HSPTA MALAPPURAM

PHYSOL-*The Solution for Learning Physics*

Question Bank

For Target Students-All Chapters

Each question scores One

1 List the fundamental forces in nature.

Ans: Gravitational Force,Electromagnetic force,Strong Force(Nuclear Force),Weak Force

2 Which is the strongest force among fundamental forces?

Ans: Strong Force(Nuclear Force)

3 The weakest force in nature
(i)Strong nuclear force (ii) weak nuclear force
(iii)Gravitation force (iv) electromagnetic force

Ans: (iii)Gravitation force

4 The dimensional formula of force is ....

Ans: MLT^{-2}

5 Pick out the odd one
(a)Kilogram (b) second (c) ampere (d)candela (e) impulse

Ans: (e) impulse

6 1 angstrom (A^0) = ------------m.

Ans:10^{-10} m

7 Which is the largest practical unit of length (distance used in astronomy)?

Ans:Parallactic second or Par second (Parsec)

8 1 Astronomical Unit (AU) = -----------m

Ans:1 Astronomical Unit (AU) = 1.496×10^{11} m

9 1 light year (ly) = -------------m

Ans:1 light year (ly) = 9.46×10^{15} m

10 "If an equation is correct all the terms will have the same dimension". This is the ----
(a) Principle of moments.
(b) Principle of homogeneity of dimensions.
(c) Principle of continuity.
(d) Principle of Bernaulli

Ans:(b) Principle of homogeneity of dimensions.

11	Which of the following equations can't be obtained by the dimensional method? (a) $T=k\sqrt{\frac{l}{g}}$ (b) $N=N_0 e^{(-\lambda t)}$ (c) $E=kmv^2$ (d) $P=h\rho g$ Ans: (b) $N=N_0 e^{(-\lambda t)}$
12	a)What do you mean by dimensions of a physical quantity? b)Give the dimensions of the following quantities. i) Momentum ii) Force Ans: (a)The dimensions of a physical quantity are the powers to which the fundamental quantity must be raised to get that quantity. (b)i) Momentum --> $[M^1L^1T^{-1}]$ ii) Force --> $[M^1L^1T^{-2}]$
13	Give four examples for dimensionless physical quantities. Ans:. 1. Angle (Plane angle) 2. Solid angle. 3. Strain 4. Relative density.
14	Can a quantity have units but still be dimensionless? Justify your answer. Ans: Yes. A quantity having units may be dimensionless. For example , the quantity 'angle' has no dimension but it has the unit 'radian'.
15	What are the uses of dimensional analysis (method) ? Ans: a) To check the correctness of an equation. b) To derive a relation for a physical quantity. c) To convert a unit from one system into another.
16	A student was asked to write the equation for displacement at any instant in a simple harmonic motion of amplitude 'a'. He wrote the equation as $y=a\sin\frac{2\pi v}{k}t$ Where 'v' is the velocity at instant't'. For the equation to be dimensionally correct, what should be the dimensions of k? Ans: Dimension of [k] = Dimension of [vt] $= [L^1T^{-1}\,T^1]$ $= [L^1]$
17	Using the principle of homogeneity of equations, check whether the equation is correct. $T=2\pi\sqrt{\frac{g}{l}}$ *T-time, g-acceleration due to gravity l-is the length* of the pendulum Ans: Dimension of [T] = $[T^1]$

