PHYSICS (861)

Aims:

1. To enable candidates to acquire knowledge and to develop an understanding of the terms, facts, concepts, definitions, fundamental laws, principles and processes in the field of physics.
2. To develop the ability to apply the knowledge and understanding of physics to unfamiliar situations.
3. To develop a scientific attitude through the study of physical sciences.
4. To develop skills in -
   (a) the practical aspects of handling apparatus, recording observations and
   (b) drawing diagrams, graphs, etc.
5. To develop an appreciation of the contribution of physics towards scientific and technological developments and towards human happiness.
6. To develop an interest in the world of physical sciences.

CLASS XI

There will be two papers in the subject.

***Paper I**: Theory - 3 hour ... 70 marks*

***Paper II**: Practical - 3 hours ... 20 marks*

Project Work ... 7 marks

Practical File ... 3 marks

PAPER I -THEORY – 70 Marks

Paper I shall be of 3 hours duration and be divided into two parts.

***Part I (20 marks):** This part will consist of compulsory short answer questions, testing knowledge, application and skills relating to elementary/fundamental aspects of the entire syllabus.*

***Part II (50 marks):** This part will be divided into three Sections A, B and C. There shall be **six** questions in Section A (each carrying 7 marks) and candidates are required to answer **four** questions from this Section. There shall be **three** questions in Section B (each carrying 6 marks) and candidates are required to answer **two** questions from this Section. There shall be **three** questions in Section C (each carrying 5 marks) and candidates are required to answer **two** questions from this Section. Therefore, candidates are expected to answer **eight** questions in Part II.*

***Note:** Unless otherwise specified, only S. I. Units are to be used while teaching and learning, as well as for answering questions.*

SECTION A

1. Role of Physics

(i) Scope of Physics.

Applications of Physics to everyday life. Inter-relation with other science disciplines. Physics learning and phenomena of nature; development of spirit of inquiry, observation, measurement, analysis of data, interpretation of data and scientific temper; appreciation for the beauty of scheme of nature.

(ii) Role of Physics in technology.

Physics as the foundation of all technical advances - examples. Quantitative approach of physics as the beginning of technology. Technology as the extension of applied physics. Growth of technology made possible by advances in physics. Fundamental laws of nature are from physics. Technology is built on the basic laws of physics.

(iii) Impact on society.

Effect of discoveries of laws of nature on the philosophy and culture of people. Effect of growth of physics on our understanding of natural phenomenon like lighting and thunder, weather changes, rain, etc. Effect of study of quantum mechanics, dual nature of matter, nuclear physics and astronomy on the macroscopic and microscopic picture of our universe.

2. Units

(i) SI units. Fundamental and derived units (correct symbols for units including conventions for symbols).

Importance of measurement in scientific studies; physics is a science of measurement. Unit as a reference standard of measurement; essential properties. Systems of unit; CGS, FPS, MKSA, and SI; the seven base units of SI selected by the General Conference of Weights and Measures in 1971 and their definitions; list of fundamental physical quantities; their units and symbols, strictly as per rule; subunits and multiple units using prefixes for powers of 10 (from atto for 10^{-18} to tera for 10^{12}); other common units such as fermi, angstrom (now outdated), light year, astronomical unit and parsec. A new unit of mass used in atomic physics is unified atomic mass unit with symbol u (not amu); rules for writing the names of units and their symbols in SI (upper case/lower case, no period after symbols, etc.)

Derived units (with correct symbols); special names wherever applicable; expression in terms of base units (eg: $N= kgm/s^2$).

(ii) Accuracy and errors in measurement, least count of measuring instruments (and the implications for errors in experimental measurements and calculations).

Accuracy of measurement, errors in measurement: instrumental errors, systematic errors, random errors and gross errors. Least count of an instrument and its implication for errors in measurements; absolute error, relative error and percentage error; combination of error in (a) sum and difference, (b) product and quotient and (c) power of a measured quantity.

(iii) Significant figures and order of accuracy with reference to measuring instruments. Powers of 10 and order of magnitude.

What are significant figures? Their significance; rules for counting the number of significant figures; rules for (a) addition and subtraction, (b) multiplication/division; 'rounding off' the uncertain digits; order of magnitude as statement of magnitudes in powers of 10; examples from magnitudes of common physical quantities - size, mass, time, etc.

