There will be two papers in the subject:

Paper I: Theory - 3 hours ... 70 marks

Paper II: Practical - 3 hours ... 15 marks

Project Work … 10 marks

Practical File … 5 marks

PAPER I- THEORY: 70 Marks

S. NO.	UNIT	TOTAL WEIGHTAGE
1.	Physical World and Measurement	
2.	Kinematics	23 Marks
3.	Laws of Motion	
4.	Work, Energy and Power	
5.	Motion of System of Particles and Rigid Body	17 Marks
6.	Gravitation	
7.	Properties of Bulk Matter	
8.	Heat and Thermodynamics	20 Marks
9.	Behaviour of Perfect Gases and Kinetic Theory of Gases	
10.	Oscillations and Waves	10 Marks
	TOTAL	**70 Marks**

PAPER I -THEORY – 70 MARKS

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

(ii) All physical quantities to be defined as and when they are introduced along with their units and dimensions.

(iii) Numerical problems are included from all topics except where they are specifically excluded or where only qualitative treatment is required.

1. Physical World and Measurement

i. Physical world:

Scope of Physics and its application in everyday life. Nature of physical laws.

Physics and its branches (only basic knowledge required); fundamental laws and fundamental forces in nature (gravitational force, electromagnetic force, strong and weak nuclear forces; unification of forces). Application of Physics in technology and society (major scientists, their discoveries, inventions and laws/principles to be discussed briefly).

ii. Units and Measurements

Measurement: need for measurement; units of measurement; systems of units: fundamental and derived units in SI; measurement of length, mass and time; errors in measurement; significant figures.

Dimensional formulae of physical quantities and constants, dimensional analysis and its applications.

(a) Importance of measurement in scientific studies; physics is a science of measurement. Unit as a reference standard of measurement; essential properties. Systems of units; CGS, FPS, MKS, 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, supplementary and derived 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prefixes for powers of 10 (from atto for 10^{-18} to tera for 10^{12}); other common units such as fermi, angstrom (now outdated), light year, astronomical unit and parsec.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.) Derived units (with correct symbols); special names wherever applicable; expression in terms of base units (e.g.: N= kg m/s^2).

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

(c) 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.

(d) Dimensions of physical quantities; dimensional formula; express derived units in terms of base units (N = kg m/s^{-2}); use symbol […] for dimensions of or base unit of; e.g.: dimensional formula of force in terms of fundamental quantities written as [F] =[MLT^{-2}]. Principle of homogeneity of dimensions. Expressions in terms of SI base units and dimensional formula may be obtained for all physical quantities as and when new physical quantities are introduced.

(e) Use of dimensional analysis to (i) check the dimensional correctness of a formula/ equation; (ii) to obtain the dimensional formula of any derived physical quantity including constants; (iii) to convert units from one system to another; limitations of dimensional analysis.

2. Kinematics

(i) Motion in a Straight Line

Frame of references, Motion in a straight line (one dimension): Position-time graph, speed and velocity.

Elementary concepts of differentiation and integration for describing motion, uniform and non-uniform motion, average speed, velocity, average velocity, instantaneous velocity and uniformly accelerated motion, velocity - time and position - time graphs. Relations for *uniformly accelerated motion (graphical treatment).*

Frame of reference, concept of point mass, 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 conclusions drawn from these graphs; kinematic equations of motion for objects in uniformly accelerated rectilinear motion derived using graphical, calculus or analytical method, motion of an object under gravity, (one dimensional motion).

Differentiation as rate of change; examples from physics – speed, acceleration, velocity gradient, 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 integrals to be mentioned (elementary calculus not to be evaluated).*

(ii) Motion in a Plane

Scalar and Vector quantities with examples. Position and displacement vectors, general vectors and their notations; equality of vectors, addition and subtraction of vectors, Unit vector; resolution of a vector in a plane, rectangular components, Scalar and Vector product of two vectors. Projectile motion and uniform circular motion.

