Chapter 1
Physical World

1.Classical physics deals with ---------------(microscopic/macroscopic) domain. Macroscopic

2.The -----------------domain includes atomic ,molecular and nuclear phenomena. Microscopic

3.Modern physics uses -------------- theory to explain microscopic domain Quantum theory

4..Branches of Physics that comes under classical physics
Mechanics, Electrodynamics, Optics, Thermodynamics

5.The branch of physics which deals with motion of particles,rigid and deformable bodies,propagation of water waves or sound waves is called --------------- Mechanics

6.The branch of physics which deals with Electric and magnetic phenomena associated with charged and magnetic bodies is called ------------- Electrodynamics

7. Name the branch of physics which deals with the phenomena involving light . Optics

8. Name the branch of physics which deals with changes in internal energy,temperatur,etc.,of the system through external work and transfer of heat.
Thermodynamics

9. The weakest force in nature.
Gravitational force

10. The strongest force in mature.
Nuclear force (Strong nuclear force)

Chapter 2
Units and Measurement

1.Name the fundamental(base) quantities and units according to SI system.

BASE QUANTITY	BASE UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Thermodynamic Temperature	kelvin	K
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

SUPPLEMENTARY QUANTITY	SUPPLEMENTARY UNITS	SYMBOL
Plane Angle	radian	rad
Solid Angle	steradian	sr

Write the dimensional formulae of following derived quantities.

Area -L^2
Volume -L^3
Density -ML^{-3}
Velocity- LT^{-1}
Acceleration - LT^{-2}
Momentum - MLT^{-1}
Force - MLT^{-2}
Work or energy - ML^2T^{-2}
Power- ML^2T^{-3}

2.Name and state the principle used to check the correctness of an equation.

The principle called the principle of homogeneity of dimensions is used to check the dimensional correctness of an equation.

The principle of homogeneity states that, for an equation to be correct, the dimesions of each terms on both sides of the equation must be the same.

Or

The magnitudes of physical quantities may be added or subtracted only if they have the same dimensions.

3. Using the method of dimension check whether the equation is dimensionally correct or not

$$s = ut + \frac{1}{2}at$$

s= displacement
u =initial velocity
a=acceleration
t=time

$$[s] = L$$
$$[ut] = LT^{-1} \times T = L$$
$$[\tfrac{1}{2}at] = LT^{-2} \times T = LT^{-1}$$

Since the dimensions of all terms of the equation are not same, this equation is wrong.

4. Using the method of dimension check whether the equation is dimensionally correct or not

$$s = ut + \frac{1}{2}at^2$$

s= displacement
u =initial velocity
a=acceleration
t=time

$$[s] = L$$
$$[ut] = LT^{-1} \times T = L$$
$$[\tfrac{1}{2}at^2] = LT^{-2} \times T^2 = L$$

Since each term on both sides of equation has the same dimension, this equation is dimensionally correct

5. Using the method of dimension check whether the equation is dimensionally correct or not

$$\frac{1}{2}mv^2 = mgh$$

$$[\tfrac{1}{2}mv^2] = M\,[LT^{-1}]^2$$
$$= ML^2T^{-2}$$

$$[mgh] = M\;LT^{-2}\;L$$
$$= ML^2T^{-2}$$

m=mas of th body
v= velocity of body
g=acceleration due to gravity
h=height

The dimensions of LHS and RHS are the same and hence the equation is dimensionally correct.

6.Check the dimensional correctness of the equation $E=mc^2$

$$[E]= ML^2T^{-2}$$

$$[m\,c^2] = M\,[LT^{-1}]^2$$
$$= ML^2T^{-2}$$

E=energy
m=mass
c=velocity of light

The dimensions of LHS and RHS are the same and hence the equation is dimensionally correct.

7.In the given equation $v = x + at$, find the dimensions of x.

(where v= velocity , a=acceleration , t=time)

$v=x+at$

$[v] = [x] = [at]$

$[x]=[v]$

$[x]=LT^{-1}$

8. In the given equatio $x= a + bt + ct^2$, find the dimensions of a,b and c.

(where x is in meters and t in seconds)

$x=a+bt+ct^2$

$[x]=[a] = [bt] = [ct^2]$

$[a]=[x]$

$[a]=L$

$[bt] = [x]$

$[b] \times T = L$

$[b] = \frac{L}{T}$

$[b] = LT^{-1}$

$[ct^2] = [x]$

$[c] \times T^2 = L$

$[c] = \frac{L}{T^2}$

$[c] = LT^{-2}$

9.The Van der waals equation of 'n' moles of a real gas is $(P+\frac{a}{V^2})(V-b)=nRT$. Where P is the pressure, V is the volume, T is absolute temperature, R is molar gas constant and a, b, c are Van der waal constants. Find the dimensional formula for a and b.

$$(P+\frac{a}{V^2})(V-b)=nRT.$$

By principle of homegeneity, the quantities with same dimensions can be added or subtracted.

$$[P]=[\frac{a}{V^2}]$$

$$[a]=[PV^2]$$

$$=ML^{-1}T^{-2}\ x\ L^6$$

$$[a]=ML^5T^{-2}$$

$$[b]=[V]$$

$$[b]=L^3$$

10.Derive the equation for kinetic energy E of a body of mass m moving with velocity v

$$E\alpha\ m^x\ v^y$$

$$E=k\,m^x v^y \longrightarrow (1)$$

Writing the dimensions on both sides,

$$M\,L^2\,T^{-2}=M^x\,(LT^{-1})^y$$

$$M^1L^2\,T^{-2}=M^x\,L^y\,T^{-y}$$

equating the dimensions on both sides,

$$x=1$$
$$y=2$$

Substituting in eq (1)

$$E=k\,m^1\,v^2$$

$$\boxed{E=k\,mv^2}$$

2) Suppose that the period of oscillation of the simple pendulum depends on its mass of the bob (m), length (l) and acceleration due to gravity (g). Derive the expression for its time period using method of dimensions.

$$T \propto m^x \; l^y \; g^z$$

$$T = k\, m^x\, l^y\, g^z \longrightarrow (1)$$

Writing the dimensions on both sides,

$$M^0L^0T^1 = M^x\; L^y\; (LT^{-2})^z$$

$$M^0L^0T^1 = M^x\; L^y\; L^z\; T^{-2z}$$

$$M^0L^0T^1 = M^x\; L^{y+z}\; T^{-2z}$$

equating the dimensions on both sides,

$$x = 0$$

$$y + z = 0$$

$$-2z = 1 \qquad z = \frac{-1}{2}$$

$$y + \frac{-1}{2} = 0 \qquad y = \frac{1}{2}$$

$$\boxed{T = k m^0\, l^{1/2} g^{-1/2}}$$

$$T = k\frac{l^{1/2}}{g^{1/2}}$$

10.Write any two limitations of dimensional analysis.

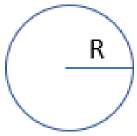
1) Dimensional analysis check only the dimensional correctness of an equation, but not the exact correctness.
2) The dimensionless constants cannot be obtained by this method.
3) We cannot deduce a relation, if a physical quantity depends on more than three physical quantities.
4) The method cannot be considered to derive equations involving more than one term
5) A formula containing trigonometric, exponential and logarithmic function can not be derived from it.
6) It does not distinguish between the physical quantities having same dimensions.

Chapter 3
Motion in a Straight Line

1. Write the differences betwee path length(distance) and displacement

1. Distance is a scalar, while displacement is a vector.
2. For a moving particle distance can never be zero or negative while displacement can be zero, positive or negative.
3. For a moving particle, distance can never decrease with time while displacement can. Decrease in displacement with time means that the body is moving towards the initial position.
4. Distance is always greater than or equal to displacement.

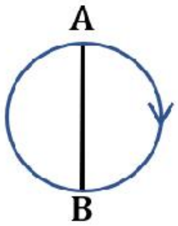
2. A body completes one full rotation in a circular path of radius R. Write the values of its
   (a) Distance travelled
   (b) Displacement



(a) $2\pi R$

(b) Zero

3.A body moving along a circular path of radius 10 m as shown below. If it travels from A to B ,find the distance and displacement of the body.



Distance $= \frac{2\pi R}{2} = \pi R = 3.14 \times 10 = 31.4$ m

Dispalcement =Diameter $= 2R = 2 \times 10 = 20$m

4. Define average velocity

Average velocity is defined as the total displacement divided by the total time interval during which the motion takes place.

$$\text{Average velocity} = \frac{\text{Displacement}}{\text{Total time interval}}$$

$$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

5. Define average speed

Average speed is defined as the total path length travelled divided by the total time interval during which the motion has taken place .

$$\text{Average speed} = \frac{\text{Total path length}}{\text{Total time interval}}$$

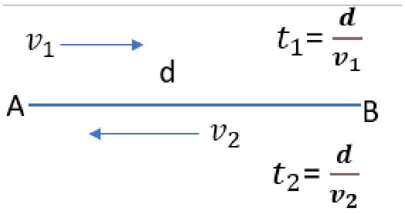
6.Write the difference between Average Speed and Velocity

1. Average speed is a scalar, while average velocity is a vector quantity.
2. For a moving body, speed can never be zero or negative while velocity can be zero, positive or negative.
3. Speed is always greater than or equal to velocity.

7.A car travels from A to B at 60km/hr and returns to A at 90km/hr . What is the average velocity and average speed?

Average velocity $=\frac{\Delta x}{\Delta t}=0$ (since $\Delta x = o$)

Average speed $=\frac{Total\ path\ length}{Total\ time\ interval}$



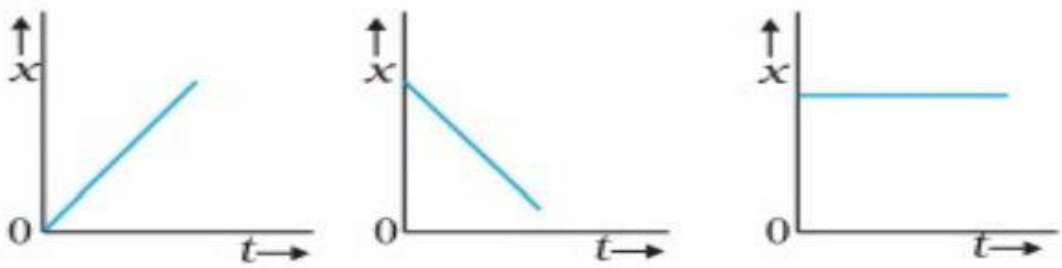
$$= \frac{2d}{\frac{d}{v_1}+\frac{d}{v_2}} = \frac{2v_1v_2}{v_1+v_2}$$

$$= \frac{2\text{x } 60 \text{ x } 90}{60+90} = 72 \text{ km/hr}$$

$$= 72 \text{ x}\frac{5}{18} = 20\text{m/s}$$

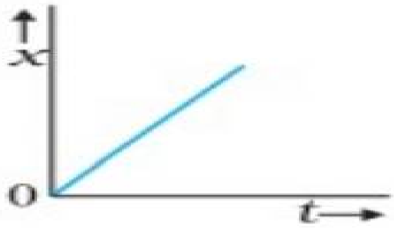
8. Draw the position -time graph of an object moving with

(a) uniform positive velocity (b) uniform negative velocity (c) at rest.



9. The position -time graph of an object in uniform motion is------------

Ans: A straight line inclined to the time axis

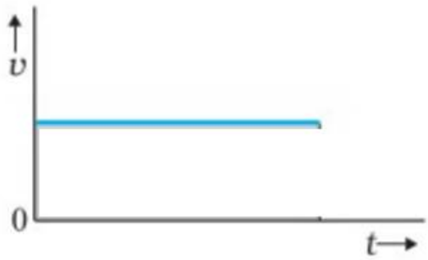


10. The slope of position-time graph gives ------------

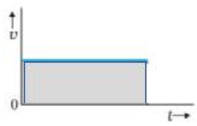
Ans: Velocity

11. The velocity -time graph of an object in uniform motion is------------

Ans: A straight line parallel to the time axis



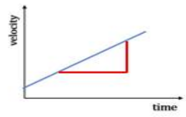
12. The area under velocity -time graph gives ----------- --



Displacement

13. The slope of velocity-time graph gives --------------

Acceleration



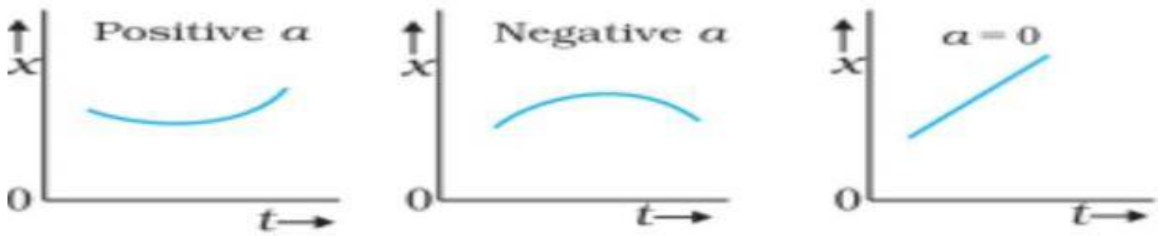
14. Define average accelaration

The average acceleration over a time interval is defined as the ratio of change in velocity to the time interval.

$$\vec{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

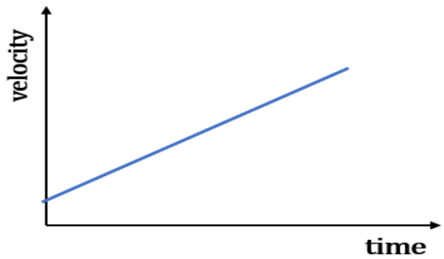
15.Draw the position- time graph of an object moving with

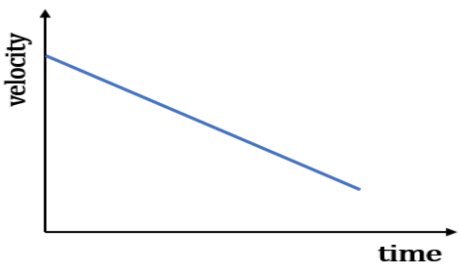
(a) positive acceleration (b) negative acceleration c)zero acceleration.



