Physics

Hand Book
(Formulas & Concepts)

Kinematics

Note: - Bold letter are used to denote vector quantity
i,j,z are the unit vector along x,y and z axis

Quick review of Kinematics formulas

S.No.	Type of Motion	Formula
	Motion in one dimension	**r**=x**i** **v**=(dx/dt)**i** **a**=d**v**/dt=(d^2x/dt^2)**i** and **a**=**v**d**v**/d**r** **v**=**u**+**a**t **s**=**u**t+1/2**a**t^2 $\mathbf{v}^2$=$\mathbf{u}^2$+2**as** In integral form **r**=∫**v**dt **v**=∫**a**dt
2	**Motion in two dimension**	**r**=x**i** +y**j** **v**=d**r**/dt=(dx/dt)**i** + (dy/dt)**j** **a**=d**v**/dt=(d^2x/dt^2)**i**+(d^2x/dt^2)**j** and **a**=**v**d**v**/d**r** Constant accelerated equation same as above
3	**Motion in three dimension**	**r**=x**i** +y**j**+z**k** **v**=d**r**/dt=(dx/dt)**i** + (dy/dt)**j**+(dz/dt)**k** **a**=d**v**/dt=(d^2x/dt^2)**i**+(d^2x/dt^2)**j**+(d^2x/dt^2)**k** **a**=**v**d**v**/d**r** Constant accelerated equation same as above
4	**Projectile Motion**	$x=(v_0\cos\theta_0)t$ $y=(v_0\sin\theta_0)t-gt^2/2$ $v_x= v_0\cos\theta_0$ and $v_y= v_0\sin\theta_0 t-gt$, where θ_0 is the angle initial velocity makes with the positive x axis.
5	**Uniform circular motion**	$a=v^2/R$, where a is centripetal acceleration whose direction of is always along radius of the circle towards the centre and $a=4\pi^2R/T^2$ acceleration in uniform circular motion in terms of time period T

Concept of relative velocity

For two objects A and B moving with the uniform velocities $\mathbf{V_A}$ and $\mathbf{V_B}$.
Relative velocity is defined as

$\mathbf{V_{BA}}=\mathbf{V_B}-\mathbf{V_A}$

where $\mathbf{V_{BA}}$ is relative velocity of B relative to A
Similarly relative velocity of A relative to B

$\mathbf{V_{AB}}=\mathbf{V_A}-\mathbf{V_B}$

Special cases: -

S.No.	Case	Description
1	**For straight line motion**	If the objects are moving in the same direction, relative velocity can be get by subtracting other. If they are moving in opposite direction ,relative velocity will be get by adding the velocities example like train problems
2	**For two dimensions motion**	if $\mathbf{v_a}=v_{xa}\mathbf{i} + v_{ya}\mathbf{j}$ $\mathbf{v_b}=v_{xb}\mathbf{i} + v_{yb}\mathbf{j}$ Relative velocity of B relative to A $=v_{xb}\mathbf{i} + v_{yb}\mathbf{j} -(v_{xa}\mathbf{i} + v_{ya}\mathbf{j})$ $=\mathbf{i}(v_{xb}-v_{xa}) + \mathbf{j}(v_{yb}-v_{ya})$
3	**For three dimensions motion**	$\mathbf{v_a}=v_{xa}\mathbf{i} + v_{ya}\mathbf{j} +v_{za}\mathbf{z}$ $\mathbf{v_b}=v_{xb}\mathbf{i} + v_{yb}\mathbf{j} + v_{zb}\mathbf{z}$ Relative velocity of B relative to A $=v_{xb}\mathbf{i} + v_{yb}\mathbf{j} + v_{zb}\mathbf{z} -(v_{xa}\mathbf{i} + v_{ya}\mathbf{j} +v_{za}\mathbf{z})$ $=\mathbf{i}(v_{xb}-v_{xa}) + \mathbf{j}(v_{yb}-v_{ya})+\mathbf{z}(v_{yb}-v_{ya})$

Free fall acceleration

S.No.	Point
1	Freely falling motion of any body under the effect of gravity is an example of uniformly accelerated motion.
2	Kinematics equation of motion under gravity can be obtained by replacing acceleration **'a'** in equations of motion by acceleration due to gravity **'g'**.
3	Thus kinematics equations of motion under gravity are $v = v_0 + gt$, $x = v_0t + ½ (gt^2)$ and $v^2 = (v_0)^2 + 2gx$
4	Value of g is equal to 9.8 $m.s^{-2}$.The value of g is taken positive when the body falls vertically downwards and negative when the body is projected up against gravity.

Laws of motion

S.No.	Term	Description
1	**Newton's first law of motion**	'A body continues to be in state of rest or uniform motion unless it is acted upon by some external force to act otherwise'
2	**Newton's second law of motion**	'Rate of change of momentum of a body is proportional to the applied force and takes place in the direction of action of force applied Mathematically, $\mathbf{F}= d\mathbf{p}/dt = m\mathbf{a}$ where, $\mathbf{p}=m\mathbf{v}$, momentum of the body $\mathbf{a}$=acceleration
3	**Impulse**	Impulse is the product of force and time which is equal to the change in momentum Impulse $=\mathbf{F}\Delta t = \Delta\mathbf{p}$
4	**Newton's third law of motion**	'To every action there is always an equal and opposite reaction' $\mathbf{F}_{AB}=-\mathbf{F}_{BA}$
5	**Law of conservation of linear momentum**	Initial momentum = final momentum $m_1\mathbf{v}1+m_2\mathbf{v}2=m_1\mathbf{v}1'+m_2\mathbf{v}2'$ For equilibrium of a body $\mathbf{F}_1+\mathbf{F}_2+\mathbf{F}_3=0$

Some points to note

S.No.	Point
1	An accelerated frame is called non inertial frame while an non accelerated frame is called inertial frame
2	Newton first law are valid in inertial frame only
3	Apparent weight of a body in the lift Going Upward with acceleration a $W=m(g + a)$ Going Down with acceleration a $W=m(g-a)$
4	Always draw free body diagram to solve the force related problems

Friction and Frame of reference

S.No.	Term	Description
1	**Friction**	Frictional force acts between the bodies whenever there is a relative motion between them. When bodies slip, frictional force is called static frictional force and when the bodies do not slip, it is called kinetic frictional force.
2	**Kinetic Frictional force**	When bodies slip over each other $f=\mu_k N$ Where N is the normal contact force between the surface and μ_k is the coefficient of kinetic Friction. Direction of frictional force is such that relative slipping is opposed by the friction
3	**Static Frictional force**	Frictional force can also act even if there is no relative motion. Such force is called static Frictional force. Maximum Static friction that a body can exert on other body in contact with it is called limiting Friction. $f_{max}=\mu_s N$ Where N is the normal contact force between the surface And μ_s is the coefficient of static Friction f_{max} is the maximum possible force of static Friction. Note that $\mu_s > \mu_k$ and Angle of friction $\tan\lambda=\mu_s$
4	**Inertial Frame Of reference**	Inertial frame of references is those attached to objects which are at rest or moving at constant Velocity. Newton's law are valid in inertial frame of reference. Example person standing in a train moving at constant velocity.
5	**Non Inertial Frame Of reference**	Inertial frame of references is attached to accelerated objects for example: A person standing in a train moving with increasing speed. Newton's law are not valid. To apply Newton's law ,pseudo force has to be introduced in the equation whose value will be $F=-ma$

Work, Energy and Power

S.No.	Term	Description
1	**Work**	**1.** Work done by the force is defined as dot product of force and displacement vector. For constant Force W=**F**.**s** where F is the force vector and s is displacement Vector **2.** For variable Force dW=**F**.**ds** or W=∫**F**.**ds** It is a scalar quantity
2	**Conservative And Non Conservative Forces**	**1.** If the work done by the force in a closed path is zero, then it is called **conservative Force** **2.** If the work done by the force in a closed path is not zero, then it is called **non conservative Force** **3.** Gravitational ,electrical force are Conservative Forces and Non Conservative Forces are frictional forces
3	**Kinetic Energy**	**1.** It is the energy possessed by the body in motion. It is defined as K.E=(1/2)mv^2 **2.** Net work done by the external force is equal to the change in the kinetic energy of the system $W=K_f-K_i$
4	**Potential Energy**	**1.** It is the kind of energy possessed due to configuration of the system. It is due to conservative force. It is defined as dU=-**F**.**dr** U_f-U_i=-∫**F**.**dr** Where F is the conservative force **F**=-(∂U/∂x)**i**-(∂U/∂y)**j**-(∂U/∂z)**k** For gravtitional Force **2.** Change in Potential Energy =mgh where h is the height between the two points **3.** Mechanical Energy is defined as E=K.E+P.E
5	**Law Of conservation of Energy**	In absence of external forces, internal forces being conservative, total energy of the system remains constant. $K.E_1+P.E_1=K.E_2+P.E_2$
6	**Power**	Power is rate of doing work i.e., P=work/Time. Unit of power is Watt. $1W=1Js^{-1}$. In terms of force P= **F**.**v** and it is a scalar quantity.