	Dimension of $\sqrt{\frac{g}{l}} = \sqrt{\frac{L^1 T^{-2}}{L^1}}$ =[T^{-1}] Dimension of LHS not equal to Dimension of RHS. Thus the equation is wrong.
18	Check whether the equation mv^2 = mgh is dimensionally consistent. Based on the above equation justify the following statement. **"A dimensionally correct equation need not be actually an exact equation"** Ans:The equation mv^2 = mgh is dimensionally consistent. But the exact equation is $\frac{1}{2} m v^2$ = mgh. Thus the given statement is correct. A dimensionally correct equation need not be physically true.
19	Mention any four limitations of dimensional analysis. Ans: 1. The method does not give any information about the dimensionless constant K. 2. It fails when a physical quantity depends on more than three physical quantities. 3. It fails when a physical quantity is the sum or difference of two or more quantities. 4. It fails to derive the equations involving trignometric, logarithmic and exponential functions.
20	The slope of position – time graph of a particle gives......... (Acceleration ,Displacement ,Velocity,Momentum) Ans: Velocity
21	The area under the velocity -time graph gives ------------- (Displacement ,Velocity ,Acceleration ,None of the these) **Ans**: Displacement
22	Acceleration is the time rate of change of velocity. Give an example of a body possessing zero velocity and still accelerating. Ans: If a body is thrown up , at the highest point the velocity is zero but there is an acceleration downwards.
23	A boy starts from a point A, travels to a point B at a distance of 1.5 km and returns to A. If he takes one hour to do so, his average velocity is (a) 3 km/h (b) zero (c) 1.5 km/h (d) 2 km/h Ans :(b) Zero
24	The angle between $\vec{A} = \hat{i} + \hat{j}$ and $\vec{B} = \hat{i} - \hat{j}$ is .... a)45^0 b) 60^0 c) 90^0 d)180^0 Ans; 90^0
25	A ball is dropped through the window of a train travelling with high velocity, to a man standing near the track. The ball............. i.Falls down vertically ii.Moves straight horizontally

	iii.Follows an elliptical path iv.Follows a parabolic path Ans: Follows a parabolic path.
26	At the top of a projectile, angle between velocity and acceleration is.... a)0° b) 45° c)60° d) 90°. Ans: zero.90°
27	An object is projected with a velocity u at an angle 20° with horizontal. To get the same range another object projected from the same point with same velocity at an angle of........ Ans :70°
28	The physical quantity which is constant at any point in projectile motion is.......... a)Velocity b)Acceleration c)Kinetic energy d)Linear momentum Ans : Acceleration
29	The rate of change of total momentum of a system of many-particles is proportional to the......................on the system. i. external force ii. a sum of the internal forces Ans: (i) external force.
30	The optimum speed of a car on a banked road to avoid wear and tear on its tyres is given by .... i. √ Rg tanθ ii. √ Rg cot θ iii. √ Rg sin θ iv. √ Rg cos θ Ans: (i) $\sqrt{Rg\,tan\theta}$
31	The force required to produce an acceleration of 2 m/s^2 on a mass of 2 kg is (a) 4 N (b) 10 N (c) 22 N (d) 18 N Ans: (a) 4N
32	A machine gun fires a bullet of mass 40 g with a velocity of 1200 ms^{-1}. The man holding it can exert a maximum force of 144 N on the gun. How many bullets can he fire per second at the most? (a) one (b) four (c) two (d) three Ans: (d) three
33	Newton’s second law defines ------------------ Ans: Force
34	Rocket propulsion is based on the principle.........? Ans: Law of conservation of momentum.
35	Maximum value of friction is called.......

	Ans: Limiting friction.
36	The area under force time graph is....... Ans: Impulse or change in momentum
37	The area under F-S graph will give....... Ans: Work done.
38	Gravitational force is a ....force (Conservative, Non Conservative) Ans: Conservative.
39	1hp=....... watt Ans: 746 watt.
40	Relation between kinetic energy and momentum is....... Ans: $\frac{p^2}{2m}$
41	1kWh = ----------- joules Ans:3600000 joules
42	Moment of linear momentum is called..... Ans: Angular momentum.
43	Moment of force is......... Ans: Torque.
44	A ring and a disc of same radius are allowed to roll from same height over an inclined plane. Which one will reach the ground first? Ans: Disc.
45	Unit of Moment of inertia is...... Ans: kgm^2
46	What are the rotational equivalents for the physical quantity force? Ans: Torque
47	Write equation connecting torque and force Ans: $\vec{\tau}=\vec{r}\ X\ \vec{F}$
48	Write equation connecting angular momentum linier momentum Ans: $\vec{L}=\vec{r}\ X\ \vec{P}$
49	In translatory motion, angular momentum......... i) is always zero ii) is always greater than one iii) may be present iv) is always infinite Ans: (iii) may be present.
50	The equation connecting angular momentum and linear momentum are .... Ans: $\vec{l}=\vec{r}\ x\ \vec{P}$
51	The inability to stop rotational motion is called......... Ans: Moment of inertia
52	Acceleration due to gravity is independent of .... (Mass of earth / mass of body) Ans: Mass of body.
53	Write the relation between acceleration due to gravity and gravitational constant.

