity and time period; note the centripetal acceleration is caused (or centripetal force is provided) by the force of gravity exerted by the earth on the satellite; the acceleration of the satellite is the acceleration due to gravity [$g' = g(R/R+h)^2$; $F'_G = mg'$].* Weightlessness; *geostationary satellites; conditions for satellite to be geostationary; parking orbit, calculation of its radius and height; basic concept of polar satellites and their uses.*

(vi) *Kepler's laws of planetary motion*: *explain the three laws using diagrams. Proof of third law (for circular orbits only).*

7. Properties of Bulk Matter

(i) Mechanical Properties of Solids: Elastic behaviour of solids, Stress-strain relationship, Hooke's law, Young's modulus, bulk modulus, shear modulus of rigidity, Poisson's ratio; elastic energy (qualitative treatment only).

Elasticity in solids, Hooke's law, Young's modulus and its determination, bulk modulus and shear modulus of rigidity, work done in stretching a wire and strain energy, Poisson's ratio.

(ii) Mechanical Properties of Fluids

Pressure due to a fluid column; Pascal's law and its applications (hydraulic lift and hydraulic brakes), effect of gravity on fluid pressure.

Viscosity, Stokes' law, terminal velocity, streamline and turbulent flow, critical velocity, Bernoulli's theorem and its applications.

Surface energy and surface tension, angle of contact, excess of pressure across a curved surface, application of surface tension ideas to drops, bubbles and capillary rise.

(a) *Pressure in a fluid, Pascal's Law and its applications, buoyancy (Archimedes Principle).*

(b) *General characteristics of fluid flow; equation of continuity $v_1a_1 = v_2a_2$; conditions; applications like use of nozzle at the end of a hose; Bernoulli's principle (theorem); assumptions - incompressible liquid, streamline (steady) flow, non-viscous and irrotational liquid - ideal liquid; derivation of equation; applications of Bernoulli's theorem atomizer, dynamic uplift, Venturimeter, Magnus effect etc.*

(c) *Streamline and turbulent flow - examples; streamlines do not intersect (like electric and magnetic lines of force); tubes of flow; number of streamlines per unit area α velocity of flow (from equation of continuity $v_1a_1 = v_2a_2$); critical velocity; Reynold's number (significance only) Poiseuille's formula with numericals.*

(d) *Viscous drag; Newton's formula for viscosity, co-efficient of viscosity and its units.*

Flow of fluids (liquids and gases), laminar flow, internal friction between layers of fluid, between fluid and the solid with which the fluid is in relative motion; examples; viscous drag is a force of friction; mobile and viscous liquids.

Velocity gradient dv/dx (space rate of change of velocity); viscous drag $F = \eta A\, dv/dx$; coefficient of viscosity $\eta = F/A\,(dv/dx)$ depends on the nature of the liquid and its temperature; units:

Ns/m^2 and $dyn.s/cm^2$= poise.1 poise=0.1 Ns/m^2.

(e) *Stoke's law, motion of a sphere falling through a fluid, hollow rigid sphere rising to the surface of a liquid, parachute, obtain the expression of terminal velocity; forces acting; viscous drag, a force proportional to velocity; Stoke's law; v-t graph.*

(f) *Surface tension (molecular theory), drops and bubbles, angle of contact, work done in stretching a surface and surface energy, capillary rise, measurement of surface tension by capillary (uniform bore) rise method. Excess pressure across a curved surface, application of surface tension for drops and bubbles.*

8. Heat and Thermodynamics

(i) Thermal Properties of Matter: Heat, temperature, thermal expansion; thermal expansion of solids, liquids and gases, anomalous expansion of water; specific heat capacity, calorimetry; change of state, specific latent heat capacity.

Heat transfer-conduction, convection and radiation, thermal conductivity, qualitative ideas of Blackbody radiation, Wien's displacement Law and Stefan's law.