Momentum and Collision

S.No.	Term	Description
1	**Linear Momentum**	The **linear momentum p** of an object of mass *m* moving with velocity **v** is defined as **p**=m**v** Impulse of a constant force delivered to an object is equal to the change in momentum of the object $F\Delta t = \Delta p = mv_f - mv_i$ Momentum of system of particles is the vector sum of individual momentum of the particle $\mathbf{p}_{total}=\Sigma \mathbf{v}_i M_i$
2	**Conservation of momentum**	When no net external force acts on an isolated system, the total momentum of the system is constant. This principle is called conservation of momentum. if $\Sigma \mathbf{F}_{ext}=0$ then $\Sigma \mathbf{v}_i M_i$=constant
3	**Collision**	**Inelastic collision** - the momentum of the system is conserved, but kinetic energy is not. **Perfectly inelastic collision** - the colliding objects stick together. **Elastic collision** - both the momentum and the kinetic energy of the system are conserved.
4	**Inelastic collision**	While colliding if two bodies stick together then speed of the

		composite body is $v=\frac{m_1u_1+m_2u_2}{m_1+m_2}$ Kinetic energy of the system after collision is less then that before collison
5	**Elastic collision in one dimension**	Final velocities of bodies after collision are $v_1=\left(\frac{m_1-m_2}{m_1+m_2}\right)u_1+\left(\frac{2m_2}{m_1+m_2}\right)u_2$ $v_2=\left(\frac{2m_1}{m_1+m_2}\right)u_1+\left(\frac{m_2-m_1}{m_1+m_2}\right)u_2$ also $u_1-u_2=v_2-v_1$

Special cases of Elastic Collision

S.No.	Case	Description
1	$m_1=m_2$	$v_1=u_2$ and $v_2=u_1$
2	When one of the bodies is at rest say $u_2=0$	$v_1=\left(\frac{m_1-m_2}{m_1+m_2}\right)u_1$ and $v_2=\left(\frac{2m_1}{m_1+m_2}\right)u_1$
3	When $m_1=m_2$ and $u_2=0$ i.e., m_2 is at rest	$v_1=0$ and $v_2=u_1$
4	When body in motion has negligible mass i.e. $m_1<<m_2$	$v_1=-u_1$ and $v_2=0$
5	When body at rest has negligible mass i.e. $m_1>>m_2$	$v_1=u_1$ and $v_2=2u_2$

Mechanics of system of particles

S.No.	Term	Description
1	**Centre of mass**	It is that point where entire mass of the system is imagined to be concentrated, for consideration of its translational motion.
2	**position vector of centre of mass**	$\mathbf{R}_{cm}=\Sigma \mathbf{r}_i M_i/\Sigma M_i$ where $\mathbf{r}_i$ is the coordinate of element i and M_i is mass of element i
3	**In coordinate system**	$x_{cm}=\Sigma x_i M_i/\Sigma M_i$ $y_{cm}=\Sigma y_i M_i/\Sigma M_i$ $z_{cm}=\Sigma z_i M_i/\Sigma M_i$
4	**Velocity of CM**	$\mathbf{v}_{CM}=\Sigma \mathbf{v}_i M_i/\Sigma M_i$ The total momentum of a system of particles is equal the total mass times the velocity of the centre of mass
5	**Force**	When Newton's second law of motion is applied to the system of particles we find $F_{tot}=Ma_{CM}$ with $a_{CM}=d^2R_{CM}/dt^2$ Thus centre of mass of the system moves as if all the mass of the system were concentrated at the centre of mass and external force were applied to that point.
6	**Momentum conservation in COM motion**	$\mathbf{P}=M\mathbf{v}_{CM}$ which means that total linear momentum of system of particles is equal to the product of the total mass of the system and the velocity of its centre of mass.

Rigid body dynamics

S.No.	Term	Description
1	**Angular Displacement**	-When a rigid body rotates about a fixed axis, the angular displacement is the angle $\Delta\theta$ swept out by a line passing through any point on the body and intersecting the axis of rotation perpendicularly -It can be positive (counter clockwise) or negative (clockwise). -Analogous to a component of the displacement vector. -SI unit: radian (rad). Other units: degree, revolution.
2	**Angular velocity**	-Average angular velocity, is equal to $\Delta\theta/\Delta t$. Instantaneous Angular Velocity $\boldsymbol{\omega}=d\theta/dt$ -Angular velocity can be positive or negative.

		-It is a vector quantity and direction is perpendicular to the plane of rotation -Angular velocity of a particle is different about different points -Angular velocity of all the particles of a rigid body is same about a point.
3	**Angular Acceleration**	Average angular acceleration= $\Delta\boldsymbol{\omega}/\Delta t$ Instantaneous Angular Acceleration $\alpha=d\boldsymbol{\omega}/dt$
4	**Vector Nature of Angular Variables**	-The direction of an angular variable vector is along the axis. - positive direction defined by the right hand rule. - Usually we will stay with a fixed axis and thus can work in the scalar form. -angular displacement cannot be added like vectors. Angular velocity and acceleration are vectors
5	**Kinematics of rotational Motion**	$\boldsymbol{\omega}=\boldsymbol{\omega_0} + \boldsymbol{\alpha}t$ $\boldsymbol{\theta}=\boldsymbol{\omega_0}t+1/2\boldsymbol{\alpha}t^2$ $\boldsymbol{\omega}.\boldsymbol{\omega}=\boldsymbol{\omega_0}.\boldsymbol{\omega_0} + 2\,\boldsymbol{\alpha}.\boldsymbol{\theta}$; Also $\alpha=d\omega/dt=\omega(d\omega/d\theta)$
6	**Relation Between Linear and angular variables**	$\mathbf{v}=\boldsymbol{\omega}X\mathbf{r}$ Where r is vector joining the location of the particle and point about which angular velocity is being computed $\mathbf{a}=\boldsymbol{\alpha}X\mathbf{r}$
7	**Moment of Inertia**	Rotational Inertia (Moment of Inertia) about a Fixed Axis For a group of particles, $I = \boldsymbol{\Sigma}mr^2$ For a continuous body, $I = \int r^2dm$ For a body of uniform density $I = \rho\int r^2dV$
8	**Parallel Axis Therom**	$I_{xx}=I_{cc}+ Md^2$ Where I_{cc} is the moment of inertia about the centre of mass
9	**Perpendicular Axis Therom**	$I_{xx}+I_{yy}=I_{zz}$ It is valid for plane laminas only.
10	**Torque**	$\boldsymbol{\tau}=\mathbf{r}X\mathbf{F}$ also $\tau=I\alpha$ where α is angular acceleration of the body.
11	**Rotational Kinetic Energy**	$KE=(1/2)I\omega^2$ where ω is angular acceleration of the body
12	**Rotational Work Done**	-If a force is acting on a rotating object for a tangential displacement of $s = r\theta$ (with θ being the angular displacement and r being the radius) and during which the force keeps a tangential direction and a constant magnitude of F, and with a constant perpendicular distance r (the lever arm) to the axis of rotation, then the work done by the force is: $W=\tau\theta$ -W is positive if the torque τ and θ are of the same direction, otherwise, it can be negative.
13	**Power**	$P =dW/dt=\tau\omega$
14	**Angular Momentum**	$\mathbf{L}=\mathbf{r}X\mathbf{p}$ $=\mathbf{r}X(m\mathbf{v})$ $=m(\mathbf{r}X\mathbf{v})$ For a rigid body rotating about a fixed axis $L=I\omega$ and $d\mathbf{L}/dt=\boldsymbol{\tau}$ if $\tau=0$ and L is constant For rigid body having both translational motion and rotational motion $\mathbf{L}=\mathbf{L_1}+\mathbf{L_2}$ $\mathbf{L_1}$ is the angular momentum of Centre mass about an stationary axis $\mathbf{L_2}$ is the angular momentum of the rigid body about Centre of mass.
15	**Law of Conservation On Angular Momentum**	If the external torque is zero on the system then Angular momentum remains contants $d\mathbf{L}/dt=\boldsymbol{\tau_{ext}}$ if $\boldsymbol{\tau_{ext}}=0$ then $d\mathbf{L}/dt=0$