3. Dimensions

(i) Dimensional formula of physical quantities and physical constants like g, h, etc. (from Mechanics only).

Dimensions of physical quantities; dimensional formula; express derived units in terms of base units ($N = kg.ms^{-2}$); use symbol [...] for dimension of or base unit of; ex: dimensional formula of force in terms of base units is written as $[F]=[MLT^{-2}]$. Expressions in terms of SI base units may be obtained for all physical quantities as and when new physical quantities are introduced.

(ii) Dimensional equation and its use to check correctness of a formula, to find the relation between physical quantities, to find the dimension of a physical quantity or constant; limitations of dimensional analysis.

Use of dimensional analysis to (i) check the dimensional correctness of a formula/ equation, (ii) to obtain the exact dependence of a physical quantity on other mechanical variables, and (iii) to obtain the dimensional formula of any derived physical quantity including constants; limitations of dimensional analysis.

4. Vectors, Scalar Quantities and Elementary Calculus

(i) Vectors in one dimension, two dimensions and three dimensions, equality of vectors and null vector.

Vectors explained using displacement as a prototype - along a straight line (one dimension), on a plane surface (two dimension) and in open space not confined to a line or plane (three dimension); symbol and representation; a scalar quantity, its representation and unit, equality of vectors. Unit vectors denoted by $\hat{i}, \hat{j}, \hat{k}$ orthogonal unit vectors along x, y and z axes respectively. Examples of one dimensional vector $\vec{V}_1 = a\hat{i}$ or $b\hat{j}$ or $c\hat{k}$ where a, b, c are scalar quantities or numbers; $\vec{V}_2 = a\hat{i} + b\hat{j}$ is a two dimensional vector, $\vec{V}_3 = a\hat{i} + b\hat{j} + c\hat{k}$ is a three dimensional vector. Define and discuss the need of a null vector. Concept of co-planar vectors.

(ii) Vector operations (addition, subtraction and multiplication of vectors including use of unit vectors $\hat{i}, \hat{j}, \hat{k}$); parallelogram and triangle law of vector addition.

Addition: use displacement as an example; obtain triangle law of addition; graphical and analytical treatment; Discuss commutative and associative properties of vector addition (Proof not required). Parallelogram Law; sum and difference; derive expression for magnitude and directions from a parallelogram; special cases; subtraction as special case of addition with direction reversed; use of Triangle Law for subtraction also; if $\vec{a} + \vec{b} = \vec{c}$; $\vec{c} - \vec{a} = \vec{b}$; *In a parallelogram, if one diagonal is the sum, the other diagonal is the difference; addition and subtraction with vectors expressed in terms of unit vectors* $\hat{i}, \hat{j}, \hat{k}$; *multiplication of a vector by real numbers.*

(iii) Resolution and components of like vectors in a plane (including rectangular components), scalar (dot) and vector (cross) products.

Use triangle law of addition to express a vector in terms of its components. If $\vec{a} + \vec{b} = \vec{c}$ *is an addition fact,* $\vec{c} = \vec{a} + \vec{b}$ *is a resolution;* $\vec{a}$ *and* $\vec{b}$ *are components of* $\vec{c}$. *Rectangular components, relation between components, resultant and angle in between. Dot (or scalar) product of vectors or scalar product* $\vec{a} \cdot \vec{b} = ab\cos\theta$; *example* $W = \vec{F} \cdot \vec{S}$ *Special case of* $\theta = 0, 90$ *and* 180^0. *Vector (or cross) product* $\vec{a} \times \vec{b} = [ab\sin\theta]\,\hat{n}$; *example: torque* $\vec{\tau} = \vec{r} \times \vec{F}$; *Special cases using unit vectors* $\hat{i}, \hat{j}, \hat{k}$ *for* $\vec{a} \cdot \vec{b}$ *and* $\vec{a} \times \vec{b}$.

[Elementary Calculus: differentiation and integration as required for physics topics in Classes XI and XII. No direct question will be asked from this subunit in the examination].

Differentiation as rate of change; examples from physics – speed, acceleration, etc. Formulae for differentiation of simple functions: x^n, *sinx, cosx,* e^x *and ln x. Simple ideas about integration – mainly.* $\int x^n.dx$. *Both definite and indefinite integral should be explained.*

5. Dynamics

(i) Cases of uniform velocity, equations of uniformly accelerated motion and applications including motion under gravity (close to surface of the earth) and motion along a smooth inclined plane.