(a) *Temperature and Heat, measurement of temperature (scales and inter conversion). Ideal gas equation and absolute temperature, thermal expansion in solids, liquids and gases. Specific heat capacity, calorimetry, change of state, latent heat capacity, steady state and temperature gradient. Thermal conductivity; co-efficient of thermal conductivity, Use of good and poor conductors, Searle's experiment, (Lee's Disc method is not required). Convection with examples.*

(b) *Black body is now called ideal or cavity radiator and black body radiation is cavity radiation; Stefan's law is now known as Stefan Boltzmann law as Boltzmann derived it theoretically. There is multiplicity of technical terms related to thermal radiation - radiant intensity I (T) for total radiant power (energy radiated/second) per unit area of the surface, in W/m^2, $I(T) = \sigma T^4$; dimension and SI unit of σ. For practical radiators $I = \epsilon . \sigma T^4$ where ϵ (dimension less) is called emissivity of the surface material; ϵ=1 for ideal radiators. The Spectral radiancy $R(\lambda)$. $I(T)=\int_0^\alpha R(\lambda)\, d\lambda$.*

Graph of $R(\lambda)$ vs λ for different temperatures. Area under the graph is I (T). The λ corresponding to maximum value of R is called λ_{max}; decreases with increase in temperature.

Wien's displacement law; Stefan's law and Newton's law of cooling. [Deductions from Stefan's law not necessary].

(ii) Thermodynamics

Thermal equilibrium and definition of temperature (zeroth law of thermodynamics), heat, work and internal energy. First law of thermodynamics, isothermal and adiabatic processes.

Second law of thermodynamics: reversible and irreversible processes.

(a) *Thermal equilibrium and zeroth law of thermodynamics: Self explanatory*

(b) *First law of thermodynamics.*

Concept of heat (Q) as the energy that is transferred (due to temperature difference only) and not stored; the energy that is stored in a body or system as potential and kinetic energy is called internal energy (U). Internal energy is a state property (only elementary ideas) whereas, heat is not; first law is a statement of conservation of energy, when, in general, heat (Q) is transferred to a body (system), internal energy (U) of the system changes and some work W is done by the system; then $Q=\Delta U+W$; also $W=\int pdV$ for working substance - an ideal gas; explain the meaning of symbols (with examples) and sign convention *carefully (as used in physics: $Q>0$ when added to a system, $\Delta U>0$ when U increases or temperature rises, and $W>0$ when work is done by the system). Special cases for $Q=0$ (adiabatic), $\Delta U=0$ (isothermal) and $W=0$ (isochoric).*

(c) *Isothermal and adiabatic changes in a perfect gas described in terms of PV graphs; PV = constant (Isothermal) and PV^{γ} = constant (adiabatic); joule and calorie relation (derivation of PV^{γ} = constant not required).*

Note that 1 cal = 4·186 J exactly and J (so-called mechanical equivalent of heat) should not be used in equations. In equations, it is understood that each term as well as the LHS and RHS are in the same units; it could be all joules or all calories.

(d) *Derive an expression for work done in isothermal and adiabatic processes; principal and molar heat capacities; C_p and C_v; relation between C_p and C_v ($C_p - C_v = R$). Work done as area bounded by PV graph.*

(e) *Second law of thermodynamics, Carnot's cycle. Some practical applications.*

Only one statement each in terms of Kelvin's impossible steam engine and Clausius' impossible refrigerator. Brief explanation of the law. Reversible and irreversible processes, Heat engine; Carnot's cycle - describe realisation from source and sink of infinite thermal capacity, thermal insulation, etc. Explain using pV graph (isothermal process and adiabatic process) expression and numericals (without derivation) for efficiency $\eta=1-T_2/T_1$.

9. Behaviour of Perfect Gases and Kinetic Theory of Gases

(i) Kinetic Theory: Equation of state of a perfect gas, work done in compressing a gas. Kinetic theory of gases - assumptions, concept of pressure. Kinetic interpretation of temperature; rms speed of gas molecules; degrees of freedom, law of equi-partition of energy (statement only) and application to specific heat capacities of gases; concept of mean free path, Avogadro's number.

(a) *Kinetic Theory of gases; derive $p=1/3\ \rho\overline{c^2}$ from the assumptions and applying Newton's laws of motion. The average thermal velocity (rms value) $c_{rms}=\sqrt{3p/\rho}$; calculations for air, hydrogen and their comparison with common speeds. Effect of temperature and pressure on rms speed of gas molecules.*

[Note that $pV=nRT$ the ideal gas equation cannot be derived from kinetic theory of ideal gas. Hence, neither can other gas laws; $pV=nRT$ is an experimental result. Comparing this with $p = ⅓\ \rho\overline{c^2}$, from kinetic theory of gases, a kinetic interpretation of temperature can be obtained as explained in the next subunit].