	Ans: $g=\frac{GM}{R^2}$
54	The value of acceleration due to gravity is maximum at the ------------------ i) Poles ii) equator iii) Centre of the earth (iv) None of these Ans: Poles
55	a) A ball bounces more on the surface of the moon than on the earth. Explain why. Ans: 1) small acceleration due to gravity at the surface of moon. 2) Zero air friction b) Acceleration due to gravity is independent of .... (mass of earth / mass of body) Ans: Mass of the body
56	A rat and a horse are to be projected from earth into space. State whether the velocity is the same or different in projecting each animal. Justify. Ans: Yes. Escape velocity is independent of the mass of the body projected.
57	Variation of g with height is given by the equation...... Ans. g'= $\frac{gR^2}{(R+h)^2}$
58	Choose the correct alternative i.g increases / decreases with increase in the altitude Ans. g decreases ii.g independent of the mass of the earth / mass of the body. Ans. Mass of the body iii.g is maximum/ minimum at the poles. Ans. Maximum iv.g increases / decreases with increase in the depth Ans. g decreases
59	Name the law relating stress and strain. Ans: Hooke's law.
60	Unit of stress is....... Ans: N/m^2
61	The maximum value of elasticity is called............ Ans. Elastic limit
62	The hydraulic lift is based on which of the following a) Bernoulli's principle b) Pascal's Law c) Archimedes' principle d) Boyle's law Ans: Pascal's Law
63	Bernoulli's theorem is in accordance with...... Ans: Law of conservation of energy.
64	Which among the following possess the highest specific heat capacity? i. Water ii. Silver iii. Copper iv. Steel

	Ans: Water
65	How does the heat energy from the sun reach the earth ? Ans: By radiation
66	A brass tumbler feels much colder than a wooden tray on a chilly day. Why? Ans: This is because, brass tumbler is a heat conductor while the wooden tray is not.
67	Amount of heat required to increase the temperature of 1Kg of the substance by 1°C is called....... Ans: Specific heat capacity
68	Write the relation among heat energy, work done and change in internal energy. Ans: dQ = dU+ dW.
69	How is the efficiency of a Carnot engine affected by the nature of the working substance? Ans: The efficiency of a Carnot engine is independent of the nature of the working substance.
70	On what factors, the efficiency of a Carnot engine depends? Ans: Temperatures of source of heat and sink.
71	Equation for pressure in terms of density of gas is..... Ans: $P= 1/3\ \rho v^2$
72	Equation for v_{rms}=...... Ans: $\sqrt{\frac{3RT}{M}}$
73	A particle executing SHM is an example of .... i) acceleration of constant magnitude and direction. ii) acceleration of changing magnitude and direction. iii) acceleration of changing magnitude but constant direction. iv) acceleration of constant magnitude but changing direction. Ans: iii) acceleration of changing magnitude but constant direction.
74	What is a seconds pendulum? Ans: Pendulum with time period = 2 second.
75	A vibrating simple pendulum of period T is placed in a lift which is accelerating downwards. What is the effect of this on the time period of the pendulum? Ans; Time period increases.
76	Give an example for periodic motion which is not oscillatory? Ans: Rotation of earth.
77	In transverse wave vibrations are.... to the direction of propogation. Ans: perpendicular
78	What is the distance between two consecutive crests or troughs? Ans:- One wave length (λ)
79	Let a wave is moving along +X direction, what is the expression for representing it ? Ans :- $Y(x,t) = A \sin(kx-\omega t+\phi)$
80	Write Newton –Laplace equation in terms of temperature

	Ans :- $V_{(sound\ in\ gas)} = \sqrt{\frac{\gamma RT}{M}}$

Each question scores Two

1 Mechanical power is represented by $P = Fv + Av^3\rho$.

Where F is the force , v is the velocity, A is the area and ρ is the density.

a) The dimensional formula of power is -------.

b) Check the dimensional validity of the above equation.