Review of rest and motion; distance and displacement, speed and velocity, average speed and average velocity, uniform velocity, instantaneous speed and instantaneous velocity, acceleration, instantaneous acceleration, s-t, v-t and a-t graphs for uniform acceleration and discussion of useful information obtained from the graphs; kinematic equations of motion for objects in uniformly accelerated rectilinear motion derived using calculus or otherwise, motion of an object under gravity, (one dimensional motion). Acceleration of an object moving up and down a smooth inclined plane.

(ii) Relative velocity, projectile motion.

Start from simple examples on relative velocity of one dimensional motion and then two dimensional motion; consider displacement first; relative displacement (use Triangle Law); $\vec{S}_{AB} = \vec{S}_A - \vec{S}_B$ *then differentiating we get* $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$; *projectile motion; Equation of trajectory; obtain equations for max. height, velocity, range, time of flight, etc; relation between horizontal range and vertical range [projectile motion on an inclined plane not included]. Examples and problems on projectile motion.*

(iii) Newton's laws of motion and simple applications. Elementary ideas on inertial and uniformly accelerated frames of reference.

[Already done in Classes IX and X, so here it can be treated at higher maths level using vectors and calculus].

Newton's first law: Statement and explanation; inertia, mass, force definitions; law of inertia; mathematically, if $\sum F=0$, $a=0$.

Newton's second law: $\vec{p} = m\vec{v}$; $\vec{F} \alpha \frac{d\vec{p}}{dt}$; $\vec{F} = k\frac{d\vec{p}}{dt}$. *Define unit of force so that* *k=1;* $\vec{F} = \frac{d\vec{p}}{dt}$*; a vector equation. For classical physics with v not large and mass m remaining constant, obtain* $\vec{F} = m\vec{a}$*. For* $v \to c$*, m is not constant. Then* $m = m_0 / \sqrt{1 - v^2/c^2}$*. Note that F= ma is the special case for classical mechanics. It is a vector equation.* $\vec{a} \parallel \vec{F}$*. Also, this can be resolved into three scalar equations* $F_x = ma_x$ *etc. Application to numerical problems; introduce tension force, normal reaction force. If a = 0 (body in equilibrium), F= 0. Impulse* $F\Delta t = \Delta p$*; unit; problems.*

Newton's third law. Simple ideas with examples of inertial and uniformly accelerated frames of reference. Simple applications of Newton's laws: tension, normal reaction; law of conservation of momentum. Systematic solution of problems in mechanics; isolate a part of a system, identify all forces acting on it; draw a free body diagram representing the part as a point and representing all forces by line segments, solve for resultant force which is equal to $m\vec{a}$*. Simple problems on "Connected bodies" (not involving two pulleys).*

(iv) Concurrent forces (reference should be made to force diagrams and to the point of application of forces), work done by constant and variable force (Spring force).

Force diagrams; resultant or net force from law of Triangle of Forces, parallelogram law or resolution of forces. Apply net force $\Sigma\vec{F} = m\vec{a}$*. Again for equilibrium a=0 and* $\Sigma F=0$*. Conditions of equilibrium of a rigid body under three coplanar forces. Discuss ladder problem. Work done* $W = \vec{F} \cdot \vec{S} = FS\cos\theta$*. If F is variable* $dW = \vec{F} \cdot d\vec{S}$ *and* $W = \int dw = \int \vec{F} \cdot d\vec{S}$*, for* $\vec{F} \parallel d\vec{S}$ $\vec{F} \cdot d\vec{S} = FdS$ *therefore,* $W = \int FdS$ *is the area under the F-S graph or if F can be expressed in terms of S,* $\int FdS$ *can be evaluated. Example, work done in stretching a spring* $W = \int Fdx = \int kxdx = \frac{1}{2}kx^2$*. This is also the potential energy stored in the stretched spring* $U = \frac{1}{2}kx^2$*.*

(v) Energy, conservation of energy, power, conservation of linear momentum, impulse, elastic and inelastic collisions in one and two dimensions.