(b) *From kinetic theory for an ideal gas (obeying all the assumptions especially no intermolecular attraction and negligibly small size of molecules, we get $p = (1/3)\rho\overline{c^2}$ or $pV = (1/3)M\overline{c^2}$. (No further, as temperature is not a concept of kinetic theory). From experimentally obtained gas laws, we have the ideal gas equation (obeyed by some gases at low pressure and high temperature) $pV = RT$ for one mole. Combining these two results (assuming they can be combined), $RT=(1/3)M\overline{c^2}=(2/3).½M\overline{c^2}=(2/3)K$; Hence, kinetic energy of 1 mole of an ideal gas $K=(3/2)RT$. Average K for 1 molecule = $K/N = (3/2)\ RT/N = (3/2)\ kT$ where k is Boltzmann's constant. So, temperature T can be interpreted as a measure of the average kinetic energy of the molecules of a gas.*

(c) *Degrees of freedom and calculation of specific heat capacities for all types of gases. Concept of the law of equipartition of energy (derivation not required). Concept of mean free path and Avogadro's number N_A.*

10. Oscillations and Waves

(i) Oscillations: Periodic motion, time period, frequency, displacement as a function of time, periodic functions. Simple harmonic motion (S.H.M) and its equation; phase; oscillations of a spring, restoring force and force constant; energy in S.H.M., Kinetic and potential energies; simple pendulum and derivation of expression for its time period.

Simple harmonic motion. Periodic motion, time period T and frequency f, $f=1/T$; uniform circular motion and its projection on a diameter defines SHM; displacement, amplitude, phase and epoch, velocity, acceleration, time period; characteristics of SHM; Relation between linear simple harmonic motion and uniform circular motion. Differential equation of SHM, $d^2y/dt^2+\omega^2y=0$ from the nature of force acting $F=-k\ y$; solution $y=A\ \sin\ (\omega t+\phi_0)$ where $\omega^2 = k/m$; obtain expressions for velocity, acceleration, time period T and frequency f. Graphical representation of displacement, velocity and acceleration. Examples, simple pendulum, a mass m attached to a spring of spring constant k. Derivation of time period of simple harmonic motion of a simple pendulum, mass on a spring (horizontal and vertical oscillations) Kinetic and potential energy at a point in simple harmonic motion. Total energy E = U+K (potential +kinetic) is conserved. Draw graphs of U, K and E Verses y.

(ii) Waves: Wave motion, Transverse and longitudinal waves, speed of wave motion, displacement relation for a progressive wave, principle of superposition of waves, reflection of waves, standing waves in strings and organ pipes, fundamental mode and harmonics, Beats.

(a) Transverse and longitudinal waves; characteristics of a harmonic wave; graphical representation of a harmonic wave. Distinction between transverse and longitudinal waves; examples; displacement, amplitude, time period, frequency, wavelength, derive $v=f\lambda$; graph of displacement with time/position, label time period/wavelength and amplitude, equation of a progressive harmonic (sinusoidal) wave, $y = A\ \sin\ (kx\pm\omega t)$ where k is a propagation factor and equivalent equations.

(b) Production and propagation of sound as a wave motion; mechanical wave requires a medium; general formula for speed of sound (no derivation). Newton's formula for speed of sound in air; experimental value; Laplace's correction; variation of speed v with changes in pressure, density, humidity and temperature. Speed of sound in liquids and solids - brief introduction only. Concept of supersonic and ultrasonic waves.

(c) Principle of superposition of waves; interference (simple ideas only); dependence of combined wave form, on the relative phase of the interfering waves; qualitative only - illustrate with wave representations. Beats (qualitative explanation only); number of beats produced per second = difference in the frequencies of the interfering waves. Standing waves or stationary waves; formation by two identical progressive waves travelling in opposite directions (e.g., along a string, in an air column - incident and reflected waves); obtain $y= y_1+y_2= [2\ y_m \sin\ (kx)] \cos\ (\omega t)$ using equations of the travelling waves; variation of the amplitude $A=2\ y_m\sin\ (kx)$ with location (x) of the particle; nodes and antinodes; compare standing waves with progressive waves.