Ans: a) The dimensional formula for power is $[ML^2T^{-3}]$

b) $[P] = [ML^2T^{-3}]$

$[Fv] = MLT^{-2} \times LT^{-1} = [ML^2T^{-3}]$

$[Av^3\rho] = [L^2 (LT^{-1})^3] = [ML^{-3}] = [L^2 L^3T^{-3}ML^{-3}] = [ML^2T^{-3}]$

All the terms have the same dimension. Therefore the equation is correct.

2 Check whether the equation

$$T = 2\pi\sqrt{\frac{m}{g}}$$ is dimensionally correct.

Where T is the time period

m is the mass of the bob

g is the acceleration due to gravity.

Ans: Given $T = 2\pi\sqrt{\frac{m}{g}}$ There fore $T^2 = 4\pi^2\left(\frac{m}{g}\right)$

Dimension of LHS , $[T^2] = M^0 L^0 T^2$

Dimension of [RHS], $\frac{m}{g} = \frac{M^1}{L^1 T^{-2}}$

$= [M^1 L^{-1} T^2]$

Dimension of LHS and RHS are not equal. Thus according to principle of homogeneity the equation is wrong.

3 The correctness of equations can be checked using the principle of homogeneity.

a) State the principle of homogeneity.

b) Using this principle, check whether the following equation is dimensionally correct.

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

Where **m** is the mass of the body, **v** is its velocity, **g** is the acceleration due to gravity and **h** is the height.

Ans; a) It states that " If an equation is correct all the terms will have the same dimension".

b) Dimension of $[mv^2] = M^1 (L^1 T^{-1})^2$

$= [M^1 L^2 T^{-2}]$

Dimension of $[mgh] = [M^1 L^1 T^{-2} L^1]$

$= [M^1 L^2 T^{-2}]$

Both the terms have the same dimension. There fore by the principle of homogeneity the equation is correct.

4 Check the correctness of given equation using the method of dimensions

a) F=ma where F is force, m-mass, a -acceleration

b) v=u+at where v-final velocity, u- initial velocity a-acceleration, t-time

5 A company manufacturing PVC pipes claims in an advertisement that the volume of water flowing out through the pipe in a given time as per the equation $\mathbf{V = KA^2 ut}$ where A is the area of cross section of the pipe, u is the speed of flow, t is the time and K is a dimensionless constant.

a)Name and State the principle that can be used to check the dimensional correctness of this equation.

b)Check the equation and state whether the claim can be correct.

Ans: a)The principle of homogeneity of dimensions.

It states that " If an equation is correct all the terms will have the same dimension"

(b) $[V] = L^3$

$[A^2 ut] = (L^2)^2 \; LT^{-1} \; T^1 = L^4 \; LT^{-1} \; T^1 = L^5$

Dimension of [V] is not equal to the dimension of $[A^2 ut]$.

The equation is not correct . That is the claim cannot be correct.

6 The correctness of an equation is checked using the principle of homogeneity for an equation $\mathbf{X = a + bt + ct^2}$, where 'X' is in meter and t in second. What will be the dimension of a,b and c?

Ans: **According to the principle of homogeneity**

$[X] = [a] + [bt] + [ct^2]$

$[X] = [a] = [L]$

[X] =[bt] which means $[b] = \frac{[X]}{[t]} = \frac{[L]}{[T]} = L T^{-1}$ $[b] = [LT^{-1}]$

[X] =[ct²] which means $[c] = \frac{[X]}{[t^2]} = \frac{[L]}{[T^2]} = L T^{-2}$ $[c] = [LT^{-2}]$

7 State the Principle of homogeneity of dimensions.

Find the dimensions of each terms in the equations given below and check whether the equations obeys the above principle.

i) $S = ut + 1/2\, at^2$

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

Where u--> initial velocity. v--> final velocity

a--> acceleration S--> displacement t--> time

Ans:

(a)It states that " If an equation is correct all the terms will have the same dimension"

(b)(i)$S = ut + 1/2\, at^2$

Dimension of $[s] = L^1$

Dimension of $[ut] = L^1 T^{-1} T^1 = L^1$

Dimension of $[at^2] = L^1 T^{-2} T^2 = L^1$

All the terms have the same dimensions. Thus the equation obeys the principle of homogeneity of dimensions.