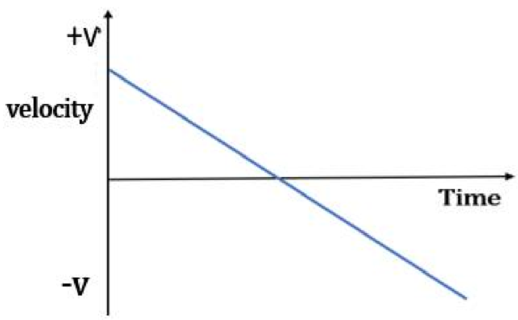
16. Draw the velocity- time graph of an object moving with

(a) uniform positive acceleration (b) uniform negative acceleration

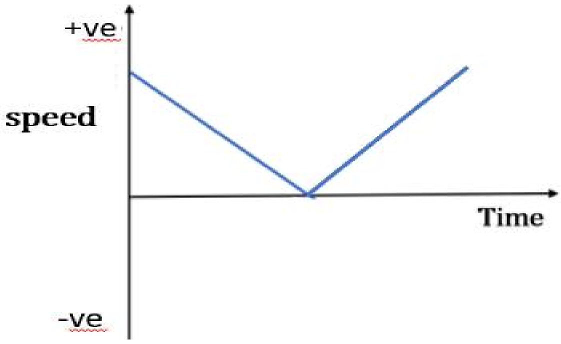




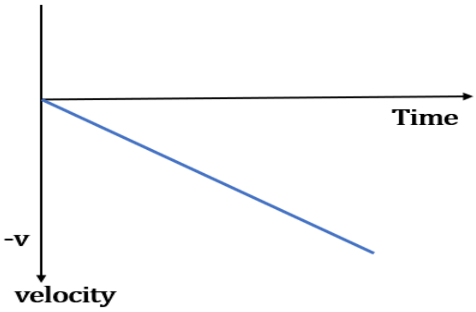
17. Draw the velocity- time graph of a stone thown vertiaccly upwrds and comes back.



18. Draw the speed- time graph of a stone thown vertiaccly upwrds and comes back.



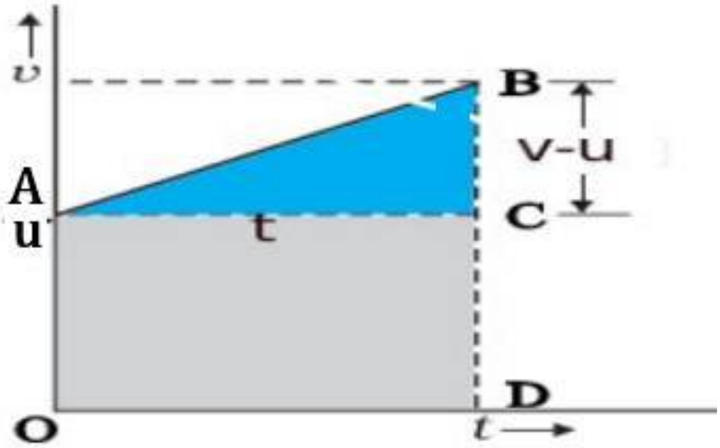
19. Draw the velocity-time graph of a freely falling body.(A stone vertically falling downwards)



20. Is it possible for a body to have zero velocity with a nonzero acceleration. Give an example.

Yes. When a body is thrown upwards ,at the highest point of projection, its velocity is zero , but it has an acceleration.

21. (a)Draw the velocity-time graph of a body with uniform aceeleration .
(b) Using the graph obtain
(i) Velocity - time relation
(ii) Displacement -tme relation
(iii) Displacement velocity relation



(1) Velocity – time relation

From the graph ,

$$\text{acceleration} = \text{slope}$$

$$a = \frac{BC}{AC}$$

$$a = \frac{v - u}{t}$$

$$v - u = at$$

$$v = u + at \text{ ------------------- } (1)$$

(2) Position-time relation

$$\text{Displacement} = \text{Area under the graph}$$

$$S = \text{Area of } \square + \text{Area of } \triangle$$

$$S = ut + \tfrac{1}{2}(v-u)\,t$$

But from equation (1) $v - u = at$

$$S = ut + \tfrac{1}{2}\,at \times t$$

$$S = ut + \tfrac{1}{2}at^2 \text{ ----------------- } (2)$$

(3)Position – velocity relation

$$\text{Displacement} = \text{Average velocity} \times \text{time}$$

$$\text{Average velocity} = \frac{v + u}{2}$$

From equation (1) , $v - u = at$

$$t = \frac{v - u}{a}$$

Substituting the values,

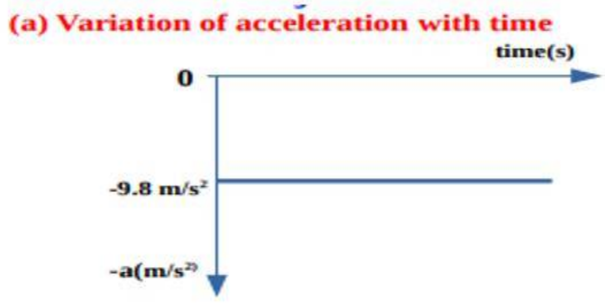
$$S = \left(\frac{v + u}{2}\right)\left(\frac{v - u}{a}\right)$$

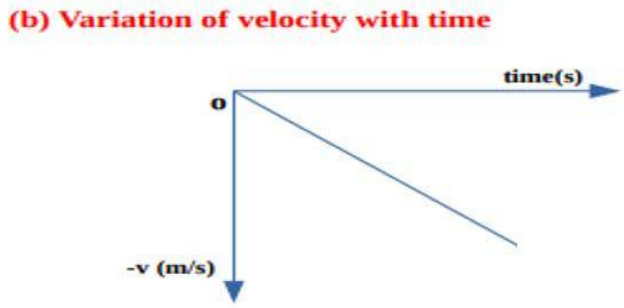
$$S = \frac{v^2 - u^2}{2a}$$

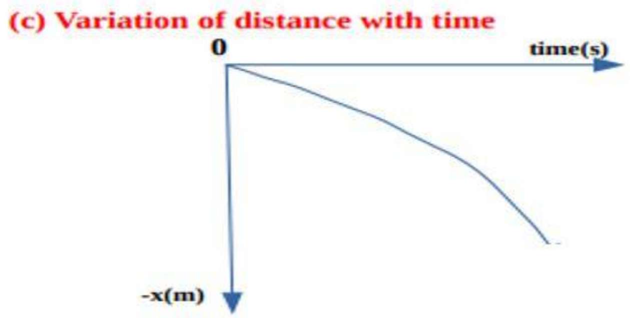
$$v^2 - u^2 = 2as$$

$$v^2 = u^2 + 2as \text{ ---------------- } (3)$$

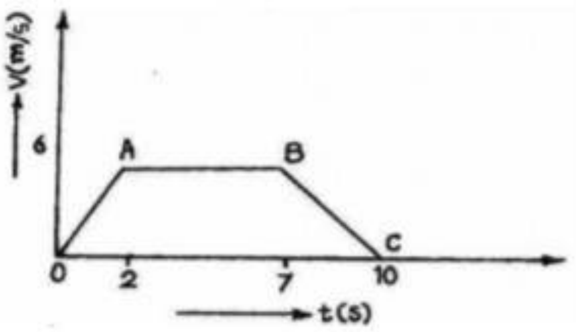
22 .An object is under freefall. Draw its (a) Acceleration -time graph
(b) Velocity- time graph
(c) Displacement-time graph







23.Velocity – time graph of a body is given below



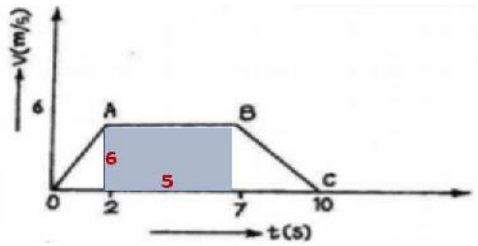
a) Which portion of the graph represents uniform retardation?
(i) OA (ii)AB (iii) BC (iv) OC

b) Find the displacement in time 2s to 7s.

c) A stone is dropped from a height h. Arrive at an expression for the time taken to reach the ground.

a) BC

b)



Displacement = area of rectangle

$= 6 \times 5 = 30m$

c) $s = ut + \frac{1}{2}at^2$

$-h = 0 - \frac{1}{2}gt^2$

$t^2 = \frac{2h}{g}$

$t = \sqrt{\frac{2h}{g}}$

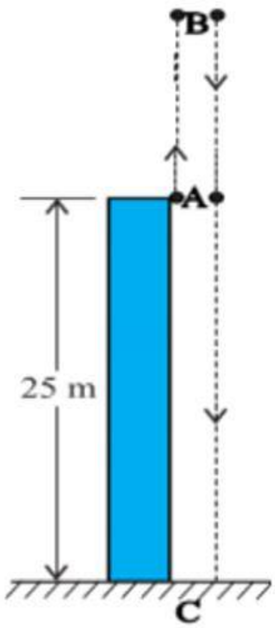
17

A ball is thrown vertically upwards with a velocity of 20 m /s from the top of a multistorey building. The height of the point from where the ball is thrown is 25.0 m from the ground.

(a) How high will the ball rise ? And

(b) how long will it be before the ball hits the ground?

Take g = 10 m/ s



a) $u = 20$ m/s

$v = 0$

$a = -10 m/s^2$

$v^2 - u^2 = 2as$

$0 - 20^2 = 2 \times -10 \times s$

$-400 = -20 s$

$s = -400/-20 = 20$ m

Total height = 20+ 25 = 45 m

(b) Total time = time fro upward motion + time for downward motion

For upward motion ,

$v = 0$

$u = 20$ m/s

$a = -10 m/s^2$

$v = u + at$

$0 = 20 + -10t$

$10 t = 20$ $t = 20/10 = 2$ s

For downward motion,

$u = 0$

$s = -45m$

$a = -10m/s^2$

$s = ut + ½ at^2$

$-45 = 0 - ½ \times 10 \times t^2$

$-45 = -5 t^2$ $t^2 = 9$, $t = 3$ s

Total time = 2 + 3 = 5s

Chapter 4
Motion in a Plane

1. Differentiate scalar and vector quantities

A scalar quantity has only magnitude and no direction.

Eg. distance , speed, mass , temperature, time ,work ,power, energy, pressure, frequency, angular frequency etc.

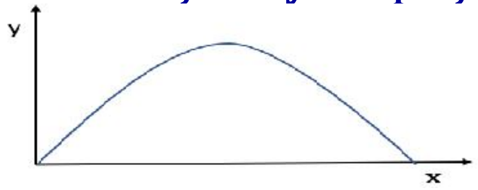
A vector quantity has both magnitude and direction and obeys the triangle law of addition or the parallelogram law of addition.

Eg. displacement, velocity, acceleration , momentum, force, angular velocity, torque, angular momentum etc.

2.What is the trajectory(path) followed by a projectile?

Parabola

3. Draw the trajectory of a projectile



4. A stone is thrown up with a velocity u , which makes an angle θ with the horizontal.

a) What are the magnitudes of horizontal and vertical components of velocity?

b) How do these components vary with time?

a) Horizontal component- $u \cos\theta$ and
vertical component - $u \sin\theta$

b) Horizontal component- $u \cos\theta$ remains constant with time.
vertical component first deceases, becomes zero at the highest point of projection and then increases in reverse direction.

5.What are the values of these components at the highest point of projection?

At the highest point,

Horizontal component= $u \cos\theta$

Vertical component = zero

6. A projectile has an acceleration of 9.8m s^{-2} in vertical direction and no acceleration in horizontal direction

7) Show that the path of the projectile is a parabola .

Displacement of the projectile after a time t

$$x = u\cos\theta\, t$$

$$t = \frac{x}{u\cos\theta}$$

$$y = u \sin\theta\, t - \frac{1}{2} g\, t^2$$

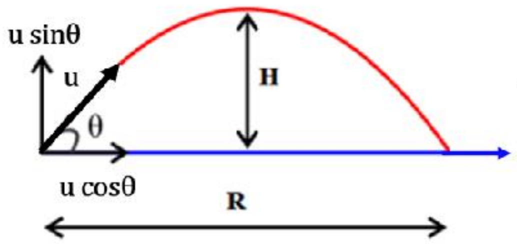
$$y = u \sin\theta \left(\frac{x}{u\cos\theta}\right) - \frac{1}{2} g \left(\frac{x}{u\cos\theta}\right)^2$$

$$y = \tan\theta\, x - \frac{g}{2\, u^2 \cos^2\theta}\, x^2$$

This equation is of the form $y = a\,x + b\,x^2$ in which a and b are constants. This is the equation of a parabola,

i. e. **the path of the projectile is a parabola**.

8. Derive the equation for Time of flight, Horizontal range and Maximum height of a projectile.



Time of Flight of a projectile (T)

Consider the motion in vertical direction,

$$s = ut + \frac{1}{2}at^2$$

$s=0, \quad u = u \sin\theta, \quad a = -g, \quad t = T$

$$0 = u \sin\theta\, T - \frac{1}{2}gT^2$$

$$\frac{1}{2}gT^2 = u \sin\theta\, T$$

$$T = \frac{2u \sin\theta}{g}$$

Horizontal range of a projectile (R)

Horizontal range = Horizontal component of velocity x Time of flight

$$R = u\cos\theta \times \frac{2u\sin\theta}{g}$$

$$R = \frac{u^2 \times 2\sin\theta\cos\theta}{g}$$

g

$$R = \frac{u^2 \sin 2\theta}{g}$$

Maximum height of a projectile (H)

It is the maximum height reached by the projectile.