16	**Equilibrium of a rigid body**	$F_{net}=0$ and $\tau_{ext}=0$
17	**Angular Impulse**	$\int\tau dt$ term is called angular impulse. It is basically the change in angular momentum
18	**Pure rolling motion of sphere/cylinder/disc**	-Relative velocity of the point of contact between the body and platform is zero -Friction is responsible for pure rolling motion -If friction is non dissipative in nature $E = (1/2)mv_{cm}^2+(1/2)I\omega^2+mgh$

Gravitation

S.No.	Term	Description	
1	**Newton's Law of gravitation**	$F=\frac{Gm_1m_2}{r^2}$ where G is the universal gravitational constant $G=6.67\times10^{-11}Nm^2Kg^{-2}$	
2	**Acceleration due to gravity**	$g=GM/R^2$ where M is the mass of the earth and R is the radius of the earth	
3	**Gravitational potential energy**	PE of mass m at point h above surface of earth is $PE=-\frac{GmM}{(R+h)}$	
4	**Gravitational potential**	$V=-\frac{GM}{(R+h)}$	
5	**Kepler's Law of planetary motion**	**Law of orbits**	Each planet revolves round the sun in an elliptical orbit with sun at one of the foci of elliptical orbit.
		Law of areas	The straight line joining the sun and the planet sweeps equal area in equal interval of time.
		Law of periods	The squares of the periods of the planet are proportional to the cubes of their mean distance from sun i.e., $T^2 \propto R^3$
6	**Escape velocity**	Escape velocity is the minimum velocity with which a body must be projected in order that it may escape earth's gravitational pull. Its magnitude is $v_e=\sqrt{(2MG/R)}$ and in terms of g $v_e=\sqrt{(2gR)}$	
7	**Satellites**	**Orbital Velocity**	The velocity which is imparted to an artificial satellite few hundred Km above the earth's surface so that it may start orbiting the earth $v_0=\sqrt{(gR)}$
		Periodic Time	$T=2\pi\sqrt{[(R+h)^3/gR^2]}$
8	**Variation of g**	**With altitude**	$g_h=g\left(1-\frac{2h}{R}\right)$
		With depth	$g_d=g\left(1-\frac{d}{R}\right)$
		With latitude	$g_\phi=g-0.037\cos^2\phi$

Elasticity

S.No.	Term	Description
1	**Elasticity**	The ability of a body to regain its original shape and size when deforming force is withdrawn
2	**Stress**	Stress=F/A where F is applied force and A is area over which it acts.
3	**Strain**	It is the ratio of the change in size or shape to the original size or shape. Longitudinal strain = $\Delta l/l$ volume strain = $\Delta V/V$ and shear strain is due to change in shape of the body.
4	**Hook's Law**	Hook's law is the fundamental law of elasticity and is stated as "for small deformations stress is proportional to strain".

		Thus, stress proportional to strain or, stress/strain = constant This constant is known as modulus of elasticity of a given material	
5	**Elastic Modulus**	**Young's Modulus of Elasticity**	$Y=Fl/A\Delta l$
		Bulk Modulus of Elasticity	$K=-V\Delta P/\Delta V$
		Modulus of Rigidity	$\eta=F/A\theta$
6	**Poisson's Ratio**	The ratio of lateral strain to the longitudinal strain is called Poisson's ratio which is constant for material of that body. $\sigma=l\Delta D/D\Delta l$	
7	**Strain energy**	Energy stored per unit volume in a strained wire is E=½(stress)x(strain)	

Hydrostatics

S.No.	Term	Description
1	**Fluid pressure**	It is force exerted normally on a unit area of surface of fluid P=F/A. Its unit is Pascal $1Pa=1Nm^{-2}$.
2	**Pascal's Law**	Pressure in a fluid in equilibrium is same everywhere.
3	**Density**	Density of a substance is defined as the mass per unit volume.
4	**Atmospheric pressure**	Weight of all the air above the earth causes atmospheric pressure which exerts pressure on the surface of earth. Atmospheric pressure at sea level is $P_0=1.01x10^5Pa$
5	**Hydrostatic pressure**	At depth h below the surface of the fluid is $P=\rho gh$ where ρ is the density of the fluid and g is acceleration due to gravity.
6	**Gauge pressure**	$P=P_0+\rho gh$, pressure at any point in fluid is sum of atmospheric pressure and pressure due to all the fluid above that point.
7	**Archimedes principle**	When a solid body is fully or partly immersed in a fluid it experience a buoyant force equal to the weight of fluid displaced by it.
8	**Upthrust**	It is the weight of the displaced liquid.
9	**Boyle's law**	PV=constant
10	**Charle's law**	V/T=constant

Hydrodynamics

S.No.	Term	Description
1	**Streamline flow**	In such a flow of liquid in a tube each particle follows the path of its preceding particle.
2	**Turbulent flow**	It is irregular flow which does not obey above condition.
3	**Bernoulli's principle**	$p+\frac{1}{2}\rho u^2+\rho gh=cons\tan t$
4	**Continuity of flow**	$A_1v_1=A_2v_2$ where A_1 and A_2 are the area of cross section of tube of variable cross section and v_1 and v_2 are the velocity of flow of liquids crossing these areas.
5	**Viscosity**	Viscous force between two layers of fluid of area A and velocity gradient dv/dx is $F=-\eta A\frac{dv}{dx}$ where η is the coefficient of viscosity.
6	**Stokes' law**	Viscous force on a spherical body of radius r falling through a liquid of viscosity η is $F=\ \pi\eta rv$ where v is the velocity of the sphere.
7	**Poiseuilli's equation**	Volume of a liquid flowing per second through a capillary tube of radius r when its end are maintained at a pressure difference P is given by $Q=\frac{\pi Pr^4}{8\eta l}$ where l is the length of the tube.

Simple Harmonic Motion

S.No.	Term	Description
1	**SHM**	In SHM the restoring force is proportional to the displacement from the mean position and opposes its increase. Restoring force is **F=-Kx** Where K=Force constant , x=displacement of the system from its mean or equilibrium position

		Differential Equation of SHM is $d^2x/dt^2 + \omega^2 x=0$ Solutions of this equation can both be sine or cosine functions .We conveniently choose **$x=A\cos(\omega t+\varphi)$** where A ,ω and φ all are constants
2	**Amplitude**	Quantity A is known as amplitude of SHM which is the magnitude of maximum value of displacement on either sides from the equilibrium position
3	**Time period**	Time period (T) of SHM the time during which oscillation repeats itself i.e, repeats its one cycle of motion and it is given by **$T=2\pi/\omega$** where ω is the angular frequency
4	**Frequency**	Frequency of the SHM is the number of the complete oscillation per unit time i.e., frequency is reciprocal of the time period $f=1/T$. Thus angular frequency $\omega=2\pi f$
5	**Velocity**	Velocity of a system executing SHM as a function of time is $v=-\omega A\sin(\omega t+\varphi)$
6	**Acceleration**	Acceleration of particle executing SHM is $a=-\omega^2 A\cos(\omega t+\varphi)$. So **$a=-\omega^2 x$** This shows that acceleration is proportional to the displacement but in opposite direction
7	**Kinetic energy**	At any time t KE of system in SHM is $KE=(1/2)mv^2 =(1/2)m\omega^2A^2\sin^2(\omega t+\varphi)$ which is a function varying periodically in time
8	**Potential energy**	PE of system in SHM at any time t is $PE=(1/2)Kx^2 =(1/2)m\omega^2A^2\cos^2(\omega t+\varphi)$
9	**Total energy**	Total Energy in SHM $E=KE+PE =(1/2)m\omega^2A^2$ and it remain constant in absence of dissipative forces like frictional forces
10	**Oscillations of a Spring mass system**	In this case particle of mass m oscillates under the influence of hook's law restoring force given by $F=-Kx$ where K is the spring constant Angular Frequency $\omega=\sqrt{(K/m)}$ Time period $T=2\pi\sqrt{(m/K)}$ frequency is $=(1/2\pi)\sqrt{(K/m)}$ Time period of both horizontal and vertical oscillation are same but spring constant have different value for horizontal and vertical motion
11	**Simple pendulum**	-Motion of simple pendulum oscillating through small angles is a case of SHM with angular frequency given by $\omega=\sqrt{(g/L)}$and Time period $T=2\pi\sqrt{(L/g)}$ Where L is the length of the string. -Here we notice that period of oscillation is independent of the mass m of the pendulum
12	**Compound Pendulum**	- Compound pendulum is a rigid body of any shape,capable of oscillating about the horizontal axis passing through it. -Such a pendulum swinging with small angle executes SHM with the timeperiod $T=2\pi\sqrt{(I/mgL)}$ Where I =Moment of inertia of pendulum about the axis of suspension L is the lenght of the pendulum
13	**Damped Oscillation**	-SHM which continues indefinitely without the loss of the amplitude are called free oscillation or undamped and it is not a real case - In real physical systems energy of the oscillator gradually decreases with time and oscillator will eventually come to rest. This happens because in actual physical systems, friction(or damping) is always present -The reduction in amplitude or energy of the oscillator is called damping and oscillation are call damped
14	**Forced Oscillations and Resonance**	- Oscillations of a system under the influence of an external periodic force are called forced oscillations - If frequency of externally applied driving force is equal to the natural frequency of the oscillator resonance is said to occur

Waves

S.No.	Term	Description
1	**Wave**	-It is a disturbance which travels through the medium due to repeated periodic motion of particles of the medium about their equilibrium position.