E=W. Units same as that of work W; law of conservation of energy; oscillating spring. $U+K = E = K_{max} = U_{max}$ *(for U = 0 and K = 0 respectively); different forms of energy* $E = mc^2$*; no derivation. Power P=W/t; units;* $P = \vec{F} \cdot \vec{v}$*; conservation of linear momentum (done under Newton's 3rd law); impulse Ft or* $F\Delta t$*. unit N.s and joule- done under 2nd law. Collision in one dimension; derivation of velocity equation for general case of* $m_1 \neq m_2$ *and* $u_1 \neq u_2 = 0$*; Special cases for* $m_1 = m_2 = m$*;* $m_1 >> m_2$ *or* $m_1 << m_2$*. Oblique collisions i.e. collision in two dimensions.*

6. Friction

(i) Friction in solids: static; sliding; rolling.

Static friction, a self-adjusting force; limiting value; kinetic friction or sliding friction; rolling friction, examples.

(ii) Laws of friction. Co-efficient of friction.

Laws of friction: Two laws of static friction; (similar) two laws of kinetic friction; coefficient of friction $\mu_s = f_s(max)/N$ *and* $\mu_k = f_k/N$*; Friction as a non conservative force; motion under friction, net force in Newton's 2nd law is calculated including* f_k*; numerical problems applying laws of friction and Newton's second law of motion. Motion along a rough inclined plane – both up and down. Pulling and pushing of a roller. Angle of friction and angle of repose.*

7. Motion in Fluids

(i) Equation of continuity of fluid flow and its application, buoyancy, Bernoulli's principle, (venturimeter, pitot tube, atomizer, dynamic uplift). Pressure in a fluid, Pascal's law.

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; buoyancy; 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 as given in the syllabus. Discuss in brief: Pressure in a fluid, Pascal's law.*

(ii) Stream line and turbulent flow, Reynold's number (derivation not required).

Streamline and turbulent flow - examples; trajectory of fluid particles; 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 - no derivation, but check dimensional correctness. (Poisseulle's formula excluded).

(iii) 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; value of η for a few selected fluids.

(iv) Stoke's law, terminal velocity of a sphere falling through a fluid or a hollow rigid sphere rising to the surface of a fluid.

Motion of a sphere falling through a fluid, hollow rigid sphere rising to the surface of a liquid, parachute, terminal velocity; forces acting; buoyancy (Archimedes principle); viscous drag, a force proportional to velocity; Stoke's law; v-t graph.

8. Circular Motion

(i) Centripetal acceleration and force, motion round a banked track, point mass at the end of a light inextensible string moving in (i) horizontal circle (ii) vertical circle and a conical pendulum.

Definition of centripetal acceleration; derive expression for this acceleration using Triangle Law to find $\Delta\vec{v}$. Magnitude and direction of $\overline{a}$ same as that of $\Delta\vec{v}$; Centripetal acceleration; the cause of this acceleration is a force - also called centripetal force; the name only indicates its direction, it is not a new type of force, it could be mechanical tension as in motion of a point mass at the end of a light inextensible string moving in a circle, or electric as on an electron in Bohr model of atom, or magnetic as on any charged particle moving in a magnetic field [may not introduce centrifugal force]; conical pendulum, formula for centripetal force and tension in the string; motion in a vertical circle; banking of road and railway track.

(ii) Centre of mass, moment of inertia: rectangular rod; disc; ring; sphere.

Definition of centre of mass (cm) for a two particle system moving in one dimension $m_1x_1+m_2x_2=Mx_{cm}$; differentiating, get the equation for v_{cm} and a_{cm}; general equation for N particles- many particles system; [need not go into more details]; concept of a rigid body; kinetic energy of a rigid body rotating about a fixed axis in terms of that of the particles of the body; hence define moment of inertia and radius of gyration; unit and dimensions; depend on mass and axis of rotation; it is rotational inertia; applications: derive expression for the moment of inertia, I (about the symmetry axis) of (i) a particle rotating in a circle (e.g. electron in Bohr model of H atom); (ii) a ring; also I of a thin rod, a rectangular strip, a rectangular block, a solid and hollow sphere, a ring, a disc and a hollow cylinder - only formulae (no derivation).

(iii) Parallel axis theorem and perpendicular axis theorem; radius of gyration.