Consider the motion in vertical direction to the highest point

$$v^2 - u^2 = 2as$$

$u = u\sin\theta, \quad v = 0, \quad a = -g, \quad s = H$

$$0 - u^2\sin^2\theta = -2gH$$

$$H = \frac{u^2\sin^2\theta}{2g}$$

9. What is the angle of projection for maximum horizontal range

45^0

10. What is the maximum value of horizontal range

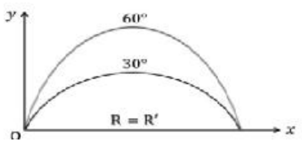
Range is maximum when $\theta = 45^0$

$$R = \frac{u^2 \sin 90}{g}$$

$$R_{max} = \frac{u^2}{g}$$

11. Find the angle of projection for which the range will be same as that in case of $\theta = 30^0$ for a given velocity of projection.

For a given velocity of projection range will be same for angles $\boldsymbol{\theta}$ and (90-$\boldsymbol{\theta}$)



Here $\theta = 30^0$

$90 - \boldsymbol{\theta} = 90 - 30 = 60^0$

The range will be same for 30^0 and 60^0 ,for a given velocity of projection.

12.A cricket ball is thrown at a speed of 28 m s $^{-1}$ in a direction 30° above the horizontal. Calculate (a) the maximum height, (b) the time taken by the ball to return to the same level, and (c) the distance from the thrower to the point where the ball returns to the same level.

(a) $H = \frac{u^2 \sin^2\theta}{2g}$

$H = \frac{28^2 \sin^2 30}{2 \times 9.8}$

$H = 10$ m

(b) $T = \frac{2 u \sin\theta}{g}$

$T = \frac{2 \times 28 \sin 30}{9.8}$

$T = 2.9$ s

(c) $R = \frac{u^2 \sin 2\theta}{g}$

$R = \frac{28^2 \sin 60}{9.8}$

$R = 69$ m

Chapter 5
Laws of Motion

1.Define momentum

Momentum, P of a body is defined to be the product of its mass m and velocity v, and is denoted by p.

$$p = m\,v$$

2.State Newton's Second Law f Motion. Write its mathematical expression.

The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts.

$$\mathbf{F} \propto \frac{\Delta \mathbf{p}}{\Delta t}$$

$$\text{or} \quad F = \frac{dp}{dt}$$

3.Why a seasoned cricketer draws his hands backwards during a catch?

By Newton's second law of motion ,

$$F = \frac{dp}{dt}$$

When he draws his hands backwards, the time interval (dt) to stop the ball increases . Then force decreases and it does not hurt his hands.

4. Derive of Equation of force from Newton's second law of motion

By Newton's second law of motion ,

$$F = \frac{dp}{dt}$$

For a body of fixed mass m, p=mv

$$F = \frac{d}{dt}mv$$

$$F = m\frac{dv}{dt}$$

$$F = ma$$

5.Define newton

$$F = m\,a$$

If $m = 1$ kg , $a = 1\,m\,s^{-2}$

$$F = 1kg \times 1\,ms^{-2}$$
$$F = 1N$$

One newton is that force which causes an acceleration of $1 m\,s^{-2}$ to a mass of 1 kg.

6. A bullet of mass 0.04 kg moving with a speed of 90 m/s enters a heavy wooden block and is stopped after a distance of 60 cm. What is the average resistive force exerted by the block on the bullet?

m=0.04 kg
u=90 m/s
v=0
s=60cm=0.6 m

The retardation 'a' of the bullet is assumed to be constant.

$$v^2 - u^2 = 2as$$

$$0 - 90^2 = 2 \times a \times 0.6$$

$$a = \frac{-90^2}{2 \times 0.6}$$

$$a = -6750 \text{ m}/s^2$$

The retarding force, F= ma

$$F = 0.04 \times -6750$$

$$F = -270 \text{ N}$$

The negative sign shows that the force is resistive or retarding.

7.Define Impulse

Impulse is the the product of force and time duration, which is the change in momentum of the body.

$$\text{Impulse} = \text{Force} \times \text{time duration}$$

$$I = F \times t$$

$$\text{Unit} = \text{kg m s}^{-1}$$

8. Define Impulsive force.

A large force acting for a short time to produce a finite change in momentum is called an impulsive force.

Eg: A cricket ball hitting a bat

9. Using Newtons second law of motion arrive at Impulse momentum Principle

Impulse is equal to the change in momentum of the body.

By Newton's second law of motion,

$$F = \frac{dp}{dt}$$

$$F \times dt = dp$$

$$I = dp$$

$$\text{Impulse} = \text{change in momentum}$$

10.A batsman hits back a ball straight in the direction of the bowler without changing its initial speed of 12 m s^{-1}. If the mass of the ball is 0.15 kg, determine the impulse imparted to the ball.

$$\text{Impulse} = \text{change of momentum}$$

$$\text{Change in momentum} = \text{final momentum} - \text{initial momentum}$$

$$\text{Change in momentum} = 0.15 \times 12 - (0.15 \times -12)$$

$$\text{Impulse} = 3.6 \text{ N s}$$

11.State the Law of Conservation of Momentum

The total momentum of an isolated system of interacting particles is conserved.

Or

When there is no external force acting on a system of particles ,their total momentum remains constant.

12.Proof of law of conservation of momentum Using Newton's second law of motion

By Newton's second law of motion , $F=\frac{dp}{dt}$

When F = 0

$$\frac{dp}{dt} = 0$$

$$dp = 0\,,$$

p=constant

Thus when there is no external force acting on a system of particles, their total momentum remains constant.

13.Explain the recoil of gun using law of conservation of linear momentum

By the law of conservation of momentum,
as the system is isolated,

$$\mathbf{P = constant}$$

Initial momentum = Final momentum

Initial momentum of gun+ bullet system = 0

Final momentum of gun+ bullet system = 0

If p_b and p_g are the momenta of the bullet and gun after firing

$$p_b + p_g = 0$$

$$p_b = -\,p_g$$

The negative sign shows that gun recoils to conserve momentum.

13.Obtain the expression for Recoil velocity and muzzle velocity

Momentum of bullet after firing , $p_b = mv$

Recoil momentum of the gun after firing , $p_g = MV$

$$p_b = - p_g$$

$$mv = -MV$$

Recoil velocity of gun , $V = \frac{-mv}{M}$

Muzzle velocity of bullet , $v = \frac{-MV}{m}$

M= mass of gun, V= recoil velocity of bullet

m= mass of bullet, v=muzzle velocity of bullet

A shell of mass 0.020kg is fired by a gun of mass 100kg. If the muzzle speed of the shell is 80 m/s, what is the recoil speed of the gun?

$$V = \frac{mv}{M} = \frac{0.020 \times 80}{100} = 0.016 m/s$$

14. Explain the collision of two bodies using law of conservation of momentum

F_{AB} changes the momentum of body A

$$F_{AB}\,\Delta t = p'_A - p_A \text{-----------------(1)}$$

F_{BA} changes the momentum of body B

$$F_{BA}\,\Delta t = p'_B - p_B \text{-----------(2)}$$

By Newton's third law

$$F_{AB} = -F_{BA} \qquad \text{-----------(3)}$$

$$p'_A - p_A = -(p'_B - p_B)$$

$$p'_A + p'_B = p_A + p_B$$

Total Final momentum = Total initial momentum

i.e. , the total final momentum of the isolated system equals its total initial momentum.

15. The maximun value of limiting friction is called ....

Limiting friction or Limiting static friction.

16.State the law of static friction

The law of static friction may thus be written as , $f_s \leq \mu_s N$

Or

$$(f_s)_{max} = \mu_s N$$

where μ_s the **coefficient of static friction,**

17.State the Law of Kinetic Friction

$$\mathbf{f_k = \mu_k N}$$

where μ_k the **coefficient of kinetic friction,**

18.Write the characteristics of static friction

- The maximum value of static friction is $(f_s)_{max}$
- The limiting value of static friction $(f_s)_{max}$, is independent of the area of contact.
- The limiting value of static friction $(f_s)_{max}$, varies with the normal force(N)

$$(f_s)_{max} \; \alpha N$$

$$\mathbf{(f_s)_{max} = \mu_s N}$$

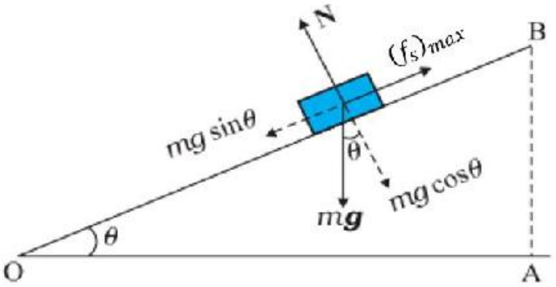
19.Write the characteristics of kinetic friction

- Kinetic friction is independent of the area of contact.
- Kinetic friction is independent of the velocity of sliding.
- Kinetic friction , f_k varies with the normal force(N)

$$f_k \; \alpha N$$

$$\mathbf{f_k = \mu_k N}$$

20.Show that $\mu_s = \tan\theta$ (the coefficient of static friction is equal to the tangent of angle of friction) when a body just begins to slide on an inclined surface



The forces acting on a block of mass m When it just begins to slide are

(i) the weight, mg

(ii) the normal force, N

(iii) the maximum static frictional force $(f_s)_{max}$

In equilibrium, the resultant of these forces must be zero.

$$m\,g\sin\theta = (f_s)_{max}$$

But $(f_s)_{max} = \mu_s N$

$$mg\sin\theta = \mu_s N \text{------------}(1)$$

$$mg\cos\theta = N \text{-------------}(2)$$

$$\text{Eqn}\frac{(1)}{(2)} \text{ --------- } \frac{\text{mg}\sin\theta}{\text{m g}\cos\theta} = \frac{\mu_s \text{N}}{\text{N}}$$

$$\mu_s = \tan\theta$$

21.Disadvantages of friction

In a machine with different moving parts, friction opposes relative motion and thereby dissipates power in the form of heat, etc.

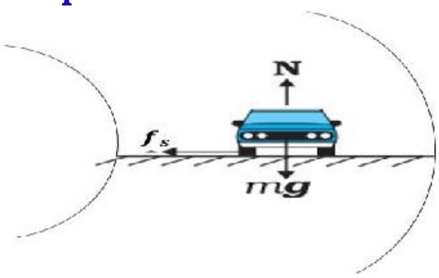
22.Advantages of friction

Kinetic friction is made use of by brakes in machines and automobiles.
We are able to walk because of static friction.
The friction between the tyres and the road provides the necessary external force to accelerate the car.

23.Methods to reduce friction

(1)Lubricants are a way of reducing kinetic friction in a machine.
(2)Another way is to use ball bearings between two moving parts of a machine.
(3) A thin cushion of air maintained between solid surfaces in relative motion is another effective way of reducing friction.

24.Derive the expression for maximum safe speed on a curved level road



Three forces act on the car.

(i) The weight of the car, mg
(ii) Normal reaction, N
(iii) Frictional force, f_s

As there is no acceleration in the vertical direction

$$N = mg$$

The static friction provides the centripetal acceleration

$$f_s = \frac{mv^2}{R}$$

$$\text{But},\ f_s \le \mu_s N$$

$$\frac{mv^2}{R} \le \mu_s mg \quad (N=mg)$$

$$v^2 \le \mu_s Rg$$

$$v_{max} = \sqrt{\mu_s Rg}$$

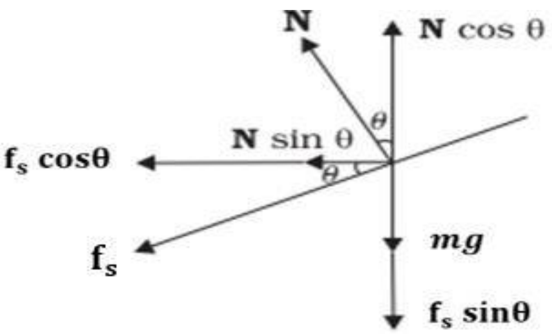
25. a) What do you mean by banking of curved roads?

b) Obtain the expression for maximum permissible speed of a vehicle on a banked road.

c)Write the expression for optimum speed (without considering frictional force)

a)Raising the outer edge of a curved road above the inner edge is called banking of curved roads.

b)



$$N\cos\theta = mg + f_s \sin\theta$$

$$N\cos\theta - f_s\sin\theta = mg \text{ --------------(1)}$$

The centripetal force is provided by the horizontal components of N and f_s.

$$N\sin\theta + f_s\cos\theta = \frac{mv^2}{R} \text{ -------------(2)}$$

$$\frac{Eqn(1)}{Eqn(2)} \text{ -----} \frac{N\cos\theta - f_s\sin\theta}{N\sin\theta + f_s\cos\theta} = \frac{mg}{\frac{mv^2}{R}}$$

Dividing throughout by N cos θ

$$\frac{1 - \frac{f_s}{N}\tan\theta}{\tan\theta + \frac{f_s}{N}} = \frac{Rg}{v^2}$$

But , $f_s = \mu_s N$ for maximum speed

$$\frac{1 - \mu_s\tan\theta}{\tan\theta + \mu_s} = \frac{Rg}{v^2}$$

$$v^2 = \frac{Rg(\mu_s + \tan\theta)}{1 - \mu_s\tan\theta}$$

$$v_{max} = \sqrt{\frac{Rg(\mu_s + \tan\theta)}{1 - \mu_s\tan\theta}}$$

c)If friction is absent, $\mu_s = 0$

Then Optimum speed, $v_{optimum} = \sqrt{Rg\tan\theta}$

26.A circular racetrack of ra dius 300 m is banked at an angle of 15°. If the coefficient of friction between the wheels of a race-car and the road is 0.2, what is the

(a) optimum speed of the race car to avoid wear and tear on its tyres, and

(b) maximum permissible speed to avoid slipping ?