		-Examples are sound waves travelling through an intervening medium, water waves, light waves etc.
2	**Mechanical waves**	Waves requiring material medium for their propagation are MECHANICAL WAVES. These are governed by Newton's law of motion. -Sound waves are mechanical waves in atmosphere between source and the listener and require medium for their propagation.
3	**Non mechanical waves**	-Those waves which does not require material medium for their propagation are called NON MECHANICAL WAVES. -Examples are waves associated with light or light waves , radio waves, X-rays, micro waves, UV light, visible light and many more.
4	**Transverse waves**	These are such waves where the displacements or oscillations are perpendicular to the direction of propagation of wave.
5	**Longitudinal waves**	Longitudinal waves are those waves in which displacement or oscillations in medium are parallel to the direction of propagation of wave for example sound waves
6	**Equation of harmonic wave**	-At any time t , displacement y of the particle from it's equilibrium position as a function of the coordinate x of the particle is $\mathbf{y(x,t)=A\sin(\omega t-kx)}$ where, A is the amplitude of the wave k is the wave number ω is angular frequency of the wave and (ωt-kx) is the phase.
7	**Wave number**	Wavelength λ and wave number k are related by the relation $\mathbf{k=2\pi/\lambda}$
8	**Frequency**	Time period T and frequency f of the wave are related to ω by $\mathbf{\omega/2\pi = f = 1/T}$
9	**Speed of wave**	speed of the wave is given by $\mathbf{v = \omega/k = \lambda/T = \lambda f}$
10	**Speed of a transverse wave**	Speed of a transverse wave on a stretched string depends on tension and the linear mass density of the string not on frequency of the wave i.e, $\mathbf{v=\sqrt{T/\mu}}$ T=Tension in the string μ=Linear mass density of the string.
11	**Speed of longitudinal waves**	Speed of longitudinal waves in a medium is given by $\mathbf{v=\sqrt{B/\rho}}$ B=bulk modulus ρ=Density of the medium Speed of longitudinal waves in ideal gas is $\mathbf{v=\sqrt{\gamma P/\rho}}$ P=Pressure of the gas , ρ=Density of the gas and $\gamma=C_p/C_V$
12	**Principle of superposition**	When two or more waves traverse thrugh the same medium,the displacement of any particle of the medium is the sum of the displacement that the individual waves would give it. $\mathbf{y=\Sigma y_i(x,t)}$
13	**Interference of waves**	If two sinusoidal waves of the same amplitude and wavelength travel in the same direction they interfere to produce a resultant sinusoidal wave travelling in that direction with resultant wave given by the relation $\mathbf{y'(x,t)=[2A_m\cos(\upsilon/2)]\sin(\omega t-kx+\upsilon/2)}$where υ is the phase difference between two waves. -If υ=0 then interference would be fully constructive. -If υ=π then waves would be out of phase and there interference would be destructive.
14	**Reflection of waves**	When a pulse or travelling wave encounters any boundary it gets reflected. If an incident wave is represented by $\mathbf{y_i(x,t)=A\sin(\omega t-kx)}$then reflected wave at rigid boundary is $\mathbf{y_r(x,t)=A\sin(\omega t+kx+\pi)}$ $\mathbf{=-A\sin(\omega t+kx)}$ and for reflections at open boundary reflected wave is given by $\mathbf{y_r(x,t)=A\sin(\omega t+kx)}$
15	**Standing waves**	The interference of two identical waves moving in opposite directions produces standing waves. The particle displacement in standing wave is given by $\mathbf{y(x,t)=[2A\cos(kx)]\sin(\omega t)}$ In standing waves amplitude of waves is different at different points i.e., at nodes amplitude is zero and at antinodes amplitude is maximum which is equal to sum of amplitudes of constituting waves.

16	**Normal modes of stretched string**	Frequency of transverse motion of stretched string of length L fixed at both the ends is given by f=nv/2L where n=1,2,3,4,....... -The set of frequencies given by above relation are called normal modes of oscillation of the system. Mode **n=1** is called the fundamental mode with frequency **f_1=v/2L.** Second harmonic is the oscillation mode with n=2 and so on. -Thus the string has infinite number of possible frequency of vibration which are harmonics of fundamental frequency f_1 such that $f_n=nf_1$
17	**Beats**	Thus beats arises when two waves having slightly differing frequencies v_1 and v_2 and comparable amplitude are superposed. -Here interfering waves have slightly differing frequencies v_1 and v_2 such that $\lvert v_1-v_2\rvert<<(v_1+v_2)/2$ The beat frequency is v_{beat}= v_1 □ v_2
18	**Doppler effect**	-Doppler effect is a change in the observed frequency of the wave when the source S and the observer O move relative to the medium. -There are three different ways where we can analyse this change in frequency. **(1) *When observer is stationary*** and source is approaching observer is $v=v_0(1+V_s/V)$ where, v_s=velocity of source relative to the medium v=velocity of wave relative to the medium v=observed frequency of sound waves in term of source frequency v_0=source frequency -Change in frequency when source recedes from stationary observer is $v=v_0(1-V_s/V)$ -Observer at rest measures higher frequency when source approaches it and it measures lower frequency when source reseeds from the observer. **(2)*Observer is moving*** with a velocity V_o towards source and the source is at rest is $v=v_0(1+V_o/V)$ **(3)*Both source and observer are moving*** then frequency observed by observer is $v=v_0(V+V_o)/(V+V_s)$ and all the symbols have respective meanings as told earlier

Thermal expansion

S.No.	Term	Description
1	**Coefficient of linear expansion**	$\alpha=\frac{l_t-l_0}{l_0 t}$ where α=coefficient of linear expansion, l_t= length at t^0C and l_0 is length at 0^0C.
2	**Length at temperature t^0C**	$l_t=l_0(1+\alpha t)$
3	**Coefficient of superficial expansion**	$\beta=\frac{A_t-A_0}{A_0 t}$
4	**Area at temperature t^0C**	$A_t=A_0(1+\beta t)$
5	**Coefficient of volume expansion**	$\gamma=\frac{V_t-V_0}{V_0 t}$
6	**Volume at temperature t^0C**	$V_t=V_0(1+\gamma t)$
7	**Coefficient of apparent expansion of a liquid**	$\gamma_\alpha=\frac{V_a-V_0}{V_0 t}$ where γ_α =coefficient of apparent expansion, V_0=volume at 0^0C and V_a= apparent volume at t^0C
8	**Coefficient of real expansion of a liquid**	$\gamma_r=\frac{V_r-V_0}{V_0 t}$ where γ_r =coefficient of real expansion, V_0=volume at 0^0C and V_r= real volume at t^0C
9	**Density variation with temperature**	$d_t=\frac{d_0}{1+\gamma t}$ where d_t=density at temperature t^0C , d_0= density at 0^0C.
10	**Pressure coefficient of gas**	$\gamma_P=\frac{P_t-P_0}{P_0 t}$

11	**Volume coefficient of gas**	$\gamma_v = \frac{V_t - V_0}{V_0 t}$
12	**Ideal gas equation**	PV=nRT where n is number of moles of gas and R is universal constant.