(ii) $V^2 = u^2 + 2as$

Dimension of $[V^2] = (L^1T^{-1})^2 = L^2T^{-2}$

Dimension of $[u^2] = (L^1T^{-1})^2 = L^2T^{-2}$

Dimension of $[as] = L^1T^{-2}\,L^1 = L^2T^{-2}$

All the terms have the same dimensions. Thus the equation obeys the principle of homogeneity of dimensions.

8 The correctness of equation can be checked using the principle of homogeneity in dimensions.

(a) State the principle of homogeneity,

(b) Using this principle, check whether the equation is dimensionally correct, $f = 2\pi\sqrt{\frac{l}{g}}$

where f-frequency, l - length and g-acceleration due to gravity.

(c) The velocity V of a particle depends on time 't' as $V = At^2 + Bt$.
Find the dimensions and units of A and B

Ans: a) It states that " If an equation is correct all the terms will have the same dimension"

b) Dimension of $f = T^{-1}$

Dimension of $\sqrt{\frac{l}{g}} = \sqrt{\frac{L^1}{L^1T^{-2}}}$

$= \sqrt{T^2}$

$= T^1$

Dimension of LHS not equal to RHS. There fore the equation is wrong.

c) Dimension of $A = L^1T^{-3}$ unit of A $= ms^{-3}$

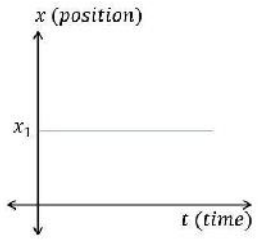
Dimension of $B = L^1T^{-2}$ unit of B $= ms^{-2}$

9 Draw the position time graph for

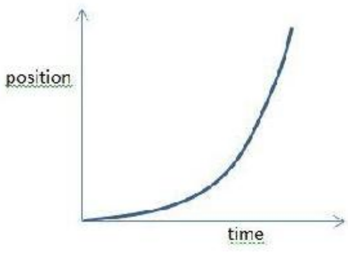
a) State of rest

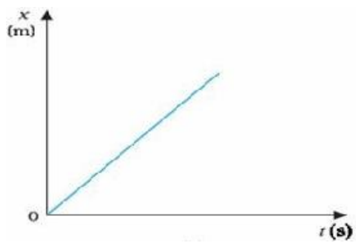
b) State of motion

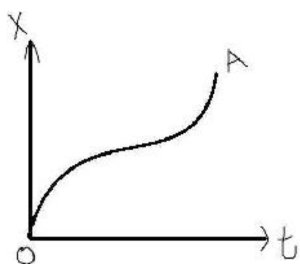
Ans: a) State of rest



b) State of Motion





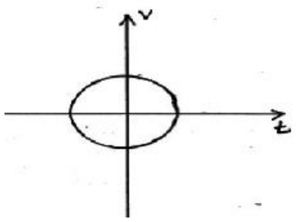


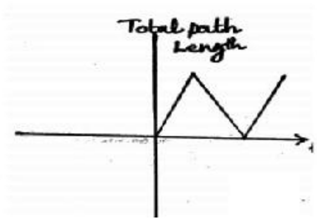
10 What are the differences between distance and displacement ?

Ans:

DISTANCE	**DISPLACEMENT**
Actual length of the path	Shortest distance from initial position to final position.
Scalar	Vector
Always positive	Can be positive ,zero and negative

11 Graph representing the motion of two bodies are shown below.. State with reason whether it can represent one-dimensional motion.





Ans:

i) Can not represent one dimensional motion. Because velocity can not have two values at the same time.

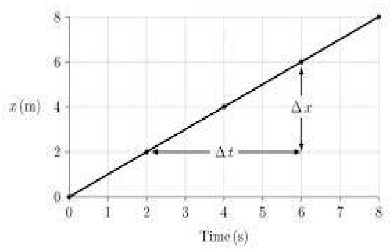
ii) Can not represent one dimensional motion. Because path length can not be decreased with time.

12 Show that the slope of position-time graph gives velocity.

Ans: The slope is given by $Slope = \tan\theta$

$= \dfrac{\Delta x}{\Delta t}$

= velocity.



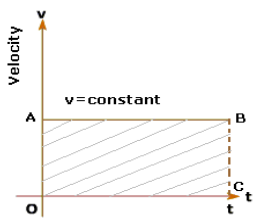
That is the slope of position time graph gives the Velocity.