(a)

$r = 300$ m ; $\theta = 15^0$; $\mu_s = 0.2$

So the optimum speed becomes,

$$v_o = \sqrt{rg\tan\theta}$$

$$\therefore v_o = \sqrt{300\times9.8\times\tan 15}$$

$$\therefore v_o = \sqrt{300\times9.8\times0.2679} = 28.1\,m/s$$

(b)

Maximum permissible speed on banked road is,

$$v_{max} = \sqrt{\frac{rg(\tan\theta+\mu_s)}{1-\mu_s\tan\theta}}$$

$$\therefore v_{max} = \sqrt{\frac{300\times9.8\times(\tan 15+0.2)}{(1-0.2\times\tan 15)}}$$

$$v_{max} = \sqrt{\frac{300\times9.8\times(\tan 15+0.2)}{(1-0.2\times\tan 15)}}$$

$$v_{max} = \sqrt{\frac{300\times9.8\times(0.2679+0.2)}{(1-0.2\times0.2679)}} = 38.1\,m/s$$

Chapter 6
Work ,Energy and Power

1.Define work.

The work done by the force is defined to be the product of component of the force in the direction of the displacement and the magnitude of this displacement.

$$\mathbf{W = \vec{F}\cdot\vec{d}}$$

2.Write the situations in which work done by a body is zero

(i) when the displacement is zero .

(ii)when the force is zero.

(iii) the force and displacement are mutually perpendicular

W=Fd cos 90 = 0.

3.Give an example for Positive Work

Workdone by Gravitational force on a freely falling body is positive

4.Give an example of Negative work

The frictional force opposes displacement and $\theta = 180°$.

Then the work done by friction is negative (cos 180 ° = –1).

5. What is the work done by centripetal force on a body moving in circular path

Zero. Here $\theta = 90°$, W =Fd cos 90 = 0.

6. 1 horse power,1HP= -----------Watt. 746W

7. 1 kilowatt-hour, 1kWh = ----------------- J 3.6×10^6 J

8. Kilowatt-hour is the unit of ------------ Energy

Find the workdone by a force $\vec{F} = (3\hat{i} + 4\hat{j} - 5\hat{k})$ N, if the displacement Produced is $\vec{d} = (5\hat{i} + 4\hat{j} + 3\hat{k})$ m.

$$W = \vec{F}.\vec{d}$$

$$W = F_x d_x + F_y d_y + F_z d_z$$

$$= (3 \times 5) + (4 \times 4) + (-5 \times 3)$$

$$W = 16 \text{ J}$$

9. The energy possessed by a body by virtue of its motion is called-----------

Kinetic energy

10. The energy stored by virtue of the position or configuration of a body(state of strain) is called------------- Potential Energy.

11. Calculate the work done in lifting a body of mass 10kg to a height of 10m above the ground

$$W = F \times d = mg \times h = 10 \times 9.8 \times 10 = 980J$$

12. Two bodies of masses m_1 and m_2 have same momenta. What is the ratio of their kinetic energies?

$$KE,\quad K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$

$$K_1 = \frac{p^2}{2\,m_1} \qquad\qquad K_2 = \frac{p^2}{2\,m_2}$$

$$K_1 / K_2 = m_2/m_2$$

$$K_1 : K_2 = m_2 : m_2$$

13. A light body and heavy body have same momenta, Which one has greater kinetic energy?

$$KE = \frac{p^2}{2m}$$

$$KE \propto \frac{1}{m}$$

Lighter body will have more Kinetic energy.

14.Power is the scalar product of force and --------------

Velocity (P= F .v)

15.Show that the gravitational potential energy of the object at height h, is completely converted to kinetic energy on reaching the ground.

PE at a height h, $V = mgh$

When the object is released from a height it gains KE

$$K = \frac{1}{2} mv^2$$

$$v^2 = u^2 + 2as$$

$$u=0,\ a=g,\ s=h$$

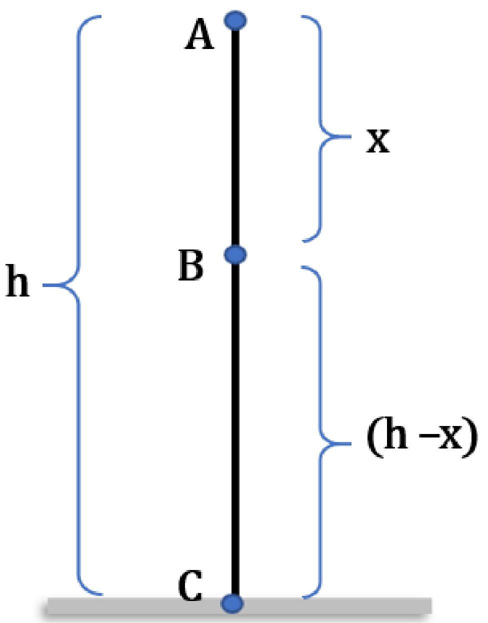
$$v^2 = 2gh$$

$$K = \frac{1}{2} m \times 2gh$$

$$K = mgh$$

16. State and prove the law of conservation of mechanical energy for a freely falling body.

The principle of conservation of total mechanical energy can be stated as,
The total mechanical energy of a system is conserved if the forces, doing work on it, are conservative.
Consider a body of mass m falling freely from a height h



At Point A

PE = mgh

KE = 0 (since v=0)

TE= mgh + 0

TE= mgh-----------(1)

At Point B

PE = mg (h-x)

KE = ½ mv²

$v^2 = u^2 + 2as$

u=0, a=g , s= x

$v^2 = 2gx$

KE = ½ m x 2gx =mgx

TE = mg (h-x) + mgx

TE = mgh--------------(2)

At Point C

PE = 0 (Since h=0

KE = ½ mv²

$v^2 = u^2 + 2as$

u=0, a=g , s= h

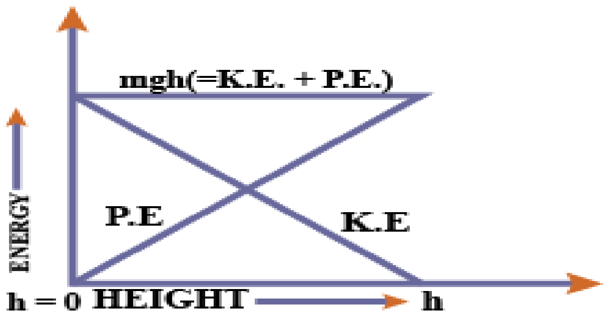
$v^2 = 2gh$

KE = ½ m x 2gh=mgh

TE = 0 + mgh

TE = mgh--------------(3)

From eqns (1), (2) and (3), it is clear that the total mechanical energy is conserved during the free fall.



Chapter 7
Systems of Particles and Rotational Motion

1. Write the relation connecting angular velocity and its linear velocity.

$$\vec{v} = \vec{\omega} \times \vec{r}$$

2. Define Angular acceleration

Angular acceleration $\vec{\alpha}$ is defined as the time rate of change of angular velocity.

$$\vec{\alpha} = \frac{d\vec{\omega}}{dt} \qquad \text{unit rad}/s^2 \quad \text{or} \quad \text{rad } s^{-2}$$

3. The rotational analogue of force is ---------------

Torque or Moment of force

4. Write the equation for torque or moment of force

$$\vec{\tau} = \vec{r} \text{ x } \vec{F}$$

5. The handle of the door is always fixed at the edge of the door which is located at a maximum possible distance away from hinges. Give reason.

$$\vec{\tau} = \vec{r} \text{ x } \vec{F} = rF \sin\theta$$

When r is maximum ,torque will be maximum.

The handle is fixed at the edge to increase r and hence to make torque maximum.

6. Find the torque of a force $7\hat{i} + 3\hat{j} - 5\hat{k}$ about the origin. The force acts on a particle whose position vector is $\hat{i} - \hat{j} + \hat{k}$.

$$\vec{\tau} = \vec{r} \text{ x } \vec{F}$$

$$\vec{\tau} = (\hat{i} - \hat{j} + \hat{k}) \text{ x} (7\hat{i} + 3\hat{j} - 5\hat{k})$$

$$\vec{\tau} = \begin{array}{c} \begin{array}{ccc} + & - & + \end{array} \\ \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -1 & 1 \\ 7 & 3 & -5 \end{vmatrix} \end{array}$$

$$\vec{\tau} = \hat{i}\,[(-1 \text{ x } -5) - (3 \text{ x } 1)] \; - \hat{j}\,[(1\text{x}-5) - (7\text{x}1)] \; + \hat{k}\,[(1\text{x}3) - (7\text{x}-1)]$$

$$\vec{\tau} = \hat{i}\,[5 - 3] \; - \hat{j}\,[-5 - 7] \; + \hat{k}\,[3 - -7]$$

$$\vec{\tau} = 2\hat{i} + 12\,\hat{j} + 10\hat{k}$$

7. Angular momentum is the rotational analogue of ---------------

linear momentum.

8. Write the relation connecting angular momentum and linear momentum.

$$\vec{l} = \vec{r} \times \vec{p}$$

9. The moment of linear momentum is called ---------------

Angular momentum

10. Write the relation connecting torque and angular momentum

$$\vec{\tau} = \frac{d\vec{l}}{dt}$$

11. Deduce the relation connecting torque and angular momentum (or) Show that the time rate of change of the angular momentum of a particle is equal to the torque acting on it.

$$\vec{l} = \vec{r} \times \vec{p}$$

Differentiating

$$\frac{d\vec{l}}{dt} = \frac{d}{dt}(\vec{r} \times \vec{p})$$

$$\frac{d\vec{l}}{dt} = \frac{d\vec{r}}{dt} \times \vec{p} + \vec{r} \times \frac{d\vec{p}}{dt}$$

$\vec{p} = m\vec{v}$, $\frac{d\vec{r}}{dt} = \vec{v}$, $\frac{d\vec{p}}{dt} = \vec{F}$

$$\frac{d\vec{l}}{dt} = \vec{v} \times m\vec{v} + \vec{r} \times \vec{F}$$

$\vec{v} \times \vec{v} = 0$, $(\vec{r} \times \vec{F} = \vec{\tau})$

$$\frac{d\vec{l}}{dt} = 0 + \vec{\tau}$$

$$\frac{d\vec{l}}{dt} = \vec{\tau}$$

$$\boldsymbol{\vec{\tau} = \frac{d\vec{l}}{dt}}$$

12.The time rate of change of the angular momentum of a particle is equal to the --------------- acting on it. Torque

13.State and prove the law of conservation of angular momentum

If the total external torque on a system of particles is zero, then the total angular momentum of the system is conserved i.e, remains constant.

$$\vec{\tau}_{ext} = \frac{d\vec{L}}{dt}$$

If external torque, $\vec{\tau}_{ext} = 0$,

$$\frac{d\vec{L}}{dt} = 0$$

$$\vec{L} = \text{constant}$$

14.Write an example of a motion in which angular momentum remains constant

Motion of planets around sun.

15. Moment of Inertia is the rotational analogue of ------------

Mass.

16.The rotational analogue of mass is called--------------------

Moment of Inertia

17. Mass is a measure of ----------------- and moment of inertia is a measure of -------------------------

Inertia , Rotational inertia

18. Writ the expression for moment of inertia of a particle of mass m rotating about an axis

$$I = mr^2$$

19. Write the equation for rotational kinetic energy

$$\text{Rotational kE} = \frac{1}{2} I\omega^2$$

20. What do you mean by radius of gyration

The radius of gyration can be defined as the distance of a mass point from the axis of roatation whose mass is equal to the whole mass of the body and whose moment of inertia is equal to moment of inertia of the whole body about the axis.

$$I = Mk^2$$

$$k = \sqrt{\frac{I}{M}}$$

21.The moment of inertia of a disc of mass 'M' and radius R about an axis passing through its centre and perpendicular to its plane is $\frac{MR^2}{2}$. What is the radius of gyration of this case.

$$k = \sqrt{\frac{I}{M}}$$

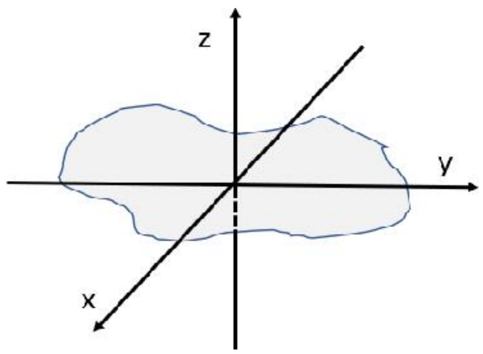
$$k = \sqrt{\frac{\frac{MR^2}{2}}{M}} = \sqrt{\frac{R^2}{2}} = \frac{R}{\sqrt{2}}$$

22.What is a flywheel

A disc with a large moment of inertia is called a flywheel. It is used in machines, that produce rotational motion.