Measurement of heat and temperature

S.No.	Term	Description
1	**Relation between Celsius, Fahrenheit and Kelvin scale of temperature**	$\frac{C}{100} = \frac{F-32}{180} = \frac{K-273}{100}$
2	**Principle of electrical resistance thermometer**	$R_t=R_0(1+\alpha t)$ where R_t is resistance at t^0C, R_0 is resistance at)^{0}C and α is temperature coefficient of resistance.
3	**Joule's mechanical equivalent to heat(J)**	W=JH where value of J is J=4.2J/cal.
4	**Heat capacity**	C=ΔQ/Δt where ΔQ is the amount of heat absorbed and Δt is rise in temperature.
5	**Specific heat**	It is the amount of heat required to raise the temperature of 1Kg of substance by 1^0C
6	**Molar specific heat**	Molar specific heat of the substance is the amount of heat required to raise the temperature of 1 mole of the substance through 1^0C.
7	**Relation between C_p and C_v**	$C_P-C_v=R$ where R is universal gas constant.
8	**Latent heat of fusion**	Heat energy required to convert a unit mass of substance from the solid to the liquid state without change in temperature.
9	**Latent heat of sublimation**	Heat energy required to convert a unit mass of substance from the liquid to the gaseous state without change in temperature.
10	**Principle of calorimetery**	Heat lost=Heat gain

Thermodynamics

S.No.	Term	Description
1	**Thermodynamic state**	It refers to the state of the system that is completely defined by pressure , volume and temperature of the system.
2	**Zeroth law of thermodynamics**	If two systems A and B are separately in equilibrium with the third system C then system A and B are in thermal equilibrium with each other
3	**First law of thermodynamics**	Heat energy given to the system is equal to the increase in internal energy of the system and the work done. Q=ΔU+W
4	**Second law of thermodynamics**	Heat can not flow from a colder body to a hotter body without some work being done by the external agency.
5	**Work in volume changes**	If pressure remains constant while the volume changes, then work is $W = P(V_2-V_1)$
6	**Quasi static Processes**	In Quasi static process deviation of system from it's thermodynamic equilibrium is infinitesimally small.
7	**Isothermal Process**	temperature of the system remains constant throughout the process and thus ΔQ =ΔW
8	**Adiabatic Process**	no heat enters or leaves a system thus $\Delta U=U_2 - U_1= - \Delta W$
9	**Isochoric process**	volume of the system remain uncharged throughout and $U_2 - U_1 = \Delta U = \Delta Q$
10	**Isobaric Process**	This process takes place at constant pressure.
11	**Work done in Isothermal process**	$W=nRT \ln(V_2/V_1)$ Where n is number of moles in sample of gas taken
12	**Ideal gas equation for adiabatic process**	$PV^\gamma = K$ (Constant) Where γ is the ratio of specific heat (ordinary or molar) at constant pressure and at constant volume $\gamma = C_p/C_v$
13	**Work done in an Adiabatic process**	$W = (P_1V_1-P_2V_2)/(\gamma-1)$ In and adiabatic process if W>0 i.e., work is done by the gas then $T_2< T_1$. If work is done on the gas (W<0) then $T_2 > T_1$ i.e., temperature of gas rises
14	**Thermal efficiency of heat engine**	$\eta = 1-(Q_2/Q_1)$

15	**Coefficient of performance of refrigerator**	$\beta = Q_2/W = Q_2/(Q_1-Q_2)$
16	**Efficiency of carnot engine**	$\beta = Q_2/W = Q_2/(Q_1-Q_2)$
17	**Carnot Theorem**	Carnot's theorem consists of two parts (i) No engine working between two given temperatures can be more efficent than a reversible Carnot engine working between same source and sink. (ii) All reversible engines working between same source and sink (same limits or temperature) have the same efficiency irrespective the working substance.

Heat transfer

S.No.	Term	description	
1	**Thermal Conductivity**	$H = \frac{kA(T_2 - T_1)}{L}$ Where H is the quantity of heat flowing through the slab and k is the constant called thermal conductivity of material of slab.	
2	**Convection**	Convection is transfer of heat by actual motion of matter	
3	**Radiation**	Radiation process does not need any material medium for heat transfer	
4	**Stefan Boltzmann law**	The rate u_{rad} at which an object emits energy via EM radiation depends on objects surface area A and temperature T in kelvin of that area and is given by $u_{rad} = \sigma\varepsilon AT^4$ Where σ= 5.6703×10^{-8} W/m^2K^4 is Stefan boltzmann constant and ε is emissivity of object's surface with value between 0 and 1	
5	**Wein's displacement law**	$\lambda_m T = b$ Where b=0.2896×10^{-2} mk for black body and is known as Wien's constant	
6	**Kirchoff's law**	**Emissive Power**	It is the energy radiated per unit area per unit solid angle normal to the area. $E = \Delta u / [(\Delta A)(\Delta\omega)(\Delta t)]$ where, Δu is the energy radiated by area ΔA of surface in solid angle Δω in time Δt.
		Absorptive Power	is defined as the fraction of the incident radiation that is absorbedby the body a(absorptive power) = energy absorbed / energy incident
		Kirchoff's Law	"It status that at any given temperature the ratio of emissive power to the absorptive power is constant for all bodies and this constant is equal to the emissive power of perfect B.B. at the same temperature. $E/a_{body} = E_{B.B}$
7	**Newton's Law of Cooling**	For small temperature difference between the body and surrounding rate of cooling is directly proportional to the temperature difference and surface area exposed i.e., $dT/dt = -bA(T_1 - T_2)$. This is known a Newton's law of cooling	

Kinetic theory of gases

S.No.	Term	Description	
1	**Gas laws**	**Boyle's law**	At constant temperature, the volume of a given mass of gas is inversely proportional to pressure. Thus PV = constant
		Charle's Law	When pressure of a gas is constant the volume of a given mass of gas is directly proportional to its absolute temperature. V/T = Constant
		Dalton's law of partial pressures	The total pressure of mixture of ideal gases is sum of partial pressures of individual gases of which mixture is made of
2	**Ideal gas equation**	PV = nRT where n is number of moles of gas	
3	**Pressure of gas**	$P = (1/3)\rho v_{mg}^2$ or $PV = (1/3) Nmv_{mg}^2$ where v_{mg}^2 known as mean	

		square speed	
4	**rms speed**	v_{rms} = √(3P/ρ) = √(3PV/M) =√(3RT/M)	
5	**Law of Equipartition of energy**	each velocity component has, on the average, an associated kinetic energy (1/2)KT	
6	**Specific Heat Capacity**	**Monatomic gases**	C_V= (3/2)R , C_P = 5/2 R and γ_{mono} = C_P/C_V= 5/3
		Diatomic gases	C_V =(5/2)R , C_P=(9/2)R and γ=C_P/C_V=9/7
7	**Specific heat Capacity of Solids**	C=3R this is Dulang and Petit law	
8	**Mean free path**	If v is the distance traversed by molecule in one second then mean free path is given by λ = total distance traversed in one second /no. of collision suffered by the molecules =v/πσ²vn =1/πσ²n	

Electric Charge, Force and Field

S.No.	Term	Description	
1	**Charge**	Charges are of two types (a) positive charge (b) negative charge like charges repel each other and unlike charges attract each other.	
2	**Properties of charge**	1. **Quantisation**: - q=ne where n=0,1, 2........ and e is charge of an electron. 2. **Additivety**: - q_{net}=Σq 3. **conservation** :- total charge of an isolated system is constant	
3	**Coulomb's law**	The mutual electrostatic force between the charges q_1 and q_2 separated by a distance r is given by Force on the charge q_1 $\mathbf{F}_1=Kq_1q_2\mathbf{r}_{12}/r^2$ where $\mathbf{r}_{12}$ is the unit vector in the direction from q_2 to q_1 For more then two charges in the system the force acting on any charges is vector sum of the coulomb force from each of the other charges. This is called principle of superposition for $q_1,q_2,q_3......q_n$ charges are present in the system. Force on charge q_1 $\mathbf{F}=Kq_1q_2\mathbf{r}_{12}/r_{12}^2+Kq_1q_3\mathbf{r}_{13}/r_{13}^2+Kq_1q_4\mathbf{r}_{14}/r_{14}^2....Kq_1q_n\mathbf{r}_{1n}/r_{1n}^2$ Similarly for the other charges...	
4	**Electric field**	-The region around a particular charge in which its electrical effects can be observed is called the electric field of the charge -Electric field has its own existence and is present even if there is no charge to experience the electric force.	
5	**Electric field Intensity**	$\mathbf{E}=\mathbf{F}/q_0$ Where **F** is the electric force experience by the test charge q_0 at this point.It is the vector quantity **Some point to note on this** 1. Electric field lines extend away from the positive charge and towards the negative charges 2. Electric field produces the force so if a charge q is placed in the electric field E the force experience by the charge is $\mathbf{F}=q\mathbf{E}$ 3 Principle of superposition also applies to electric field so $\mathbf{E}=\mathbf{E}_1+\mathbf{E}_2+\mathbf{E}_3+\mathbf{E}_4+......$ Electric field intensity due to point charge $\mathbf{E}=KQ\mathbf{r}/r^2$ Where r is the distance from the point charge and **r** is the unit vector along the direction from source to point.	
6	**Some useful Formula**	**Electric field for the Uniformly charged ring**	$E=KQx/(r^2+x^2)^{3/2}$ Where x is the distance from the centre of the ring. At x=0 E=0
		Electric Field due to uniformly charged disc	$E= (\sigma/2\varepsilon_0)(1- x/(\sqrt{R^2}+x^2))$ σ=Surface charge density of the disc. At x=0 $E=\sigma/2\varepsilon_0$
		Electric Field Intensity due to Infinite sheet of the charge	$E=\sigma/2\varepsilon_0$
7	**Charge density**	Linear charge density λ=Q/L=dQ/dL Surface charge density σ=Q/A=dQ/dA	