13 Draw the velocity-time graph for an object in uniform motion. Show that area under the velocity – time graph gives displacement.

Ans: From the graph

Area under the graph = v x t

= Displacement.



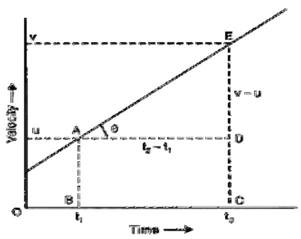
That is the area under the Velocity – time graph represents the displacement.

14 Draw the velocity -time graph for uniformly accelerated motion. Show that the slope of velocity-time graph gives acceleration.

Ans: The slope of the graph = tan θ

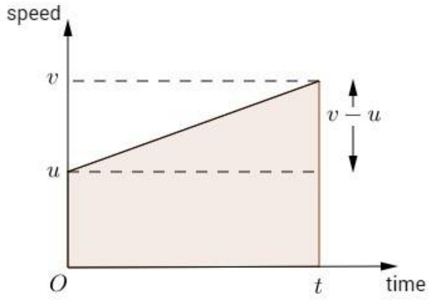
$= \dfrac{\Delta V}{\Delta t}$

= acceleration.



That is the slope of velocity-time graph gives the acceleration of the body.

15 Show that area under the velocity-time graph of an object moving with constant acceleration in a straight line in certain time interval is equal to the distance covered by the object in that interval.



B

A

D

Ans: Area under the velocity-time graph = Area of trapezium OABD

$$= \frac{1}{2}(OA + BD) \times OD$$

$$= \frac{1}{2}(u + v) \times t$$

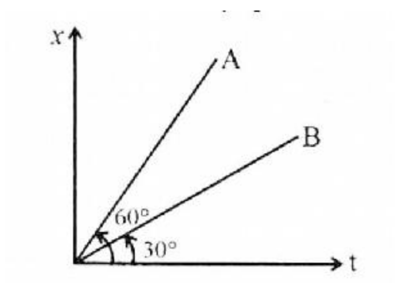
= Average velocity x time interval

= Distance travelled.

16 The position - time graph of two objects A and B are shown below.

(a) Which body has greater velocity?

(b) Find the ratio of velocities of A and B.



Ans: a) Body A.[The slope of position time graph gives the velocity. Higher the slope greater the velocity]

b) Ratio of velocities

$$\frac{V_A}{V_B} = \frac{Slope\ of\ A}{Slope\ of\ B}$$

$$\frac{V_A}{V_B} = \frac{\tan 60}{\tan 30}$$

$$\frac{V_A}{V_B} = \frac{\sqrt{3}}{1/\sqrt{3}}$$

= 3

17 A football is kicked into the air vertically upwards. What is its

(a) acceleration at the highest point

(b) velocity at the highest point?

Ans: (a) At highest point the acceleration remains same as acceleration due to gravity

(b) At highest point, velocity becomes zero

18 If horizontal range is equal to 4 times maximum height. Find the angle of projection?

Ans:

$\tan \theta = \frac{4H}{R}$

Here R = 4H   So θ=45

19 A ball is projected with a velocity 30m/s. Find the maximum range?(take $g=10m/s^2$)

Ans : R = $\frac{u^2}{g}$

R= 30x30/10

R=900/10

R=90m

20 State the law of conservation of Linear momentum

Ans: The law of conservation of momentum states that "The total momentum of an isolated system is conserved."

21 Using Newton's second law of motion, derive the equation F = ma

Ans: By Newton's second law,

$$\vec{F}=k\frac{d\vec{P}}{dt}$$

But $\vec{P}=m\vec{v}$

Therefore

$$\vec{F}=k\frac{d(m\vec{v})}{dt}$$

$$\vec{F}=km\frac{d\vec{v}}{dt}$$

$$\vec{F}=km\vec{a}$$

But k=1 Therefore $\vec{F}=m\vec{a}$

22 State the law of conservation of linear momentum and prove it on the basis of second law of motion.

Ans: The law of conservation of momentum states that "The total momentum of an isolated system is conserved."

Consider two bodies A and B, with initial momenta $P_A$and P_B. And after collision the final momenta P'_A and P'_B respectively.