23.State perpendicular axes theorem

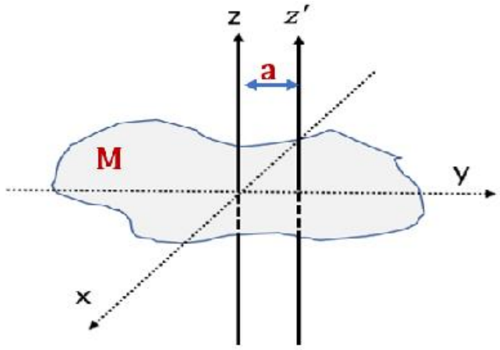
The moment of inertia of a plane lamina about z axis is equal to the sum of its moments of inertia about x-axis and y-axis, if the lamina lies in xy plane.



$$I_z = I_x + I_y$$

24. State Parallel Axes Theorem

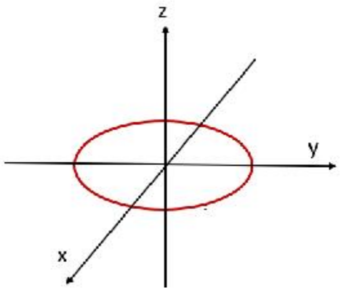
The moment of inertia of a body about any axis is equal to the sum of the moment of inertia of the body about a parallel axis passing through its centre of mass and the product of its mass and the square of the distance between the two parallel axes.



$$\mathbf{I_{z'} = I_z + Ma^2}$$

25. The moment of inertia of a ring about an axis passing through its centre and perpendicular to its plane is MR^2 .Determine its moment of inertia about a diameter.

By perpedicular axes theorem $I_z = I_x + I_y$



But $I_x = I_y$

$I_z = 2I_x$

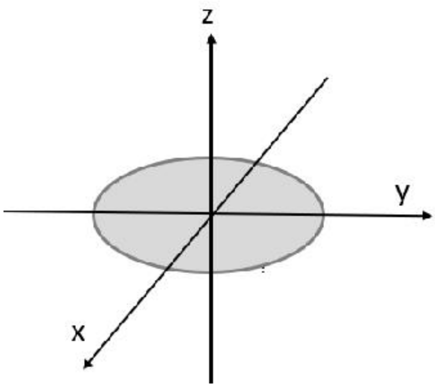
$I_x = \frac{I_z}{2}$

But $I_z = MR^2$

$$\mathbf{I_x = \frac{MR^2}{2}}$$

26.The moment of inertia of a disc about an axis passing through its centre and perpendicular to its plane is $\frac{MR^2}{2}$ .Determine its moment of inertia about a diameter.

By perpedicular axes theorem $I_z = I_x + I_y$



But $I_x = I_y$

$I_z = 2I_x$

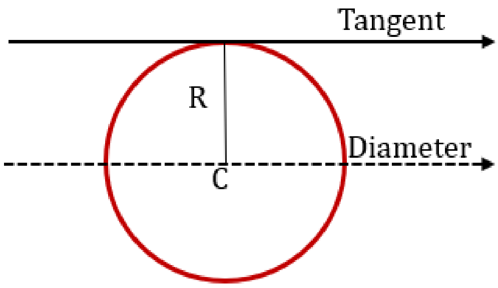
$I_x = \frac{I_z}{2}$

But $I_z = \frac{MR^2}{2}$

$$\mathbf{I_x = \frac{MR^2}{4}}$$

26. The moment of inertia of a ring about an axis passing through its diameter is $\frac{MR^2}{2}$ .Determine its moment of inertia about a tangent.

By parallel axes theorem $I_{z'} = I_z + Ma^2$



$$I_{tangent} = I_{diameter} + MR^2$$

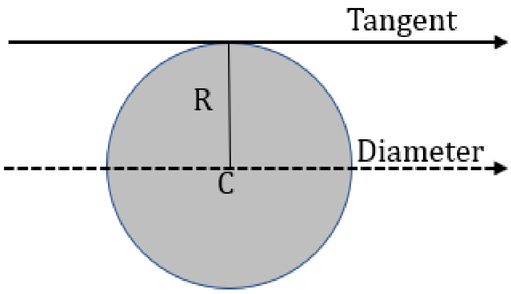
$$I_{diameter} = \frac{MR^2}{2}$$

$$I_{tangent} = \frac{MR^2}{2} + MR^2$$

$$\mathbf{I_{tangent} = \frac{3}{2} MR^2}$$

27. The moment of inertia of a disc about an axis passing through its diameter is $\frac{MR^2}{4}$ .Determine its moment of inertia about a tangent.

By parallel axes theorem $I_{z'} = I_z + Ma^2$



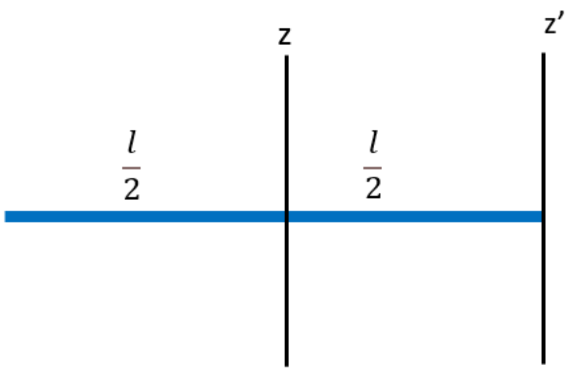
$$I_{tangent} = I_{diameter} + MR^2$$

$$I_{diameter} = \frac{MR^2}{4}$$

$$I_{tangent} = \frac{MR^2}{4} + MR^2$$

$$\mathbf{I_{tangent} = \frac{5}{4} MR^2}$$

28.The moment of inertia of a rod of mass M, length l about an axis passing through its centre and perpendicular to it is $\frac{Ml^2}{12}$. Find its moment of inertia about an axis perpendicular to it through one end.



$$I_{z'} = I_z + Ma^2$$

$$I_{end} = I_{mid\ point} + M\left(\frac{l}{2}\right)^2$$

$$\text{But } I_{mid\ point} = \frac{Ml^2}{12}$$

$$I_{end} = \frac{Ml^2}{12} + \frac{Ml^2}{4}$$

$$\mathbf{I_{end} = \frac{Ml^2}{3}}$$

Chapter 8
Gravitation

1.State Universal Law of Gravitation

Every body in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them .

$$F = G\frac{m_1m_2}{r^2}$$

2. The value of Gravitational Constant.

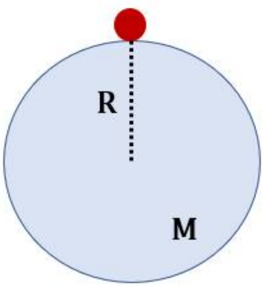
$$G = 6.67\times10^{-11}\ N\ m^2/kg^2$$

3.Define acceleration due to gravity of the Earth

The acceleration gained by a body due to the gravitational force of earth is called acceleration due to gravity.

4. Obtain the expression for acceleration due to gravity on the surface of the earth (or) Obtain the relation connecting g and G.

Consider a body of mass m on the surface of earth of mass M and radius R. The gravitational force between body and earth is given by



$$F = \frac{GMm}{R^2}\ \text{-----------(1)}$$

By Newton's second law

$$F=mg$$

where g is acceleration due to gravity

$$g=\frac{F}{m}$$

From Eq (1) $g=\frac{GM}{R^2}$

5.The average value of g on the surface of earth is -------.

$9.8ms^{-2}$.

6. Acceleration due to gravity is independent of------------(mass of the body/mass of earth).

mass of the body

7.A man can lift a mass of 15kg on earth.What will be the maximum mass that can be lifted by him by applying the same force on moon.

6x15 =90kg

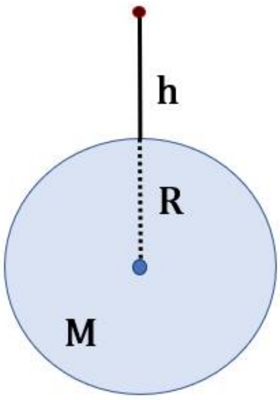
(Acceleration due to gravity on the surface of moon is $\frac{1}{6}$ times that on earth. So he can lift 6 times massive objects on the surface of moon)

8.A mass of 30kg is taken from earth to moon. What will be its mass and weight on the surface of moon

Mass on the moon=30kg (mass remains the same)

Weight on the moon $=\frac{30 \times 9.8}{6} = 49N$

9.Obtain the expression for Acceleration due to gravity at a height h above the surface of the earth.



Acceleration due to gravity on the surface of earth

$$g = \frac{GM}{R^2} \text{ ------------(1)}$$

Acceleration due to gravity at a height above the surface of earth

$$g_h = \frac{GM}{(R+h)^2} \text{ ----------(2)}$$

For , h << R

$$g_h = \frac{GM}{R^2(1+\frac{h}{R})^2}$$

$$g_h = \frac{GM}{R^2}(1+\frac{h}{R})^{-2}$$

Substituting from eq(1)

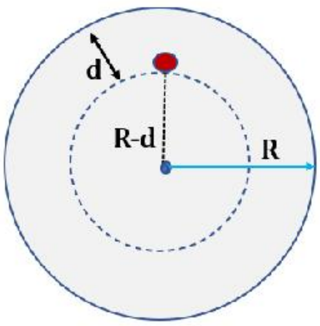
$$g_h = g(1+\frac{h}{R})^{-2}$$

Using binomial expression and neglecting higher order terms.

$$\mathbf{g_h \cong g\,(1-\frac{2h}{R})}$$

10.Derive the expression for acceleration due to gravity at a depth d below the surface of the earth

We assume that the entire earth is of uniform density. Then mass of earth



Acceleration due to gravity on the surface of earth

$$g=\frac{GM}{R^2} \text{ -------------(1)}$$

$$\text{But } M=\frac{4}{3}\pi R^3\rho$$

$$g=\frac{G}{R^2}\left(\frac{4}{3}\pi R^3\rho\right)$$

$$g = \frac{4}{3}\pi R\rho G \text{ ---------------(2)}$$

Acceleration due to gravity at a depth d below the surface of earth

$$g_d = \frac{4}{3}\pi(R-d)\rho G \text{ ---------(3)}$$

$$\frac{eq(3)}{eq(2)} \text{------} \quad \frac{g_d}{g} = \frac{\frac{4}{3}\pi(R-d)\rho G}{\frac{4}{3}\pi R\rho G}$$

$$\frac{g_d}{g} = \frac{(R-d)}{R}$$

$$\mathbf{g_d = g(1 - \frac{d}{R})}$$

11.The acceleration due gravity ---------------(decreases/increases) , as we go above earth's surface and ---------------(decreases/increases) ,as we go down below earth's surface.

Decreases ,Decreases.

12.The acceleration due gravity is --------------------at the centre of earth.

Zero

13.At what height the value of acceleration due to gravity will be half of that on surface of earth. (Given the radius of earth R =6400km)

.

$$g_h = g(1 + \frac{h}{R})^{-2}$$

$$g_h = \frac{g}{2}$$

$$\frac{g}{2} = g(1 + \frac{h}{R})^{-2}$$

$$\frac{1}{2} = (1 + \frac{h}{R})^{-2}$$

$$2 = (1 + \frac{h}{R})^{2}$$

$$\sqrt{2} = 1 + \frac{h}{R}$$

$$\frac{h}{R} = \sqrt{2}\text{-}1$$

$$h = (\sqrt{2}\text{-}1)\ R$$

$$h = (1.414\ \text{-}1)\ 6400$$

$$h = 2650\ \text{km}$$

14.Calculate the value of acceleration due to gravity at a height equal to haif of the radius of earth.

$$g_h = \frac{GM}{(R+h)^2}$$

$$h = \frac{R}{2}$$

$$g_h = \frac{GM}{\left(R+\frac{R}{2}\right)^2} = \frac{GM}{\left(\frac{3}{2}R\right)^2}$$

$$= \frac{GM}{\frac{9}{4}R^2} = \frac{4}{9}\frac{GM}{R^2} = \frac{4}{9}\ g$$

Chapter 9
Mechanical Properties of Solids

1.Define Stress

The restoring force per unit area is known as stress.

If F is the force applied and A is the area of cross section of the body,

$$\text{Stress} = \frac{F}{A}$$

The SI unit of stress is N m^{-2} or pascal (Pa)

2.Define Strain

Strain is defined as the **fractional change in dimension.**

$$\text{Strain} = \frac{\text{Change in dimension}}{\text{Original dimension}}$$

Strain has no unit and dimension.

3.Wrte three types of stress and strain.