		Volume charge density ρ=Q/V=dQ/dV
8	**Electrostatics in Conductor**	1. E=0 inside the conductor 2. All charge resides on the outer surface of the conductor 3.Electric at the surface is Perpendicular to the surface
9	**Electric Flux**	dφ=**E.da** **da** is the area vector to the surface and it is taken positive along the outward normal to the surface dφ=Edacosθ φ=∫ **E.da**
10	**Gauss's Theorem**	Flux in closed surface is equal net charge inside divided by ε ∫ **E.da**=q_{in}/ε
11	**Some points**	a. **E** is the electric field present due to all charges in the system not just the charge inside b. Flux crossing a closed surface does not depend on the shapes and size of Gaussian surface

Electric potential

S.No.	Term	Description
1	**Electric Potential energy**	**ΔU=-W** Where ΔU = Change in Potential energy and W= Work done by the electric lines of forces For a system of two particles $U(r)=q_1q_2/4\pi\varepsilon r$ where r is the separation between the charges. We assume U to be zero at infinity Similarly for a system of n charges U=Sum of potential energy of all the distinct pairs in the system For example for three charges $U=(1/4\pi\varepsilon)(q_1q_2/r_{12}+q_2q_3/r_{23}+q_1q_3/r_{13})$
2	**Electric PE of a charge**	=qV where V is the potential there
3	**Electric Potential**	Liken Electric field intensity is used to define the electric field; we can also use Electric Potential to define the field. Potential at any point P is equal to the work done per unit test charge by the external agent in moving the test charge from the reference point(without Change in KE) $V_p=W_{ext}/q$ So for a point charge $V_p=Q/4\pi\varepsilon r$ where r is the distance of the point from charge
4	**Some points about Electric potential**	. It is scalar quantity **2**.Potential at point due to system of charges will be obtained by the summation of potential of each charge at that point $V=V_1+V_2+V_3+V_4$ **3**.Electric forces are conservative force so work done by the electric force between two point is independent of the path taken **4**. $V_2-V_1=-\int E.dr$ **5**. In Cartesian coordinates system dV=-E.dr $dV=-(E_xdx+E_ydy+E_zdz)$ So $E_x=\partial V/\partial x$, $E_y=\partial V/\partial y$ and $E_z=\partial V/\partial z$ Also $E=-[(\partial V/\partial x)i+(\partial V/\partial y)j+(\partial V/\partial z)k]$ **6**. Surface where electric potential is same everywhere is call equipotential surface Electric field components parallel to equipotential surface is always zero
5	**Electric dipole**	A combination of two charge +q and -q separated by the distance d **p**=q**d** Where d is the vector joining negative to positive charge
6	**Electric potential due to dipole**	$V=(1/4\pi\varepsilon)(p\cos\theta/r^2)$ where r is the distance from the center and θ is angle made by the line from the axis of dipole
7	**Electric field due to dipole**	$E_\theta=(1/4\pi\varepsilon)(p\sin\theta/r^3)$ $E_r=(1/4\pi\varepsilon)(2p\cos\theta/r^3)$ Total $E=\sqrt{E_\theta^2+E_r^2}$

		$=(p/4\pi\varepsilon r^3)(\sqrt{(3\cos^2\theta+1)})$ Torque on dipole=**p**X**E** Potential Energy U=-**p**.**E**
8	**Few more points**	1. ∫**E**.**dl** over closed path is zero 2.Electric potential in the spherical charge conductor is Q/4πεR where R is the radius of the shell and the potential is same everywhere in the conductor 3. Conductor surface is a equipotential surface

Capacitance

S.No.	Term	Description
1	**Capacitance C of the capacitor**	C=q/V or q=CV -Unit of capacitance is Farads or CV^{-1} capacitance of a capacitor is constant and depends on shape, size and separation of the two conductors and also on insulating medium being used for making capacitor.
2	**Capacitance of parallel plate cap**	$C=(\varepsilon_0 A)/d$ where, C= capacitance of capacitor A= area of conducting plate d= distance between plates of the capacitor $\varepsilon_0=8.854\times 10^{-12}$ and is known as electric permittivity in vacuum.
3	**parallel plate air capacitor in presence of dielectric medium**	C=εA/d
4	**Capacitance of spherical capacitor having radii a, b (b>a)**	(a) air as dielectric between them $C=(4\pi\varepsilon_0 ab)/(b-a)$ (b) dielectric with relative permittivity ε C=(4πεab)/(b-a)
5	**Parallel combination of capacitors**	$C=Q/V= C_1+C_2+C_3$, resultant capacitance C is greater then the capacitance of greatest individual one.
6	**Series combination of capacitors**	$1/C=1/C_1+1/C_2+1/C_3$, resultant capacitance C is less then the capacitance of smallest individual capacitor.
7	**Energy stored in capacitor**	Energy stored in capacitor is E=QV/2 or $E=CV^2/2$ or $E=Q^2/2C$ factor 1/2 is due to average potential difference across the capacitor while it is charged.
8	**Force between plates of capacitor**	$F=\frac{Q}{2K\varepsilon_0 A}$
9	**Force per unit area of plates**	$f=\frac{\sigma^2}{2K\varepsilon_0}$ Where σ is charge per unit area.

Electric current and D.C. circuits

S.No.	Term	Description
1	**Electromotive force**	EMF of a cell is the total energy per unit charge when the cell is on an open circuit i.e., when the current through the cell is zero.
2	**Electric current**	I=q/t it is the rate of flow of electric charge. Unit of current is ampere.
3	**Drift speed of electron in a conductor**	$v_d=\frac{I}{neA}$ Where I is the current, n is the number of electrons per unit volume and A is the area of cross section of conductor.
4	**Resistivity of conductor**	$\rho=\frac{m}{ne^2\tau}$ where m is the mass of electron and τ is the relaxation time
5	**Ohm's law**	V=IR where R is the resistance of the given conductor and unit of resistance is ohm(Ω)

6	**Electrical resistivity**	P=RA/l where l is the length of the wire and A is its area of cross-section
7	**Resistors in series**	$R=R_1+R_2+R_3+....$
8	**Resistors in parallel**	$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+.....$
9	**Terminal voltage**	It is equal to emf of battery minus potential drop across internal resistance r across the battery. Terminal voltage = E-Ir
10	**Kirchoff's first law**	The algebraic sum of current at any junction in a circuit is zero.
11	**Kirchoff's second law**	The algebraic sum of the products of the current and resistances and the emf in a closed loop is zero.
12	**Heating effect of current**	Heat energy delivered by current when it flows through resistance of R ohm for t sec. maintained at potential difference V is $H=V^2t/R$
13	**Electrical power**	$P = VI = I^2R = V^2/R$
14	**Variation of resistance with temperature**	$R=R_0(1+\alpha(T-T_0))$
15	**Variation of resistivity with temperature**	$\rho=\rho_0(1+\alpha(T-T_0))$

Magnetic effect of current

S.No.	Term	Description
1	**Biot-Savart law**	Magnetic fiels dB at any point whose position vector is **r** wrt current elemant d**l** is given by $d\boldsymbol{B}=\frac{\mu_0 I}{4\pi}\frac{(d\boldsymbol{l}\times\boldsymbol{r})}{r^3}$
2	**Magnetic field due to long current carrying conductor**	$B=\frac{\mu_0 2I}{4\pi r}$
3	**Magnetic field at centre of a circular loop**	$B=\frac{\mu_0 I}{2r}$
4	**Magnetic field at centre of coil of n turns**	$B=\frac{\mu_0 In}{2r}$
5	**Magnetic field on the axis of a circular loop**	$B=\frac{\mu_0 Ir^2}{2(r^2+x^2)^{3/2}}$ if there are n turns in the coil then $B=\frac{\mu_0 Inr^2}{2(r^2+x^2)^{3/2}}$
6	**Ampere's circuital law**	$\oint \boldsymbol{B}\cdot d\boldsymbol{l}=\mu_0 I$
7	**Field due to toroidal solenoid**	$B=\mu_0 nI$
8	**Field inside straight solenoid**	$B=\mu_0 nI$ and direction of field is parallel to the axis of solenoid
9	**Force on moving charge in magnetic field**	$\boldsymbol{F}=q(\boldsymbol{v}\times\boldsymbol{B})$ Direction of force is perpendicular to both ***v*** and ***B***
10	**Force on current carrying conductor in the magnetic field**	$\boldsymbol{F}=I(\boldsymbol{l}\times\boldsymbol{B})$ where l is the length of the conductor in the direction of current in it
11	**Force between two parallel wires carrying current**	$F=\frac{\mu_0 I_1 I_2}{2\pi R}$
12	**Torque on a current carrying loop**	$\boldsymbol{\tau}=(\boldsymbol{m}\times\boldsymbol{B})$ Where ***m*** is the magnetic moment of the dipole and magnitude of magnetic moment is m=NIB where A is the area of the loop and N is the number of turns in the loop.
13	**Lorentz force**	Force on electron moving with velocity ***v*** in presence of both uniform electric and magnetic field is $\boldsymbol{F}=-e(\boldsymbol{E}+\boldsymbol{v}\times\boldsymbol{B})$
14	**Magnetic dipole moment of bar magnet**	**m**=q(2**a**) where q is the pole strength and (2**a**) is the length of the bar magnet. It is the vector pointing from south to north pole of the magnet.
15	**torque on the bar magnet**	$\boldsymbol{\tau}=\boldsymbol{m}\times\boldsymbol{B}$
16	**Potential energy of a magnetic dipole**	$U=-mB\cos\theta$