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

b) *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 expressions for magnitude and direction from parallelogram law; 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* $\hat{\imath}, \hat{\jmath}, \hat{k}$ *; multiplication of a vector by a real number.*

c) *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 between them. Dot (or scalar) product of vectors* $\vec{a}.\vec{b} = ab\cos\theta$; *example* $W = \vec{F}.\vec{S} = FS\,Cos\theta$. *Special case of* $\theta = 0^o, 90^o$ *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 $\hat{\imath}, \hat{\jmath}, \hat{k}$ for vectors $\vec{a}.\vec{b}$ and vectors $\vec{a} \times \vec{b}$.

d) *Concept of relative velocity, start from simple examples on relative velocity of one dimensional motion and then two dimensional motion; consider displacement first; relative displacement (use Triangle Law or parallelogram Law).*
e) *Various terms related to projectile motion; obtain equations of trajectory, time of flight, maximum height, horizontal range, instantaneous velocity, [projectile motion on an inclined plane not included]. Examples of projectile motion.*
f) *Examples of uniform circular motion: details to be covered in unit 3 (d).*

3. Laws of Motion

General concept of force, inertia, Newton's first law of motion; momentum and Newton's second law of motion; impulse; Newton's third law of motion.

Law of conservation of linear momentum and its applications.

Equilibrium of concurrent forces. Friction: Static and kinetic friction, laws of friction, rolling friction, lubrication.

Dynamics of uniform circular motion: Centripetal force, examples of circular motion (vehicle on a level circular road, vehicle on a banked road).

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

Newton's second law: $\vec{p} = m\vec{v}$; ; $\vec{F} \,\alpha\, \frac{d\vec{p}}{dt}$. 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 $m = m_0 \Big/ \sqrt{1 - v^2/c^2}$ Note that

F= ma is the special case for classical mechanics. It is a vector equation. $\vec{a} \,||\, \vec{F}$. 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. Statement, derivation and explanation of principle of conservation of linear momentum. Impulse of a force: $F\Delta t = \Delta p$.

Newton's third law. Obtain it using Law of Conservation of linear momentum. Proof of Newton's second law as real law. 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 a ρ . Simple problems on "Connected bodies" (not involving two pulleys).

(b) *Force diagrams; resultant or net force from Triangle law of Forces, parallelogram law or resolution of forces. Apply net force $\sum \vec{F}=m\vec{a}$. Again for equilibrium a=0 and $\sum F=0$. Conditions of equilibrium of a rigid body under three coplanar forces. Discuss ladder problem.*

(c) *Friction; classical view and modern view of friction, static friction a self-adjusting force; limiting value; kinetic friction or sliding friction; rolling friction, examples.*

Laws of friction: Two laws of static friction; (similar) two laws of kinetic friction; coefficient of friction $\mu_x = f_s(max)/N$ *and* $\mu_k = f_k/N$*; graphs. Friction as a nonconservative force; motion under friction, net force in Newton's 2nd law is calculated including* f_k*. Motion along a rough inclined plane – both up and down. Pulling and pushing of a roller. Angle of friction and angle of repose. Lubrication, use of bearings, streamlining, etc.*

(d) *Angular displacement (θ), angular velocity (ω), angular acceleration (α) and their relations. Concept of centripetal acceleration; obtain an expression for this acceleration using* $\Delta\vec{v}$*. Magnitude and direction of* $\vec{a}$ *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, motion in a vertical circle; banking of road and railway track (conical pendulum is excluded).*

4.Work, Power and Energy

Work done by a constant force and a variable force; kinetic energy, work-energy theorem, power.

Potential energy, potential energy of a spring, conservative forces: conservation of mechanical energy (kinetic and potential energies); Conservative and non-conservative forces. Concept of collision: elastic and inelastic collisions in one and two dimensions.

(i) *Work done* $W = \vec{F}.\vec{S} = FS\cos\theta$*. If F is variable* $dW = \vec{F}.d\vec{S}$ *and* $W = \int dw = \int \vec{F}.d\vec{S}$*, for* $\int \vec{F} \parallel d\vec{S}$ $\vec{F}.d\vec{S} = Fds$ *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* $U = \frac{1}{2}kx^2$*.*
Kinetic energy and its expression, Work-Energy theorem E=W. Law of Conservation of Energy; oscillating spring. $U+K = E = K_{max} = U_{max}$ *(for U = 0 and K = 0 respectively); graph different forms of energy and their transformations.* $E = mc^2$ *(no derivation). Power P=W/t;* $P = \vec{F}\vec{v}$ *.*

(ii) *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.*

5.Motion of System of Particles and Rigid Body

Idea of centre of mass: centre of mass of a two particle system, momentum conservation and centre of mass motion. Centre of mass of a rigid body; centre of mass of a uniform rod.