1. Longitudinal Stress and Longitudinal Strain
2. Shearing Stress and Shearing Strain
3. Hydraulic Stress and Hydraulic Strain (Volume Strain)

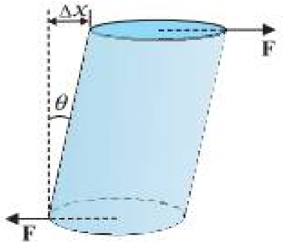
4. Define Longitudinal strain

Longitudinal strain is defined as the ratio of change in length(ΔL) to original length(L) of the body .

$$\text{Longitudinal strain} = \frac{\text{Change in length}}{\text{Original length}}$$

$$\text{Longitudinal strain} = \frac{\Delta L}{L}$$

5.Define Shearing strain



Shearing strain is defined as the ratio of relative displacement of the faces Δx to the length of the cylinder L

$$\text{Shearing strain} = \frac{\Delta x}{L} = \tan\theta = \theta$$

6.Volume strain (hydraulic strain)

Volume strain(hydraulic strain) is defined as the ratio of change in volume (ΔV) to the original volume (V).

$$\text{Volume strain} = \frac{\text{Change in volume}}{\text{Original volume}}$$

$$\text{Volume strain} = \frac{\Delta V}{V}$$

7.State Hooke's Law

For small deformations the stress is directly proportional to strain. This is known as Hooke's law.

$$\textbf{Stress} \propto \textbf{Strain}$$

$$\frac{\textbf{Stress}}{\textbf{strain}} = \boldsymbol{k}$$

The constant k is called **Modulus of Elasticity.**

The SI unit of modulus of elasticity is N m^{-2} or pascal (Pa)

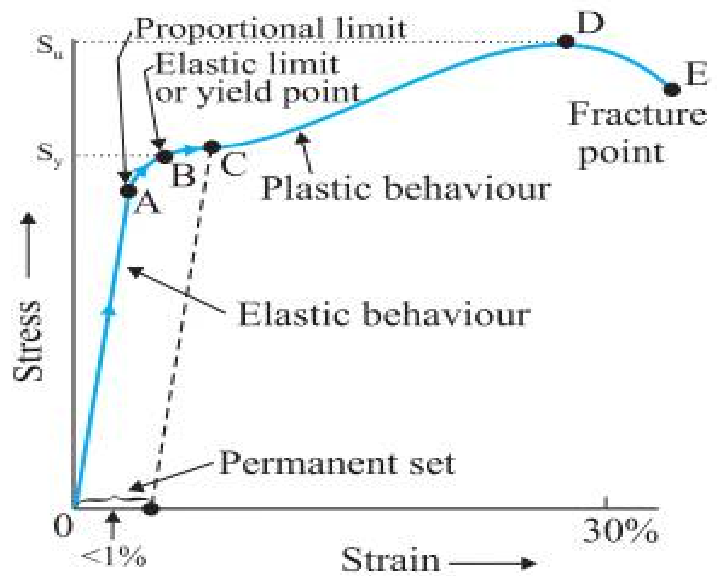
7.Define modulus of elasticity. Write its unit.

$$\text{Modulus of elasticity} = \frac{\textbf{Stress}}{\textbf{strain}}$$

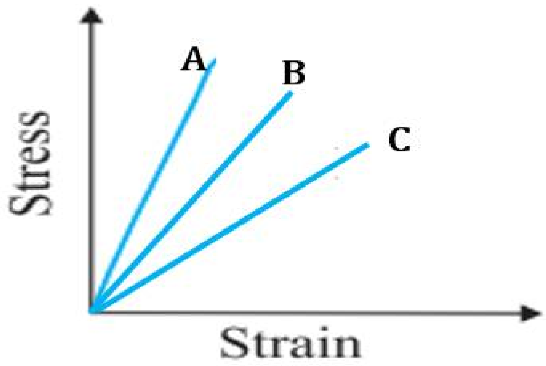
Unit =N m^{-2} or pascal (Pa)

8.The stress-strain curve for a metal is given in figure. Mark

1)Elastic limt (or) yield point 2) Fracture point 3) Proportional limit 4)Elastic region 5) Plastic region 6)permanent set 7) yield strength (S_y) 8) ultimate tensile strength (S_u)



9.The stress-strain graph for three materials A B and C are shown below



Which is more elastic A ,B or C. Justify your answer.

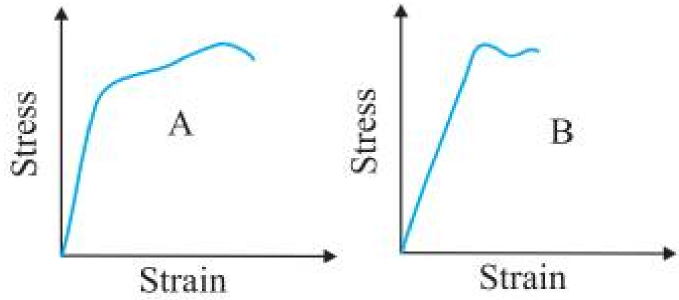
Material A is more elastic

Modulus of elasticity $= \frac{\text{stress}}{\text{strain}}$ = slpoe of the graph

Slope of graph for material A is greater than that of B and C

So material A is more elstic.

10.The stress-strain graphs for materials A and B are shown in Figure.



The graphs are drawn to the same scale.

(a) Which of the materials is more elastic?

(b) Which of the two is the stronger material?

(c) Which of the two materials is more ductile?

(a) Slope of graph for material A is greater than that of B.
So material A is more elstic than B

(b) Strength of a material is determined by the amount of stress required to cause fracture.
The fracture point is greater for material A.
So material A is stronger than B

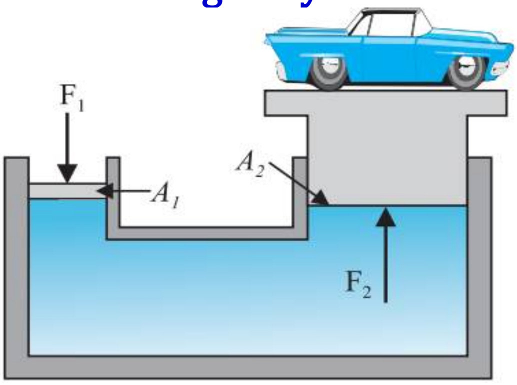
(c) The fracture point is far apart for material A than B.
So material A is more ductile than B.

Chapter 10
Mechanical Properties Of Fluids

1.State Pascal's law for transmission of fluid pressure.

Whenever external pressure is applied on any part of a fluid contained in a vessel, it is transmitted undiminished and equally in all directions.

2.Briefly explain the working of hydraulic lift.



The pressure on smaller piston

$$P = \frac{F_1}{A_1} \text{-------------}(1)$$

This pressure is transmitted equally to the larger piston of area A_2.

Upward force on A_2, $\quad F_2 = P\,A_2$

Substituting from eq(1), $\quad F_2 = \frac{F_1}{A_1} A_2$

$$\mathbf{F_2 = F_1 \frac{A_2}{A_1}}$$

3. A hydraulic automobile lift is designed to lift cars with a maximum mass of 3000kg. The area of cross section of the piston carrying $425\ cm^2$. What maximum pressure would the smaller piston have to bear?

Pressure on two two pistons will be same.

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$P = \frac{F_2}{A_2} = \frac{mg}{A_2}$$

$$= \frac{2000\ x\ 9.8}{425\ x10^{-4}} = 6.92\ x10^5\ Nm^{-2} \text{ or Pa}$$

4.Two syringes of diffrent cross sections (without needles) filled with water are connected with a tightly fitted rubber tube filled with water. Diameters of the smaller piston and larger piston are 1.0 cm and 3.0 cm respectively. Find the force exerted on the larger piston when a force of 10 N is applied to the smaller piston.

$$F_2 = F_1 \frac{A_2}{A_1}$$

$$F_2 = 10 \text{ x} \frac{\pi \text{ x } (1.5 \text{ x } 10^{-2})^2}{\pi \text{ x } (0.5 \text{ x } 10^{-2})^2}$$

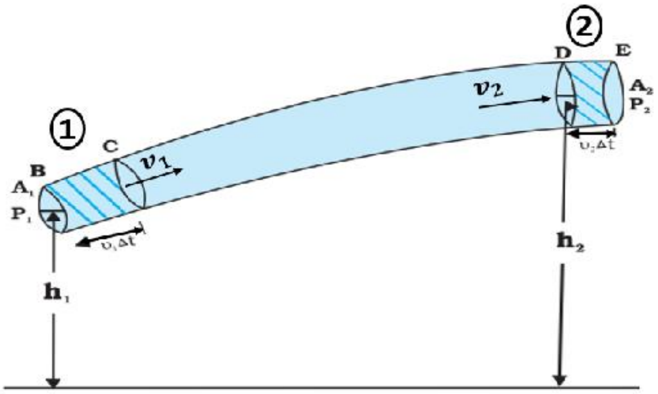
$$= 10 \text{ x} 9 = 90 \text{ N}$$

4. State and prove Bernoulli's Principle

Bernoulli's principle states that as we move along a streamline, the sum of the pressure , the kinetic energy per unit volume and the potential energy per unit volume remains a constant.

$$\mathbf{P + \frac{1}{2}\rho v^2 + \rho g h = constant}$$

Proof



The total work done on the fluid is

$$W_1 + W_2 = P_1 \Delta V - P_2 \Delta V$$

$$\mathbf{W_1 + W_2 = (P_1 - P_2)\Delta V}\text{-------------(1)}$$

The change in its kinetic energy is

$$\Delta K = \frac{1}{2} m(v_2^2 - v_1^2) \text{ ---------------(2)}$$

The change in gravitational potential energy is

$$\Delta U = mg(h_2 - h_1) \text{---------------(3)}$$

By work – energy theorem

$$W_1 + W_2 = \Delta K + \Delta U$$

Substituting from eq(1),(2) and (3)

$$\mathbf{(P_1 - P_2)\Delta V = \frac{1}{2} m(v_2^2 - v_1^2) + mg(h_2 - h_1)}\text{-------------(4)}$$

Divide each term by ΔV to obtain $\left(\frac{m}{\Delta V} = \rho\right)$

$$P_1 - P_2 = \frac{1}{2}\rho(v_2^2 - v_1^2) + \rho g(h_2 - h_1)$$

$$P_1 - P_2 = \frac{1}{2}\rho v_2^2 - \frac{1}{2}\rho v_1^2 + \rho g h_2 - \rho g h_1$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

$$\mathbf{P + \frac{1}{2}\rho v^2 + \rho g h = constant}$$

Chapter 11
Thermal Properties of Matter

1.Expression for coefficient of linear expansion

$$\boldsymbol{\alpha_l = \frac{\Delta l}{l\,\Delta T}}$$

2.Expression for coefficient of area expansion

$$\boldsymbol{\alpha_a = \frac{\Delta A}{A\,\Delta T}}$$

3.Expression for coefficient of volume expansion

$$\boldsymbol{\alpha_v = \frac{\Delta V}{V\Delta T}}$$

4. Obtain the relation between α_l and α_a

$$\alpha_a = \frac{\Delta A}{A\,\Delta T}$$

$$\Delta A = (l + \Delta l)^2 - l^2$$

$\Delta A = 2\ l\,\Delta l$ (Neglecting term $(\Delta l)^2$)

$$A = l^2$$

$$\alpha_a = \frac{2\,l\,\Delta l}{l^2 \Delta T}$$

$$\alpha_a = 2\ \frac{\Delta l}{l\,\Delta T}$$

$$\frac{\Delta l}{l\,\Delta T} = \alpha_l$$

$$\boldsymbol{\alpha_a = 2\ \alpha_l}$$

5.Relation between α_l and α_v

$$\alpha_v = \frac{\Delta V}{V\Delta T}$$

$$\Delta V = (l + \Delta l)^3 - l^3$$

$\Delta V = 3\ l^2\ \Delta l$ (Neglecting terms $(\Delta l)^2$ and $(\Delta l)^3$)

$$\mathbf{V} = l^3$$

$$\alpha_v = \frac{3\ l^2\ \Delta l}{l^3 \Delta T}$$

$$\alpha_v = 3\ \frac{\Delta l}{l\,\Delta T}$$

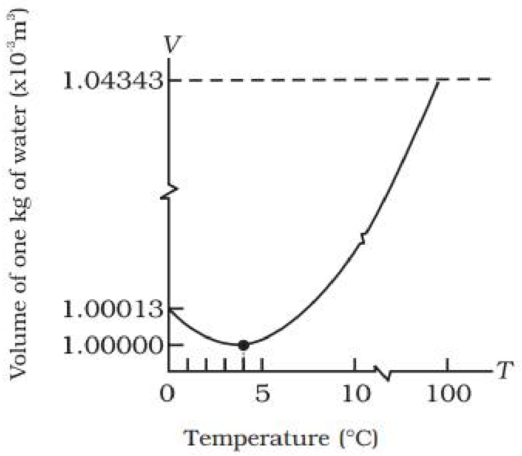
$$\frac{\Delta l}{l\,\Delta T} = \alpha_l$$

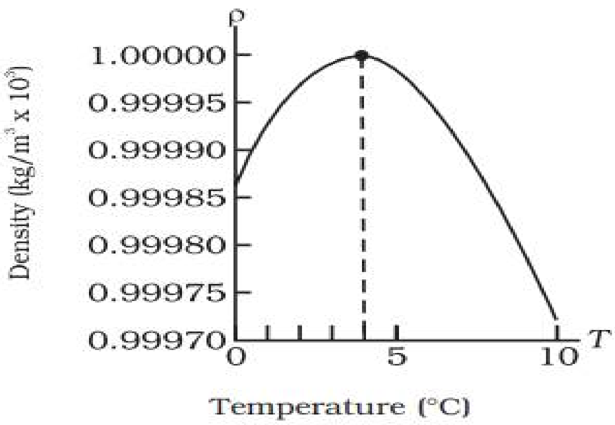
$$\boldsymbol{\alpha_v = 3\ \alpha_l}$$

6.What is the ratio of α_l , α_a and α_v

$$\boldsymbol{\alpha_l : \alpha_a : \alpha_v = 1 : 2 : 3}$$

7.Based on the graph given below explain the anomalous expansion of water.





Water exhibits an anomalous behaviour; it contracts on heating from 0 °C to 4 °C. When it is heated after 4 °C ,it expands like other liquids. **This means that water has minimum volume and hence maximum density at 4 °C .**

8.Why the bodies of water, such as lakes and ponds, freeze at the top first?

This is due to anomalous expansion of water. water has minimum volume and hence maximum density at 4 °C .

As a lake cools toward 4 °C, water near the surface becomes denser, and sinks. Then the warmer, less dense water near the bottom rises. When this layer cools to 0 °C, it freezes, and being less dense, remain at the surfaces.

9.The change of state from solid to liquid is called ---------------

melting ,

10. The change of state from liquid to solid is called ------------------.

Fusion

11.The temperature at which the solid and the liquid states of the substance coexist in thermal equilibrium with each other is called its -------------

melting point.

12.Melting point ------------ with increase in pressure_.

decreases

13. The change of state from liquid to vapour (or gas) is called -----------------

vaporisation

14.The temperature at which the liquid and the vapour states of the substance coexist in thermal equilibrium is called its---------------

boiling point.

15. The boiling point <u>increases</u> with increase in pressure and <u>decreases</u> with decreases in pressure.

16 .Cooking is difficult on hills. Give reason

The boiling point decreases with decreases in pressure. At high altitudes, atmospheric pressure is lower, boiling point of water decreases as compared to that at sea level. So cooking is difficult.