Electromagnetic induction

S.No.	Term	Description
1	**Magnetic flux**	$\phi = \boldsymbol{B} \cdot \boldsymbol{A} = BA\cos\theta$ where θ is the angle between normal to the plane of the coil and magnetic field s.I. unit of flux is Weber
2	**Faraday's law**	$e = -\frac{d\phi}{dt}$ and for a closely packed coil of N turns $e = -N\frac{d\phi}{dt}$ where e is the induced EMF
3	**Lenz's law**	The induced current has such a direction such that magnetic field of the current opposes the change in the magnetic flux that produces current.
4	**Inductance L of inductor**	$L = \frac{N\phi}{i}$ Where N is windings of inductor, I is the current associated with each winding of inductor.
5	**Self induction**	Phenomenon by which an opposing EMF is introduced in the coil because of varying current in coil itself. Self induction EMF is $e = -L\frac{di}{dt}$
6	**Series RL circuit**	Rise of current $i = \frac{e}{R}(1 - e^{-t/\tau_L})$ where $\tau_L = L/R$ is inductive time constant of the circuit. On removing emf current decays from a value i_0 according to equation $i = i_0 e^{-t/\tau_L}$
7	**Magnetic energy**	Energy stored by inductor's magnetic field is $U=½Li^2$.
8	**Density of stored magnetic energy**	$u=B^2/2\mu_0$
9	**Mutual induction**	It refers to the phenomenon by which a current I is induced in a coil when current in a neighbouring coil circuit is changed. It is described by $e_2 = -M\frac{di_1}{dt}$ and $e_1 = -M\frac{di_2}{dt}$ where M is the mutual induction for the coil arrangement.

Magnetism of matter

S.No.	Term	Description
1	**Gauss's law for magnetic fields**	$\phi = \oint \boldsymbol{B} \cdot d\boldsymbol{A} = 0$ i.e., net magnetic flux through any closed Gaussian surface is zero.
2	**Spin magnetic dipole moment**	$\boldsymbol{\mu}_s = -\frac{e}{m}\boldsymbol{S}$ where **S** is spin angular momentum.
3	**Orbital magnetic dipole moment**	$\boldsymbol{\mu}_L = -\frac{e}{2m}\boldsymbol{L}$ where **L** is orbital angular momentum
4	**Diamagnetism**	Diamagnetic materials are those materials which on being placed in magnetic field get feebly magnetised in the direction opposite to the magnetic field.
5	**Paramagnetism**	In Paramagnetic materials each atom has permanent magnetic moment but dipole moments are randomly oriented and material as a whole lacks property of magnetism but dipoles can be aligned in the presence of external magnetic field to give net dipole moment and material gets feebly magnetised in the direction of the field.
6	**Ferromagnetism**	Ferromagnetic materials when placed in external magnetic field gets strongly magnetised in the direction of the magnetic field.
7	**Maxwell's extension of ampere's law**	$\oint \boldsymbol{B} \cdot \boldsymbol{ds} = \mu_0 \varepsilon_0 \frac{d\varphi}{dt}$

Transient Currents

S.No.	Term	Description
1	**Growth of charge in CR circuit**	$q = q_0(1 - e^{-\frac{t}{CR}})$ and current in CR circuit is $i = i_0 e^{-\frac{t}{CR}}$

2	**Decay of charge in CR circuit**	$q = q_0 e^{-\frac{t}{CR}}$ and current in CR circuit is $i = -i_0 e^{-\frac{t}{CR}}$
3	**Capacitive time constant**	CR has dimensions of time and is called capacitive time constant for circuit
4	**Energy stored in inductor**	$U = \frac{1}{2}(Li^2)$
5	**Energy stored in capacitor**	$U = \frac{1}{2}(CE^2) = \frac{1}{2}(q_0 E)$ Where E is the maximum value of potential difference set up across the plates.
6	**LC oscillations**	Frequency of oscillations is $f = \frac{1}{2\pi\sqrt{LC}}$

Alternating Current

S.No.	Term	Description
1	**Alternating current**	It is current whose magnitude changes with time and direction reverses periodically. $I = I_0 \sin\omega t$ where I_0 is the peak value of a.c. and $\omega = 2\pi/T$ is the frequency
2	**Mean value of a.c.**	$I_m = 2I_0/\pi = 0.636I_0$
3	**RMS value**	$I_{rms} = I_0/\sqrt{2}$
4	**a.c. through resistor**	Alternating emf is in phase with current
5	**a.c. through inductor**	Emf leads the current by an phase angle $\pi/2$
6	**a.c. through capacitor**	Emf lags behind the current by an phase angle $\pi/2$
7	**Inductive reactance**	Opposition offered by inductor to the flow of current mathematically, $X_L = \omega L = 2\pi f L$
8	**Capacitive reactance**	Opposition offered by capacitor to the flow of current mathematically, $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$
9	**a.c. through series LR circuit**	Emf leads the current by an phase angle ϕ given by $\tan\phi = \frac{\omega L}{R}$ and impedance of circuit is $Z = \sqrt{R^2 + (\omega^2 L^2)}$
10	**a.c. through series CR circuit**	Emf lags behind the current by an phase angle ϕ given by $\tan\phi = \frac{1/\omega C}{R}$ and impedance of circuit is $Z = \sqrt{R^2 + \left(\frac{1}{\omega^2 C^2}\right)}$
11	**a.c. through series LCR circuit**	Emf **leads/lags behind** the current by an phase angle ϕ given by $\tan\phi = \frac{\omega L - 1/\omega C}{R}$ emf leads the current when $\omega L > \frac{1}{\omega C}$ and lags behind when $\omega L < \frac{1}{\omega C}$ and impedance of circuit is $Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$
12	**Average power of an a.c. circuit**	$P_{avg} = I_{rms}^2 R = E_{rms} I_{rms} \cos\phi$ Where ϕ is called power factor of the circuit.
13	**Transformer**	It is a device used to change low alternating voltage at high current into high voltage at low current and vice-versa. Primary and secondary voltage for a transformer are related as $V_S = V_P \frac{N_S}{N_P}$ and current through the coils is related as $I_S = I_P \frac{N_P}{N_S}$

Electromagnetic waves

S.No.	Term	Description
1	**Conduction current**	It is the current due to the flow of electrons through the connecting wires in an electric circuit

2	**Displacement current**	It arises due to time rate of change of electric flux in some part of circuit $I_D = \varepsilon_0 \frac{d\varphi}{dt}$	
3	**Modified ampere's circuital law**	$\oint B.dl = \mu_0(I_C + I_D) = \mu_0(I_C + \varepsilon_0 \frac{d\varphi_E}{dt})$ where I_C is the conduction current.	
4	**Maxwell's Equations**	**Gauss's law in electrostatics**	$\oint E \cdot ds = \frac{q}{\varepsilon_0}$
		Gauss's law in magnetism	$\oint B \cdot ds = 0$
		Faraday's law of EM induction	$\oint E \cdot dl = -\frac{d\phi_B}{dt}$
		Ampere-Maxwell's circuital law	$\oint B.dl == \mu_0(I_C + \varepsilon_0 \frac{d\varphi_E}{dt})$
5	**Velocity of EM waves in free space**	$v = \frac{1}{\varepsilon_0 \mu_0} = 3\times10^8 m/s$	