(d) Laws of vibrations of a stretched string. Obtain equation for fundamental frequency $f_0=(½l)\sqrt{T/m}$; sonometer.

(e) Modes of vibration of strings and air columns (closed and open pipes); standing waves with nodes and antinodes; also in resonance with the periodic force exerted usually by a tuning fork; sketches of various modes of vibration; obtain expressions for fundamental frequency and various harmonics and overtones; mutual relations.

PAPER II

PRACTICAL WORK- 15 Marks

Given below is a list of required experiments. Teachers may add to this list, keeping in mind the general pattern of questions asked in the annual examinations.

In each experiment, students are expected to record their observations in a tabular form with units at the column head. Students should plot an appropriate graph, work out the necessary calculations and arrive at the result.

Students are required to have completed all experiments from the given list (excluding demonstration experiments):

1. To measure the diameter of a spherical body using Vernier calipers. Calculate its volume with appropriate significant figures. Also measure its volume using a graduated cylinder and compare the two.
2. Find the diameter of a wire using a micrometer screw gauge and determine percentage error in cross sectional area.
3. Determine radius of curvature of a spherical surface like watch glass by a spherometer.
4. Equilibrium of three concurrent coplanar forces. To verify the parallelogram law of forces and to determine weight of a body.
5. (i) Inclined plane: To find the downward force acting along the inclined plane on a roller due to gravitational pull of earth and to study its relationship with angle of inclination by plotting graph between force and $\sin\theta$.

   (ii) Friction: To find the force of limiting friction for a wooden block placed on horizontal surface and to study its relationship with normal reaction. To determine the coefficient of friction.
6. To find the acceleration due to gravity by measuring the variation in time period (T) with effective length (L) of a simple pendulum; plot graphs of T vs $\sqrt{L}$ and T^2 vs L. Determine effective length of the seconds pendulum from T^2 vs L graph.
7. To find the force constant of a spring and to study variation in time period of oscillation with mass m of a body suspended by the spring. To find acceleration due to gravity by plotting a graph of T against $\sqrt{m}$.
8. Boyle's Law: To study the variation in volume with pressure for a sample of air at constant temperature by plotting graphs between p and $1/V$ and between p and V.
9. Cooling curve: To study the fall in temperature of a body (like hot water or liquid in calorimeter) with time. Find the slope of the curve at four different temperatures of the hot body and hence, deduce Newton's law of cooling.
10. To study the variation in frequency of air column with length using resonance column apparatus or a long cylindrical vessel and a set of tuning forks. Hence, determine velocity of sound in air at room temperature.
11. To determine frequency of a tuning fork using a sonometer.
12. To determine specific heat capacity of a solid using a calorimeter.

Demonstration Experiments ***(The following experiments are to be demonstrated by the teacher)*****:**

1. Searle's method to determine Young modulus of elasticity.
2. Capillary rise method to determine surface tension of water.
3. Determination of coefficient of viscosity of a given viscous liquid by terminal velocity method.

PROJECT WORK AND PRACTICAL FILE – 15 Marks

Project Work – 10 Marks

All candidates will be required to do **one** project involving some Physics related topic/s, under the guidance and regular supervision of the Physics teacher. Candidates are to prepare a technical report including an abstract, some theoretical discussion, experimental setup, observations with tables of data collected, analysis and discussion of results, deductions, conclusion, etc. (after the draft has been approved by the teacher). The report should be kept simple, but neat and elegant. Teachers may assign or students may choose any one project of their choice.

Suggested Evaluation criteria:

▪ Title and Abstract (summary)
▪ Introduction / purpose
▪ Contents/Presentation
▪ Analysis/ material aid (graph, data, structure, pie charts, histograms, diagrams, etc.)
▪ Originality of work
▪ Conclusion/comments

Practical File – 5 Marks

Teachers are required to assess students on the basis of the Physics practical file maintained by them during the academic year.

NOTE: For guidelines regarding Project Work, please refer to Class XII.