Statement of the theorems with illustrations [derivation not required]. Simple applications to the cases derived under 8(ii), with change of axis.

(iv) Torque and angular momentum, relation between torque and moment of inertia and between angular momentum and moment of inertia; conservation of angular momentum and applications.

Definition of torque (vector); $\vec{\tau} = \vec{r} \times \vec{F}$ and angular momentum $\vec{l} = \vec{r} \times \vec{p}$ for a particle; differentiate to obtain $d\vec{l}/dt = \vec{\tau}$; similar to Newton's second law of motion (linear); angular velocity $\omega = v/r$ and angular acceleration $\alpha = a/r$, hence $\tau = I\alpha$ and $l = I\omega$; (only scalar equation); Law of conservation of angular momentum; simple applications.

(v) Two-dimensional rigid body motion, e.g. point mass on string wound on a cylinder (horizontal axis rotation), cylinder rolling down inclined plane without sliding.

In addition to the above, also cover: motion of a ring and a ball rolling down an inclined plane; expression for linear and rotational acceleration (a, α) and tension (T) in the string in the first case (point mass on a string) and kinetic energy (K) for the second case (rolling down an inclined plane).

9. Gravitation

(i) Newton's law of universal gravitation; gravitational constant (G); gravitational acceleration on surface of the earth (g).

Statement; unit and dimensional formula of universal gravitational constant, G [Cavendish experiment not required]; weight of a body W= mg from F=ma.

(ii) Relation between G and g; variation of gravitational acceleration above and below the surface of the earth.

From the Newton's Law of Gravitation and Second Law of Motion $g = Gm/R^2$ applied to earth. Variation of g above and below the surface of the earth; graph; mention variation of g with latitude and rotation, (without derivation).

(iii) Gravitational field, its range, potential, potential energy and intensity.

Define gravitational field, intensity of gravitational field and potential at a point in earth's gravitational field. $V_p = W_{\infty p}/m_o$. Derive the expression (by integration) for the gravitational potential difference $\Delta V = V_B - V_A = G.M(1/r_A - 1/r_B)$; here $V_p = V(r) = -GM/r$; negative sign for attractive force field; define gravitational potential energy of a mass m in the earth's field; obtain expression for gravitational potential energy $U(r) = W_{\infty p} = m.V(r) = -G\ M\ m/r$; show that for a not so large change in distance $\Delta U = mgh$. Relation between intensity and acceleration due to gravity. Compare its range with those of electric, magnetic and nuclear fields.

(iv) Escape velocity (with special reference to the earth and the moon); orbital velocity and period of a satellite in circular orbit (particularly around the earth).

Define and obtain expression for the escape velocity from earth using energy consideration; v_e depends on mass of the earth; from moon v_e is less as mass of moon is less; consequence - no atmosphere on the moon; satellites (both natural (moon) and artificial satellite) in uniform circular motion around the earth; 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 [$g' = g(R/R+h)^2$; $F'_G = mg'$].

(v) Geostationary satellites - uses of communication satellites.

Conditions for satellite to be geostationary. Uses.

(vi) Kepler's law of planetary motion.

Explain the three laws using diagrams. Proof of second and third law (circular orbits only); derive only $T^2 \alpha R^3$ from 3rd law for circular orbits.

SECTION B

10. Properties of Matter - Temperature

(i) Properties of matter: Solids: elasticity in solids, Hooke's law, Young modulus and its determination, bulk modulus and modulus of rigidity, work done in stretching a wire. Liquids: 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 rise methods. Gases: kinetic theory of gases: postulates, molecular speeds and derivation of $p = \frac{1}{3}\rho\overline{c^2}$, equation

of state of an ideal gas pV = nRT (numerical problems not included from gas laws).

For solids and liquids; the scope as given above is clear. For 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)* $c_{rms}=\sqrt{3p/\rho}$*; calculate for air, hydrogen and their comparison with common speeds of transportation. 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 $p = \frac{1}{3}\rho\overline{c^2}$ *, from kinetic theory of gas a kinetic interpretation of temperature can be obtained as explained in the next subunit].*

(ii) Temperature: kinetic interpretation of temperature (relation between $\overline{c^2}$ and T); absolute temperature. Law of equipartition of energy (statement only).