By the Second Law

$$\mathbf{F}_{AB}\Delta t = \mathbf{p}'_A - \mathbf{p}_A \quad \text{and}$$

$$\mathbf{F}_{BA}\Delta t = \mathbf{p}'_B - \mathbf{p}_B$$

Since $\mathbf{F}_{AB} = -\mathbf{F}_{BA}$ by the third law,

$$\mathbf{p}'_A - \mathbf{p}_A = -(\mathbf{p}'_B - \mathbf{p}_B)$$

i.e. $$\mathbf{p}'_A + \mathbf{p}'_B = \mathbf{p}_A + \mathbf{p}_B$$

which shows that the total final momentum of the isolated system equals its initial momentum.

23 A cricketer moves his hands backwards while holding a catch. Write the reason.

Ans: To reduce the impact of momentum by increasing the time of contact.

24 Explain why a passenger standing in a moving bus tends to fall forward while the driver applies a sudden brake ?

Ans: explanation based on Inertia of motion

25 Find out the sign of work done in the following cases:

a) Work done by a man in lifting a bucket out of well.
b) Work done by friction on a body sliding down an inclined plane.
c) Work done by an applied force on a body moving on a rough horizontal surface.
d) Work done by the resistive force of air on a vibrating pendulum.

Ans: a) Positive.
b) Negative.
c) Positive
d) Negative.

26 Two bodies of masses m_1 and m_2 have the same linear momentum. What is the ratio of their kinetic energies ?

Ans: Kinetic Energy $KE=\frac{P^2}{2m}$

Given momentum of masses m_1 and m_2 are same.

Therefore $\frac{KE_1}{KE_2}=\frac{m_2}{m_1}$

27 Write any two properties of conservative force

Ans: 1. The work done by the conservative force depends only on the end points.
2. The work done by this force in a closed path is zero.

28 A light body and a heavy body have equal kinetic energies, which one has greater momentum? Why?

Ans: Heavy body.

Kinetic Energy $KE=\frac{P^2}{2m}$

Given Kinetic Energy are same.

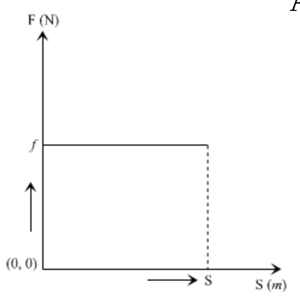
There fore $P^2 \alpha m$ Thus heavy body have greater momentum.

29 Ramesh lifts a body of mass 'm' to a height 'h' near the surface of the earth in a time 't'.

a) Draw the force-displacement graph.

b) If 'A' is the area of the graph, what quantity does $\frac{A}{t}$ indicate?

Ans: a)



b) Area under the graph , A = Work.

Therefore $\frac{A}{t}=\frac{Work}{time}=Power$

30 Work is required to lift a body through a height from the ground.
Calculate the work done in lifting a body of mass 10 kg to a height of 10 m above the ground.
Ans:
Workdone= m g h = 10×9.8×10 = 980 J

31 A car and a truck have the same kinetic energies at a certain instant while they are moving along two parallel roads.
a) Which one will have greater momentum?
Ans
KE is same = E say. We have P = $\sqrt{2mK.E}$
P_c = $\sqrt{2m_c E}$ P_t = $\sqrt{2m_t E}$ since m_t > m_c we get P_t > P_c
b) If the mass of truck is 100 times greater than that of the car, find the ratio of the velocity of the truck to that of the car.
Ans: E = $\frac{1}{2}m_c v_c^2 = \frac{1}{2}m_t v_t^2$ => $\frac{V_t}{V_c} = \sqrt{\frac{m_c}{m_t}} = \sqrt{\frac{1}{100}} = \frac{1}{10}$
c) A motorcycle and a bus are moving with same momentum. Which of them has greater kinetic energy? Justify.
Ans: $P_m = P_b$ = P (say) K. E = $\frac{P^2}{2m}$
$E_m = \frac{P^2}{2m_m}$ $E_b = \frac{P^2}{2m_b}$ since $m_m < m_b$ we get $E_m > E_b$

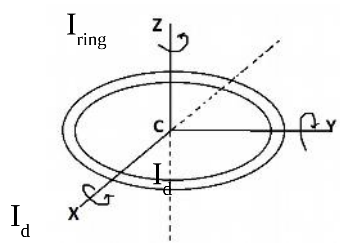
32 Moment of inertia can be regarded as a measure of rotational inertia. Why?
Write any two factors on which the moment of inertia of a rigid body depends.