Moment of a force, torque, angular momentum, laws of conservation of angular momentum and its applications.

Equilibrium of rigid bodies, rigid body rotation and equations of rotational motion, comparative study of linear and rotational motions.

Moment of inertia, radius of gyration, moments of inertia for simple geometrical objects (no derivation). Statement of parallel and perpendicular axes theorems and their applications.

(i) *Definition of centre of mass (cm), centre of mass (cm) for a two particle system $m_1x_1+m_2x_2=Mx_{cm}$; differentiating, get the equation for v_{cm} and a_{cm}; general equation for N particles- many particles system; [need not go into more details];centre of gravity, principle of moment, discuss ladder problem, 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; physical significance of moment of inertia; unit and dimension; depends on mass and axis of rotation; it is rotational inertia; equations of rotational motions. Applications: only expression for the moment of inertia, I (about the symmetry axis) of: (i) a ring; (ii) a solid and a hollow cylinder, (iii) a thin rod (iv) a solid and a hollow sphere, (v) a disc - only formulae (no derivations required).*

a) *Statements of the parallel and perpendicular axes theorems with illustrations [derivation not required]. Simple examples with change of axis.*
b) *Definition of torque (vector); $\vec{\tau} = \vec{r}x\vec{F}$ and angular momentum $\vec{L} = \vec{r}x\vec{p}$ for a particle (no derivations); differentiate to obtain $d\vec{L}/dt = \vec{\tau}$ similar to Newton's second law of motion (linear);hence $\tau = I\alpha$ and $L = I\omega$; (only scalar equation); Law of conservation of angular momentum; simple applications. Comparison of linear and rotational motions.*

6.Gravitation

Kepler's laws of planetary motion, universal law of gravitation. Acceleration due to gravity (g) and its variation with altitude, latitude and depth.

Gravitational potential and gravitational potential energy, escape velocity, orbital velocity of a satellite, Geo-stationary satellites.

(i) *Newton's law of universal gravitation; Statement; unit and dimensional formula of universal gravitational constant, G [Cavendish experiment not required]; gravitational acceleration on surface of the earth (g), weight of a body W= mg from F=ma.*

(ii) *Relation between g and G. Derive the expression for 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, intensity of gravitational field and potential at a point in earth's gravitational field. $V_p = W_{\alpha p}/m$. Derive 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; expression for gravitational potential energy $U(r) = W_{\alpha p} = m.V(r) = -G\,M\,m/r$; 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.

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 and Greenhouse.

(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; $\epsilon=1$ for ideal radiators. The Spectral radiancy $R(\lambda)$. $I(T) = \int_0^{\infty} R(\lambda)\, d\lambda$.

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]. Greenhouse effect – self-explanatory.

(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. Heat engine and refrigerator.

(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 $p=1/3\ \rho\ c^2$ 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 $p = \frac{1}{3}\rho c^2$, 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 $p = (1/3)\rho c^2$ or $pV = (1/3)M c^2$. (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), $RT= (1/3) Mc^2= (2/3). ½Mc^2= (2/3) K$; 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.

Free, forced and damped oscillations (qualitative ideas only), resonance.

(a)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, $d^2 y/dt^2 +\omega^2 y=0$ from the nature of force acting F=-k y; solution $y=A \sin (\omega t+\varphi 0)$ 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.

(b) 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 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(f) of the applied force and it is maximum when the frequency 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).

(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, Doppler effect.

(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.

(f) Doppler effect for sounds; obtain general expression for apparent frequency when both the source and listener are moving, given as $fL = fr\left[\frac{v \pm v_L}{v \pm v_r}\right]$ *which can be reduced to any one of the floor special cases, by using proper sign.*

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.