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),* $RT=(1/3)M\overline{c^2}=(2/3).\frac{1}{2}M\overline{c^2}=(2/3)K$*; 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. Degrees of freedom, statement of the law of equipartition of energy. Scales of temperature - only Celsius, Fahrenheit and Kelvin scales.*

11. Internal Energy

(i) First law of thermodynamics.

Review the 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 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).*

(ii) Isothermal and adiabatic changes in a perfect gas described in terms of curves for PV = constant and PV^γ = constant; joule and calorie relation (derivation for PV^γ = constant not included).

Self-explanatory. 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.

(iii) Work done in isothermal and adiabatic expansion; principal molar heat capacities; C_p and C_v; relation between C_p and C_v ($C_p - C_v = R$). C_p and C_v for monatomic and diatomic gasses.

Self-explanatory. Derive the relations.

Work done as area bounded by PV graph.

(iv) 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 law. Carnot's cycle - describe realisation from source and sink of infinite thermal capacity, thermal insulation, etc. Explain pV *graph (isothermal and adiabatic of proper slope); obtain expression for efficiency $\eta=1-T_2/T_1$.*

(vi) Thermal conductivity; co-efficient of thermal conductivity, Use of good and poor conductors, Searle's experiment. [Lee's Disc method is not required]. comparison of thermal and electrical conductivity. Convection with examples.

Define coefficient of thermal conductivity from the equation for heat flow $Q = KA\, d\theta/dt$; temperature gradient; Comparison of thermal and electrical conductivities (briefly). Examples of convection.

(vii) Thermal radiation: nature and properties of thermal radiation, qualitative effects of nature of surface on energy absorbed or emitted by it; black body and black body radiation, Stefan's law (using Stefan's law to determine the surface temperature of the sun or a star by treating it as a black body); Newton's law of cooling, Wien's displacement law, distribution of energy in the spectrum of black body radiation (only qualitative and graphical treatment).

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, $I(T) = \sigma T^4$; dimensions and SI unit of σ. For practical radiators $I = \in .\ \sigma T^4$ where $\in$ (dimension less) is called emmissivity of the surface material; $\in=1$ 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.

$\lambda_{max}\ \alpha\ 1/T$; $\lambda_m.T=2898\mu m.K$ - Wein's displacement law; application to determine temperature of stars, numerical problems. From known temperature, we get $I(T)= \sigma T^4$. The luminosity (L) of a star is the total power radiated in all directions $L=4\pi r^2.I$ from the solar radiant power received per unit area of the surface of the earth (at noon), the distance of the sun and the radius of the sun itself, one can calculate the radiant intensity I of the sun and hence the temperature T of its surface using Stefan's law. Numerical problems. Cover Newton's law of cooling briefly, numerical problems to be covered. [Deductions from Stefan's law not necessary].

SECTION C

12. Oscillations

(i) Simple harmonic motion.

(ii) Expressions for displacement, velocity and acceleration.

(iii) Characteristics of simple harmonic motion.

(iv) Relation between linear simple harmonic motion and uniform circular motion.

(v) Kinetic and potential energy at a point in simple harmonic motion.

(vi) Derivation of time period of simple harmonic motion of a simple pendulum, mass on a spring (horizontal and vertical oscillations).

Periodic motion, 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; differential equation of SHM, $d^2y/dt^2+\omega^2 y=0$ from the nature of force acting $F=-k\,y$; solution $y=A\sin(\omega t+\phi_0)$ where $\omega^2 = k/m$; expression for time period T and frequency f. Examples, simple pendulum, a mass m attached to a spring of spring constant k. Total energy $E = U+K$ (potential +kinetic) is conserved. Draw graphs of U, K and E Vs y.

(vii) Free, forced and damped oscillations (qualitative treatment only). Resonance.

Examples of damped oscillations (all oscillations are damped); graph of amplitude vs time for undamped and damped oscillations; damping force (-bv) in addition to restoring force (-ky); forced oscillations, examples; action of an external periodic force, in addition to restoring force. Time *period is changed to that of the external applied force, amplitude (A) varies with frequency of the applied force and it is maximum when the f of the external applied force is equal to the natural frequency of the vibrating body. This is resonance; maximum energy transfer from one body to the other; bell graph of amplitude vs frequency of the applied force. Examples from mechanics, electricity and electronics (radio).*

13. Waves

(i) Transverse and longitudinal waves; relation between speed, wavelength and frequency; expression for displacement in wave motion; characteristics of a harmonic wave; graphical representation of a harmonic wave; amplitude and intensity.