Huygens' Principle and Interference of Light

S.No.	Term	Description
1	**Wave front**	It is the locus of points in the medium which at any instant are vibrating in the same phase.
2	**Huygens' Principle**	1 Each point on the given primary Wavefront acts as a source of secondary wavelets spreading out disturbance in all direction. 2 The tangential plane to these secondary wavelets constitutes the new wave front
3	**Interference**	It is the phenomenon of non uniform distribution of energy in the medium due to superposition of two light waves.
4	**Condition of maximum intensity**	$\phi = 2n\pi$ or x=nλ where n=0,1,2,3,….
6	**Condition of minimum intensity**	$\phi = (2n+1)\pi$ or x=(2n+1)λ/2 where n=0,1,2,3,….
7	**Ratio of maximum and minimum intensity**	$\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2}$
8	**Distance of nth bright fringe from centre of the screen**	$y_n = \frac{nD\lambda}{d}$ where d is the separation distance between two coherent source of light, D is the distance between screen and slit, λ is the wavelength of light used.
9	**Angular position of nth bright fringe**	$\theta_n = \frac{y_n}{D} = \frac{n\lambda}{d}$
10	**Distance of nth dark fringe from centre of the screen**	$y_n' = \frac{(2n+1)D\lambda}{2d}$
11	**Angular position of nth dark fringe**	$\theta_n' = \frac{y_n'}{D} = \frac{(2n+1)\lambda}{2d}$
12	**Fringe width**	$\beta = \frac{D\lambda}{d}$

Diffraction and polarisation of light

S.No.	Term	Description
1	**Diffraction**	It is the phenomenon of bending of light waves round the sharp corners and spreading into the regions of geometrical shadow of the object.
2	**Single slit diffraction**	Condition for dark fringes is $\sin\theta = \frac{n\lambda}{a}$ where n=$\pm 1, \pm 2, \pm 3, \pm 4$……. , a is the width of slit and θ is angle of diffraction. Condition for bright fringes is $\sin\theta = \frac{(2n+1)\lambda}{2a}$
3	**Width of central maximum is**	$\theta_0 = \frac{2\lambda D}{a}$ where D is the distance between slit and screen.
4	**Diffraction**	The arrangement of large number of narrow rectangular slits of equal

	grating	width placed side by side parallel to each other. the condition for maxima in the interference pattern at the angle θ is ***d*sin θ=nλ** where n=0,1,2,3,4………
6	**resolving power of the grating**	For two nearly equal wavelengths λ_1 and λ_2 between which a diffraction grating can just barely distinguish resolving power is $R=\frac{\lambda}{\lambda_2-\lambda_1}=\frac{\lambda}{\Delta\lambda}$ where $\lambda=(\lambda_1+\lambda_2)/2$
7	**Diffraction of X-Rays by crystals**	the condition for constructive interference is **2*d*sin θ=nλ** where n=1,2,3,4………
8	**Polarisation**	It is the phenomenon due to which vibrations of light are restricted in a particular plane.
9	**Brewster's law**	$\mu=\tan p$ where μ is refractive index of medium and p is angle of polarisation.
10	**Law of Malus**	$I=I_0\cos^2\theta$ where I is the intensity of emergent light from analyser, I_0 is the intensity of incident plane polarised light and θ is the angle between planes of transmission of analyser and the polarizer.

Reflection and Refraction of light

S.No.	Term	Description	
1	**Laws of reflection**	1.	The incident ray, the normal at a point of incidence and reflected ray all lie on the same plane.
		2.	Angle of incidence is always equal to angle of reflection.
2	**Relation between f and R**	f=R/2 both f and R are positive for concave mirror and negative for convex mirror.	
3	**Mirror formula**	$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$	
4	**Magnification**	$m=\frac{I}{O}=\frac{f-v}{f}$	
5	**Refraction**	The phenomenon of change in path of light as it goes from one medium to another	
6	**Laws of refraction**	1	The incident ray, the normal at a point of incidence and refracted ray all lie on the same plane.
		2	The ratio of sine of angle of incidence to the sine of angle of refraction is constant for any two given media. This is known as Snell's law. Mathematically $\frac{\sin i}{\sin r}=\mu_b^a$ where μ_b^a is relative refractive index of medium b w.r.t. medium a.
7	**Lateral shift**	$d=\frac{t\sin(i-r)}{\cos r}$	
8	**Spherical refracting surface**	$-\frac{\mu_1}{u}+\frac{\mu_2}{v}=\frac{\mu_2-\mu_1}{R}$ for object situated in rarer medium $-\frac{\mu_2}{u}+\frac{\mu_1}{v}=\frac{\mu_1-\mu_2}{R}$ for object situated in denser medium	
9	**Power of spherical refracting surface**	$P=\frac{\mu_2-\mu_1}{R}$	
10	**Lens maker's formula**	$\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ focal length of convex lens is positive and that of concave lens is negative	
11	**Lens equation**	$-\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$	
12	**Linear magnification**	$m=\frac{I}{O}=\frac{f-v}{f}$	
13	**Power of lens**	$P=\frac{1}{f}=(\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$	
14	**For thin lenses placed in contact**	Focal length	$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$

		Power of equivalent lens	$P=P_1+P_2$
		Magnification of equivalent lens	$m=m_1+m_2$
15	**Spherical aberration**	The inability of lenses of aperture to bring all the rays in wide beam of light falling on it to focus a single point is called spherical aberration.	

Dual nature of waves and matter

S.No.	Term	Description
1	**Energy of a photon**	$\varepsilon = h\nu$ where h is the plank's constant.
2	**Photoelectric effect**	$h\nu = KE_{max} + \phi$ where $\phi = h\nu_0$ is the work function of a metal and ν_0 is the critical frequency for that metal.
3	**Compton effect**	$\lambda' - \lambda = \lambda_C(1-\cos\phi)$ where $\lambda_c=h/m_0c$ is Compton wavelength
4	**De Brogli wavelength**	$\lambda = \frac{h}{mv}$
5	**De Brogli phase velocity**	$v_P = \nu\lambda = \frac{c^2}{v}$
6	**Wave formula**	$y = A\cos 2\pi\left(\nu t - \frac{x}{\lambda}\right)$ or $y = A\cos(\omega t - kx)$ where $\omega = 2\pi\nu$ is angular frequency and $k = \frac{2\pi}{\lambda} = \frac{\omega}{v_P}$ is the wave number.
7	**Phase velocity**	$v_P = \frac{\omega}{k}$
8	**Group velocity**	$v_g = \frac{d\omega}{dk}$
9	**Uncertainty principle**	It is impossible to know both the exact position and exact momentum of an object at same time. Mathematically , $\Delta x\Delta p \geq \frac{h}{4\pi}$
10	**Uncertainty in energy and time**	$\Delta E\Delta t \geq \frac{h}{4\pi}$

Atomic structure

S.No.	Term	Description	
1	**Velocity of electron in an orbit**	$v = \frac{e}{\sqrt{4\pi\varepsilon_0 mr}}$ where r is the orbit radius	
2	**Total energy of hydrogen atom**	$E = -\frac{e^2}{8\pi\varepsilon_0 r}$	
3	**Atomic spectra**	Lyman	$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$ where R is Rydberg constant
		Balmer	$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$ $R=1.097\times10^{-7}m^{-1}$
		Paschen	$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right)$
		Brackett	$\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n^2}\right)$
		Pfund	$\frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{n^2}\right)$

4	**Orbital electron wavelength according to Bohr atom model**	$\lambda = \frac{h}{e}\sqrt{\frac{4\pi\varepsilon_0 r}{m}}$
5	**Condition for orbital stability**	$n\lambda=2\pi r_n$ where n=1,2,3…. And r_n is radius of orbit that contains n wavelengths.
6	**Orbital radii in Bohr atom**	$r_n = \frac{n^2 h^2 \varepsilon_0}{\pi m e^2}$

Atomic nucleus and nuclear energy

S.No.	Term	Description
1	**Isotopes**	Nuclei having same atomic number but different mass number.
2	**Isobars**	Nuclei having different atomic number but same mass number.
3	**Atomic mass unit**	One atomic mass unit is defined as one twelfth part of the mass of $^{12}C_6$ atom. Value of a mass unit is $1u=1.66054 \times 10^{-27}$Kg=931 MeV
4	**Nuclear radius**	$R=R_0A^{1/3}$ Where value of $R_0 \cong 1.2 \times 10^{-15} \cong 1.2$ fm and is known as nuclear radius parameter
5	**Nuclear density**	The density of nuclear matter is approximately of the order of 10^{17} Kg/m^3 and is very large compared to the density of ordinary matter.
6	**Nuclear forces**	It is the force which holds the nucleons together inside the nucleus.
7	**Mass defect**	$\Delta m = [Zm_p + (A-Z)m_n] - m$
8	**Binding energy**	$BE = \Delta mc^2 = [[Zm_p + (A-Z)m_n] - m]c^2$
9	**Binding energy per nucleon**	=BE/A
10	**Radioactive decay law**	$N = N_0 e^{-\lambda t}$
11	**Half life**	$T=\ln 2/\lambda$
12	**Average life**	$T_{av}=1/\lambda$