17.Cooking is faster using a pressure cooker. Give reason

The boiling point increases with increase in pressure.
Boiling point is increased inside a pressure cooker by increasing the pressure. Hence cooking is faster.

18.Define Sublimation. Give an example of a substance that sublime.

The change from solid state to vapour state without passing through the liquid state is called sublimation.

Eg: Dry ice (solid CO_2) , Iodine ,Camphor

19.Define Latent Heat

The amount of heat per unit mass transferred during change of state of the substance is called latent heat of the substance for the process.

$$\mathbf{L = \frac{Q}{m}}$$

SI unit of Latent Heat is $\mathrm{J\,kg^{-1}}$

20.Define Latent Heat of Fusion ($\mathbf{L_f}$)

The latent heat for a solid -liquid state change is called the latent heat of fusion ($\mathbf{L_f}$) or simply heat of fusion.

$\mathbf{L_f}$ of water $= 3.33 \times 10^5\ \mathrm{J\,kg^{-1}}$.

21.Define Latent Heat of Vaporisation ($\mathbf{L_v}$)

The latent heat for a liquid-gas state change is called the latent heat of vaporisation ($\mathbf{L_v}$) or heat of vaporisation.

$\mathbf{L_v}$ of water$= 22.6 \times 10^5\ \mathrm{J\,kg^{-1}}$

22. Calculate the amount of heat energy required to convert10kg of water at 100^0 C to steam at 100^0 C.

$$L_v = \frac{Q}{m}$$

$$Q = L_v m$$

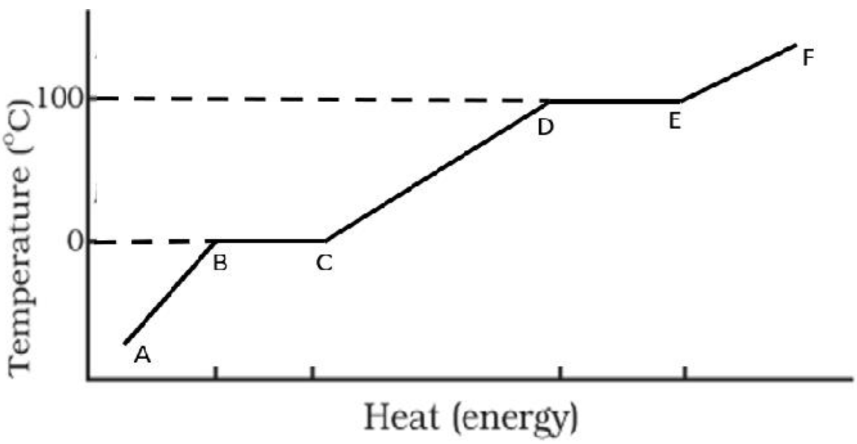
$$Q = 22.6 \times 10^5 \text{ x } 10$$

$$Q = 22.6 \times 10^6 \, J$$

23.Why burns from steam are usually more serious than those from boiling water?

For water, the latent heat of vaporisation is $\mathbf{L_v} = 22.6 \times 10^5$ J kg^{-1}.
That is 22.6×10^5 J of heat is needed to convert 1 kg of water to steam at 100 °C. So, steam at 100 °C carries 22.6×10^5J kg^{-1}more heat than water at 100 °C. This is why burns from steam are usually more serious than those from boiling water.

24.The graph given below represents the temperature versus heat for water at 1 atm pressure. Answer the following questions.



Fill up the table

Graph	Process	Phase(state)
BC	------------ Ans:**Melting**	------------- Ans: **solid + liquid**
DE	------------ Ans: **Vaporisation**	-------------Ans: **liquid + gas**

Graph	Phase
AB	---------- Ans: **Solid (ice)**
CD	---------- Ans: **Liquid(water)**
EF	---------- Ans: **Gas(steam)**

The heat energy corresponding to BC is called ------------

Latent heat of fusion

The heat energy corresponding to DE is called ------------

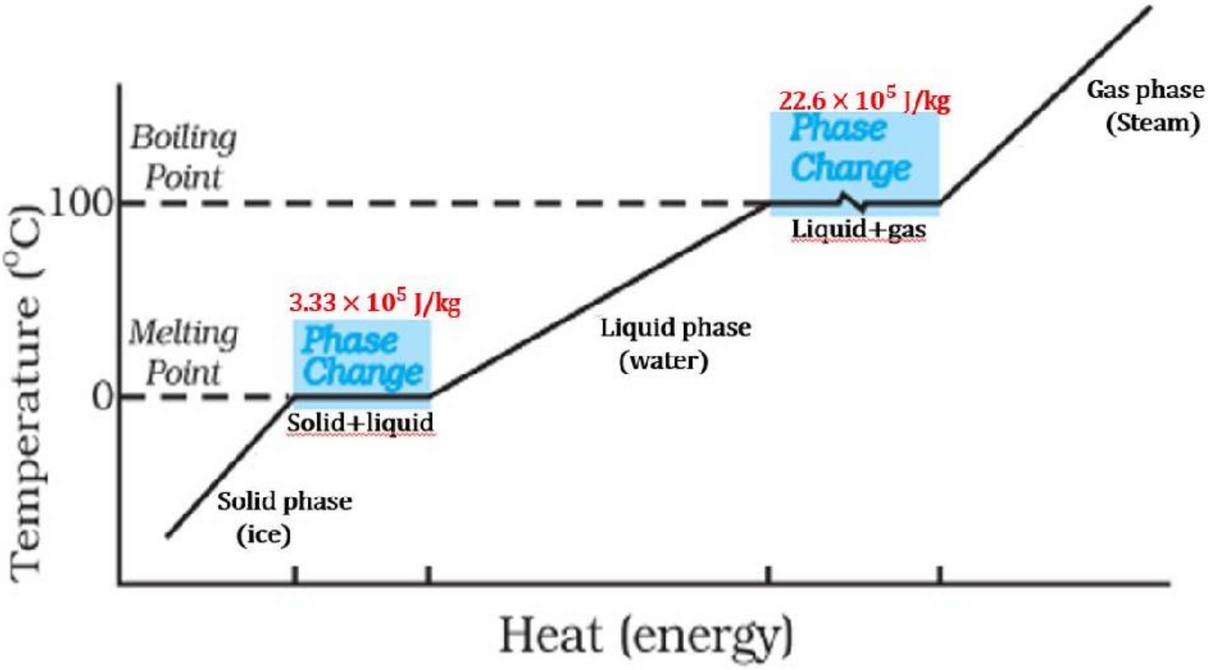
Latent heat of Vaporisation

The slope of AB and CD are different.Why?

Different slopes indicates that specific heat capacity of ice and water are different.

When slope of graph is less, it indicates a high specific heat capacity .

Slope of CD is less than that of AB ,i.e., specific heat capacity of water is greater than that of ice.



Chapter 12
Thermodynamics

1.State first law of Thermodynamics

The heat supplied to the system is partly used to increase the internal energy of the system and the rest is used to do work on the environment .

$$\Delta Q = \Delta U + \Delta W$$

2.First law of thermodynamics is in accordance with law of conservation of---------------------. Energy

3.Different thermodynamic processes

Type of processes	Feature	
Isothermal	Temperature constant	$\Delta Q = \Delta W$ $(\Delta U=0)$
Isobaric	Pressure constant	$\Delta Q = \Delta U + \Delta W$
Isochoric	Volume constant	$\Delta Q = \Delta U$ $(\Delta V=0)$
Adiabatic	No heat flow between the system and the surroundings $(\Delta Q = 0)$	$\Delta Q = 0$ $\Delta W = -\Delta U$

4.Write the equation of state for an isothermal process

$$PV = \text{constant}$$

5.Write the equation of state for an adiabatic process

$$PV^{\gamma} = \text{constant}$$

6.Derive the expression for work done by an ideal gas during an isothermal process

Consider an ideal gas undergoes a change in its state isothermally (at temperature T) from (P_1, V_1) to the final state (P_2, V_2).

$$\Delta W = P\,\Delta V$$

In the limit $\Delta V \rightarrow 0$

$$dW = P\,dV$$

$$W = \int_{V_1}^{V_2} P\,dV$$

$$PV = \mu R T$$

$$P = \frac{\mu R T}{V}$$

$$W = \int_{V_1}^{V_2} \frac{\mu R T}{V}\,dV$$

$$W = \mu R T \int_{V_1}^{V_2} \frac{1}{V}\,dV$$

$$W = \mu R T\,[\ln V]_{V_1}^{V_2}$$

$$W = \mu R T\,[\ln V_2 - \ln V_1]$$

$$\mathbf{W = \mu RT \ln \left[\frac{V_2}{V_1}\right]}$$

7.Derive the expression for workdone by an Ideal gas during an Adiabatic Process

Consider an ideal gas undergoes a change in its state adiabatically from (P_1, V_1) to the final state (P_2, V_2).

$$W = \int_{V_1}^{V_2} P\,dV$$

$$PV^{\gamma} = k$$

$$P = \frac{k}{V^{\gamma}}$$

$$P = k\,V^{-\gamma}$$

$$W = k\int_{V_1}^{V_2} V^{-\gamma}\,dV$$

$$W = k\left[\frac{V^{-\gamma+1}}{-\gamma+1}\right]_{V_1}^{V_2}$$

$$W = \frac{k}{1-\gamma}\left[v_2^{1-\gamma} - v_1^{1-\gamma}\right]$$

$$W = \frac{1}{1-\gamma}\left[\frac{k}{v_2^{\gamma-1}} - \frac{k}{v_1^{\gamma-1}}\right]$$

$$PV^{\gamma} = k$$

$$P_1V_1^{\gamma} = P_2V_2^{\gamma} = k$$

$$W = \frac{1}{1-\gamma}\left[\frac{P_2V_2^{\gamma}}{v_2^{\gamma-1}} - \frac{P_1V_1^{\gamma}}{v_1^{\gamma-1}}\right]$$

$$\mathbf{W = \frac{1}{1-\gamma}[\,P_2V_2 - P_1V_1\,]}$$

(or) $$\mathbf{W = \frac{\mu R}{1-\gamma}[\,T_2 - T_1\,]}$$

8.Workdone in an isochoric process is ------------

Zero

9.Work done by the gas in an Isobaric process

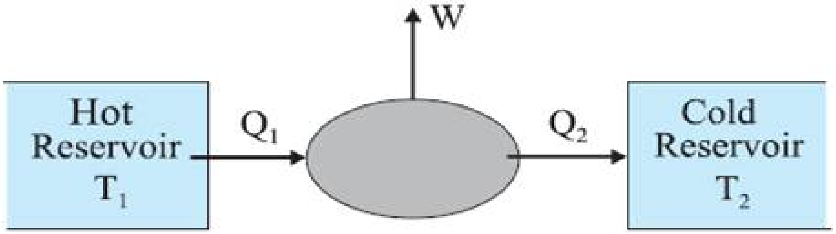
$$\Delta W = P\,\Delta V$$

$$\mathbf{W = P\,(V_2 - V_1)}$$

10.Heat engines convert heat energy into -------------------

mechanical energy.

11.Draw a schematic diagram of a heat engine



12. Obtain the equation for efficiency of heat engine

The efficiency (η) of a heat engine is defined by

$$\boldsymbol{\eta = \frac{W}{Q_1}}$$

Q_1 is the heat absorbed by the system from the source

W is the work done by the system on the environment in a cycle.

$$\mathbf{W = Q_1 - Q_2}$$

$$\boldsymbol{\eta = \frac{Q_1 - Q_2}{Q_1}}$$

$$\boldsymbol{\eta = 1 - \frac{Q_2}{Q_1}}$$

or

$$\boldsymbol{\eta = 1 - \frac{T_2}{T_1}}$$

13.Is it possible for an engine to have 100% efficiency.

No,. Efficiency, $\eta = 1 - \frac{Q_2}{Q_1}$

For $\eta = 1$ or 100% , Q_2 should be zero , which is not possible.

14.What is the efficiency of a heat engine working between 233K and 373K.

Or

What is the efficiency of a heat engine working between ice point 0^0C and steam point 100^0C .

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\eta = 1 - \frac{273}{373}$$

$$\eta = 1 - 0.732 \quad =0.268=26.8\%$$

15.Give an example for an external combustion engine

Eg: steam engine

16.Give an example of an internal combustion engines

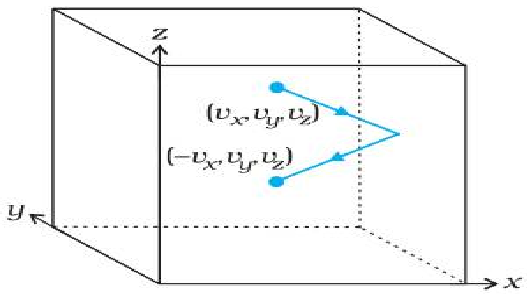
Eg: Petrol engine ,Diesel engine.

Chapter 13
Kinetic Theory

1.Write any four postulates of kinetic theory of an Ideal Gas

- A given amount of gas is a collection of a large number of molecules that are in random motion.
- At ordinary pressure and temperature, the average distance between molecules is very large compared to the size of a molecule (2 Å).
- The interaction between the molecules is negligible.
- The molecules make elastic collisions with each other and also with the walls of the container .
- As the collisions are elastic , total kinetic energy and total momentum are conserved .
- The average kinetic energy of a molecule is proportional to the absolute temperature of the gas.