Review wave motion covered in Class IX. Distinction between transverse and longitudinal waves; examples; define displacement, amplitude, time period, frequency, wavelength and derive $v=f\lambda$; graph of displacement with time/position, label time period/wavelength and amplitude, equation of a progressive harmonic (sinusoidal) wave, $y = A \sin (kx-\omega t)$; amplitude and intensity.

(ii) Sound as a wave motion, Newton's formula for the speed of sound and Laplace's correction; variation in the speed of sound with changes in pressure, temperature and humidity; speed of sound in liquids and solids (descriptive treatment only).

Review of production and propagation of sound as 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; calculation of value at STP; numerical problems; variation of speed v with changes in pressure, density, humidity and temperature. Speed of sound in liquids and solids - brief introduction only. Some values. Mention the unit Mach 1, 2, etc. Concept of supersonic and ultrasonic.

(iii) Superimposition of waves (interference, beats and standing waves), progressive and stationary waves.

The principle of superposition; 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; numerical problems. Standing waves or stationary waves; formation by two traveling waves (of λ and f same) traveling in opposite directions (ex: 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 traveling 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.

(iv) Laws of vibrations of stretched strings.

Equation for fundamental frequency $f_0=(\frac{1}{2}l)\sqrt{T/m}$; sonometer, experimental verification.

(v) Modes of vibration of strings and air columns; resonance.

Vibrations of strings and air column (closed and open pipe); standing waves with nodes and antinodes; also in resonance with the periodic force exerted usually by a tuning fork; sketches of various nodes; fundamental and overtones-harmonics; mutual relation.

(vi) Doppler Effect for sound.

Doppler effect for sound; general expression for the Doppler effect when both the source and listener are moving can be given by $f_L = f_r\left(\frac{v \pm v_L}{v \pm v_r}\right)$ which can be reduced to any one of the four special cases, by applying proper sign convention.

NOTE: *Numerical problems are included from all topics except where they are specifically excluded or where only qualitative treatment is required.*

PAPER II

PRACTICAL WORK- 20 Marks

The following experiments are recommended for practical work. In each experiment, students are expected to record their observations in tabular form with units at the column head. Students should plot an appropriate graph, work out the necessary calculations and arrive at the result. The teacher may alter or add.

1. Measurement by Vernier callipers. Measure the diameter of a spherical body. Calculate the volume with appropriate significant figures. Measure the volume using a graduated cylinder and compare it with calculated value.
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. 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 θ.
6. Friction: To find the force of kinetic friction for a wooden block placed on horizontal surface and to study its relationship with normal reaction. To determine the coefficient of friction.
7. To find the acceleration due to gravity by measuring the variation in time period (T) with effective length (L) of simple pendulum; plot graph of T vs $\sqrt{L}$ and T^2 vs L.
8. To find the force constant of a spring and to study variation in time period of oscillation of a body suspended by the spring. To find acceleration due to gravity by plotting graph of T against $\sqrt{m}$.
9. Oscillation of a simple meter rule used as bar pendulum. To study variation in time period (T) with distance of centre of gravity from axis of suspension and to find radius of gyration and moment of inertia about an axis through the centre of gravity.
10. 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.
11. Cooling curve: To study the fall in temperature of a body (like hot water or liquid in calorimeter) with time. Find the slope of curve at four different temperatures of hot body and hence deduce Newton's law of cooling.
12. Determine Young's modulus of elasticity using Searle's apparatus.
13. To study the variation in frequency of air column with length using resonance column apparatus or a long cylinder and set of tuning forks. Hence determine velocity of sound in air at room temperature.
14. To determine frequency of a tuning fork using a sonometer.
15. To verify laws of vibration of strings using a sonometer.

PROJECT WORK AND PRACTICAL FILE – 10 Marks

Project Work – 7 Marks

All candidates will do project work involving some Physics related topics, under the guidance and regular supervision of the Physics teacher. Candidates are to prepare a technical report formally written 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. No extra credit shall be given for type-written material/decorative cover, etc. Teachers may assign or students may choose any one project of their choice.

Practical File – 3 Marks

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