2.Derive the expression for pressure of an ideal gas



The change in momentum of the molecule $= -mv_x - mv_x$

$$= -2\,mv_x$$

Momentum imparted to wall in the collision $= 2mv_x$

Distance travelled by the molecule in time $\Delta t = v_x\,\Delta t$
Volume covered by the molecule $= Av_x\,\Delta t$
No of molecules in this volume $= n\,Av_x\,\Delta t$
(n is number density of molecules)
Only half of these molecules move in +x direction
So no of molecules $= \frac{1}{2}nA\,v_x\,\Delta t$

The number of molecules with velocity v_x hitting the wall in time Δt

$$= \frac{1}{2}\,nA\,v_x\,\Delta t$$

The total momentum transferred to the wall

$$Q = (2mv_x)\left(\frac{1}{2}nA\,v_x\,\Delta t\right)$$

$$Q = nmAv_x^{\,2}\,\Delta t$$

The force on the wall, $F = \frac{Q}{\Delta t}$

$$F = nmAv_x^{\,2}$$

Pressure, $P = \frac{F}{A}$

$$P = nmv_x^{\,2}$$

All molecules in a gas do not have the same velocity; so average velocity is to be taken

$$P = nm\overline{v_x^2}$$

$\overline{v^2} = \overline{v_x^2} + \overline{v_y^2} + \overline{v_z^2}$
$\overline{v_x^2} = \overline{v_y^2} = \overline{v_z^2}$
$\overline{v^2} = 3\,\overline{v_x^2}$
$\overline{v_x^2} = \frac{1}{3}\overline{v^2}$

$$\mathbf{P = \frac{1}{3}\,nm\overline{v^2}}$$

3.Show that the average kinetic energy of a molecule is proportional to the absolute temperature of the gas;

$$P=\frac{1}{3}nm\overline{v^2}$$

$$n=\frac{N}{V}\ ,\quad N=nV$$

$$PV=\frac{1}{3}Nm\overline{v^2}$$

where N is the number of molecules in the sample.

$$PV=\frac{2}{3}\left(N\ \frac{1}{2}m\overline{v^2}\right)$$

$$PV=\frac{2}{3}\ E\text{---------------------}(1)$$

E= Average translational kinetic energy of molecule

Ideal gas equation, $PV = Nk_BT$ -------------------(2)

From eq(1)and (2) $\quad \frac{2}{3}\ E = Nk_BT$

$$E = \frac{3}{2}Nk_BT$$

$$\mathbf{E/N = \frac{3}{2}k_BT}$$

The average kinetic energy of a molecule is proportional to the absolute temperature

4.Obtain the expression for Root Mean Square (rms) Speed of a molecule of an ideal gas

$$\mathbf{E/N = \frac{3}{2}k_BT}$$

$$\frac{1}{2}m\overline{v^2} = \frac{3}{2}k_BT$$

$$\overline{v^2} = \frac{3k_B\ T}{m}$$

$$\mathbf{v_{rms} = \sqrt{\frac{3k_B\ T}{m}}}$$

5.Estimate the average thermal energy of helium atom at a temperature of 27^0C. (Boltzmann constant is 1.38×10^{-23}JK)

Average thermal energy(average kinetic energy) $= \frac{3}{2}k_BT$

$$T=27+273=300K$$

$$\text{Average thermal energy} = \frac{3}{2} \times 1.38 \times 10^{-23} \times 300$$

$$=6.21 \times 10^{-21}J$$

Chapter 14
Oscillations

1.Define Simple Harmonic Motion(SHM)

Simple harmonic motion is the motion executed by a particle subject to a force, which is proportional to the displacement of the particle and is directed towards the mean position.

2.Write a mathematical expression for an SHM

$$\mathbf{x\ (t) = A\cos(\omega t + \phi)}$$

x (t) =displacement, A=amplitude , ω =angular frequency,

$(\omega t + \phi)$ = phase ,ϕ=phase constant or initial phase angle

3.Write the expression for angular frequency

$\omega = \frac{2\pi}{T}$ or $\omega = 2\pi\nu$

where T=period, ν= frequency

Unit of ω is rad/s

Angular frequency is a scalar quantity

4.An SHM is given by $x = 8\sin(10\pi t + \frac{\pi}{4})$ m

Find the (i) amplitude (ii)Angular frequency (iii)period (iv)frequency(v) initial phase angle or phase constant

$$x = 8\sin(10\pi t + \frac{\pi}{4})$$

Comparing with general expression for SHM

$$x\ (t) = A\cos(\omega t + \phi)$$

(i)Amplitude , A=8 m

(ii)Angular frequency , $\omega = 10\pi$ rad/s

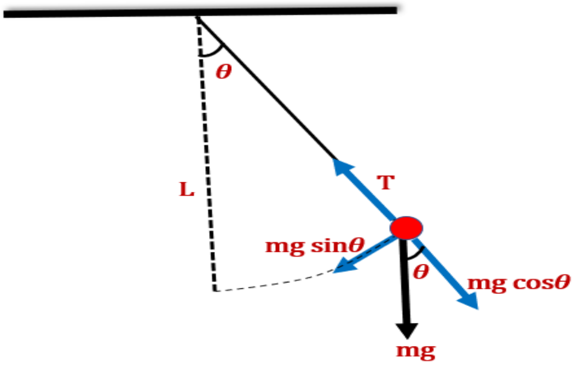
(iii)$\omega = \frac{2\pi}{T}$

Period , $T = \frac{2\pi}{\omega} = \frac{2\pi}{10\pi} = 1/5$ s

(iv)Frequency , $\nu = \frac{1}{T} = \frac{5}{1} = 5$Hz

(v)Initial phase angle, $\phi = \frac{\pi}{4}$ rad

5.Derive the expression for period of oscillations of a simple pendulum



$$\tau = -L\,(mg \sin\theta\,) \text{ --------------(1)}$$

For rotational motion we have,

$$\tau = I\,\alpha \text{ -----------------(2)}$$

From eqn (1) and (2)

$$I\,\alpha = -L\,mg\,\sin\theta$$

$$\alpha = \frac{-mgL}{I}\,\theta \text{ ---------------(3)} \qquad \text{(since } \theta \text{ is very small, } \sin\theta \approx \theta\text{)}$$

Acceleration of SHM , $a = -\,\omega^2 x$ -------------------(4)

Comparing eqns (3) and (4)

$$\omega^2 = \frac{mgL}{I}$$

$$I = mL^2$$

$$\omega^2 = \frac{mgL}{mL^2} = \frac{g}{L}$$

$$\omega = \sqrt{\frac{g}{L}}$$

Period, $$T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{\frac{g}{L}}}$$

$$\mathbf{T = 2\pi\sqrt{\frac{L}{g}}}$$

6.A girlis swinging on a swing in sitting position with period T. What will happen to the period of oscillation when she stands up?

$$T = 2\pi\sqrt{\frac{L}{g}}$$

When she stands up ,the length of the pendulum decreases and hence period of oscillation decreases.

7.What is a seconds pendulum?

A simple pendulum of period T = 2 second is called a seconds pendulum.

8.What is the length of a simple pendulum, which ticks seconds? Or What is the length of a seconds pendulum ?

A simple pendulum of period T = 2 second is called a seconds pendulum.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$T^2 = 4\pi^2\frac{l}{g}$$

$$L = \frac{T^2 g}{4\pi^2}$$

For seconds pendulum ,$T = 2s$

$$L = \frac{2^2 \text{ x } 9.8}{4 \text{ x } 3.14^2} = 0.994 \approx 1\text{m}$$

Chapter 15
Waves

1.Write the displacement relation for a progressive wave travelling along the positive direction of the x-axis .

$$y\ (x, t\ ) = a \sin\ (kx - \omega t + \phi)$$

$$\overbrace{y\ (x,\ t)}^{\text{Displacement}} = \overbrace{a}^{\text{Amplitude}}\ \sin\ \overbrace{(\underset{\substack{\uparrow \\ \text{Angular} \\ \text{Wave} \\ \text{Number}}}{kx} - \underset{\substack{\uparrow \\ \text{Angular} \\ \text{Frequency}}}{\omega t} + \underset{\substack{\uparrow \\ \text{Initial} \\ \text{Phase} \\ \text{Angle}}}{\phi})}^{\text{Phase}}$$

2.Write the displacement relation for a progressive wave travelling along the negative direction of the x-axis.

$$y\ (x, t\ ) = a \sin\ (kx + \omega t + \phi)$$

3.The magnitude of the maximum displacement of the elements from their equilibrium positions as the wave passes through them is called -----------

Amplitude

4.Define propagation constant or angular wave number

Propagation constant or Angular Wave Number is defined as

$$k = \frac{2\pi}{\lambda}$$

Its SI unit is radian per metre or rad m^{-1}

5.A wave travelling along a string is described by,
$y(x, t) = 0.005 \sin(80.0\,x - 3.0\,t)$, in which the numerical constants are in SI units (0.005 m, 80.0 rad m^{-1}, and 3.0 rad s^{-1}). Calculate

(a) the amplitude,
(b) the wavelength,
(c) the period and frequency of the wave.
(d) Calculate the displacement y of the wave at a distance x = 30.0 cm and time t = 20 s ?

Answer

$$y(x, t) = 0.005 \sin(80.0\,x - 3.0\,t)$$

Comparing with the general expression for a travelling wave

$$y(x,t) = a \sin(kx - \omega t + \phi)$$

(a) Amplitude , **a=0.005m**

(b) k=80 rad m^{-1}

but , $k = \frac{2\pi}{\lambda}$

$$\frac{2\pi}{\lambda} = 80$$

$$\lambda = \frac{2\pi}{80} = 0.0785 \text{ m}$$

$$\boldsymbol{\lambda = 7.85\ cm}$$

(c) ω=3

but, $\omega = \frac{2\pi}{T}$

$$\frac{2\pi}{T} = 3$$

Period , $T = \frac{2\pi}{3} = \mathbf{2.09\ s}$

Frequency, $\nu = 1/T = 1/2.09$ **= 0.48 Hz**

(d) $y(x, t) = 0.005 \sin(80.0\,x - 3.0\,t)$

x = 30.0 cm =0.3m

t = 20 s

$$y(x, t) = 0.005 \sin(80.0 \times 0.3 - 3.0 \times 20)$$

$= (0.005 \text{ m}) \sin(-36)$

$= (0.005 \text{ m}) \sin(-36 + 12\pi)$

12 π is added ,so tht (−36 + 12 π) becomes positive

$= (0.005 \text{ m}) \sin(1.699)$

$= (0.005 \text{ m}) \sin(97^0)$

= 5 mm

6.Obtain the expression for Speed of a Travelling Wave

Consider a wave propagating in positive x direction with initial phase $\phi = 0$

$$y(x, t) = a \sin(kx - \omega t)$$

Here $(kx - \omega t) = \text{constant}$

$$\frac{d}{dt}(kx - \omega t) = 0$$

$$k\frac{dx}{dt} - \omega\frac{dt}{dt} = 0$$

$$\frac{dx}{dt} = \frac{\omega}{k}$$

$$\mathbf{v = \frac{\omega}{k}}$$

$$\omega = 2\pi\nu, \quad k = \frac{2\pi}{\lambda}$$

$$v = \frac{2\pi\nu}{\frac{2\pi}{\lambda}}$$

$$\mathbf{v = \nu\lambda}$$

7.Write the expression for speed of a transverse wave on stretched string

$$\mathbf{v = \sqrt{\frac{T}{\mu}}}$$

μ = linear mass density or mass per unit length

T=tension on string

8.Write the expression for speed of longitudinal wave in a fluid

$$\mathbf{v = \sqrt{\frac{B}{\rho}}}$$

B= the bulk modulus of medium

ρ = the density of the medium

9.Write the expression for speed of a longitudinal wave in a solid bar

$$\mathbf{v = \sqrt{\frac{Y}{\rho}}}$$

Y =Young's modulus

ρ=density of the medium,

10.Write Newtons Formula for speed of a longitudinal wave in an ideal gas

$$\mathbf{v = \sqrt{\frac{P}{\rho}}}$$

P= Pressure of gas

ρ = density of gas

11. Write Laplace correction to Newton's formula for speed of a longitudinal wave in an ideal gas

$$\mathbf{v = \sqrt{\frac{\gamma P}{\rho}}}$$

P= Pressure of gas

ρ = density of gas

$\gamma = \frac{C_P}{C_V}$

12.Obtain Newtons Formula for speed of a longitudinal wave in an ideal gas

$$\mathbf{v}=\sqrt{\frac{B}{\rho}}$$

Newton assumed that, the pressure variations in a medium during propagation of sound are isothermal.

For isothermal process, $PV = \text{constant}$

$$V\Delta P + P\Delta V = 0$$

$$V\Delta P = - P\Delta V$$

$$\frac{-V\Delta P}{\Delta V} = P$$

$$B = P$$

$$\mathbf{v}=\sqrt{\frac{P}{\rho}}$$

13.Obtain Laplace correction to Newton's formula for speed of a longitudinal wave in an ideal gas

$$\mathbf{v}=\sqrt{\frac{B}{\rho}}$$

Laplace that the pressure variations in the propagation of sound waves are so fast that there is little time for the heat flow to maintain constant temperature. These variations, therefore, are adiabatic and not isothermal.

For adiabatic process, $PV^{\gamma} = \text{constant}$

$$\Delta\, PV^{\gamma} = 0$$

$$P\gamma V^{\gamma-1}\Delta V + V^{\gamma}\,\Delta P = 0$$

$$P\,\gamma V^{\gamma-1}\Delta V = -\,V^{\gamma}\,\Delta P$$

$$\gamma\,P = \frac{-V^{\gamma}\Delta P}{V^{\gamma-1}\Delta V}$$

$$\gamma\,P = \frac{-V\Delta P}{\Delta V} = B$$

$$B = \gamma\,P$$

$$\mathbf{v}=\sqrt{\frac{\gamma\,P}{\rho}}$$

14.The speed of sound in air at STP = ---------------

331.3 m s^{-1}

Seema Elizabeth
MARM Govt HSS Santhipuram
Thrissur