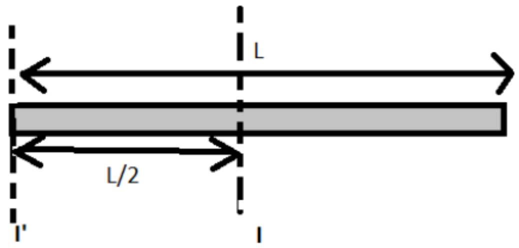
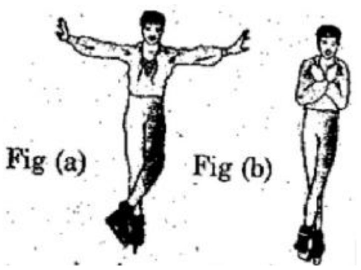
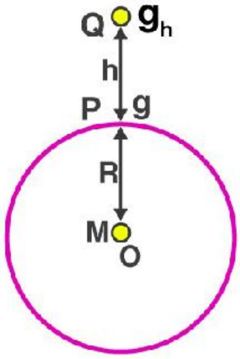
Ans: Moment of inertia resists any change in the rotational motion of the body. So it is called rotational inertia. (Note: Inertia means "resistance to change")

33 Remya stands at the centre of a turntable with her two arms outstretched. The table with an angular speed of 40 revolutions / minute.
a) What will happen to the moment of inertia if she folds her hands back?
b) If the angular speed is increased to 100 revolutions / minute, what will be the new moment of inertia?
Ans: a) Moment of inertia decreases.
b) We have according to the law of conservation of angular momentum, $I_1 \omega_1 = I_2 \omega_2$
$I_1 \times 40 = I_2 \times 100$ or $I_2 = I_1 \times 0.4$. Moment of inertia will be 0.4 times initial value.

34 Derive the relation between torque and angular momentum
Ans:
Angular momentum $\vec{L} = \vec{r} \times \vec{P}$ P=m×v
$\frac{d\vec{L}}{dt} = \frac{d}{dt}(\vec{r} \times \vec{P}) = \vec{r} \times \frac{d\vec{P}}{dt} + \frac{d\vec{r}}{dt} \times \vec{P}$ Where $\frac{d\vec{r}}{dt} \times \vec{P} = \vec{v}\, x\, m\, x\, \vec{v} = 0$
$\frac{d\vec{L}}{dt} = \vec{r} \times \vec{F}$ =τ (Torque)

35 Find the moment of inertia of the ring about its diameter.
Ans: We have $I_{ring} = MR^2$
By Perpendicular axes theorem
$I_d + I_d = MR^2$
$2I_d = MR^2$
$$I_d = \frac{MR^2}{2}$$



	This is the Moment of inertia of a thin circular ring of radius 'R' and mass 'M' about an axis passing through diameter.
36	The moment of inertia of a thin rod of mass M and length l about an axis perpendicular to the rod at its mid point is $\frac{ML^2}{12}$. Find the moment of inertia of the rod about an axis perpendicular to it and passing through one end of the rod. Ans:  Moment of inertia of a thin rod (scale) of length 'L' about an axis passing through mid point and perpendicular is given by $I_{rod}=\frac{ML^2}{12}$ By Parallel axis theorm, $I_{end}=I_{rod}+M\left(\frac{L}{2}\right)^2$ $I_{end}=\frac{ML^2}{12}+\frac{ML^2}{4}$ $I_{end}=\frac{ML^2}{3}$ This is the moment of inertia of the rod about an axis perpendicular to it and passing through one end of the rod.
37	The figure shows two different spinning poses of a ballet dancer. In which spinning pose does the ballet dancer have less angular velocity? Justify your answer.  Ans: Figure (a). Angular momentum L =Iω is a constant . Thus when she stretches his hands moment of inertia 'I' increases and hence angular velocity 'ω' decreases.
38	Derive an expression for variation of 'g' with height 'h' from the surface of earth. Ans:  Let g--> acceleration due to gravity on the surface of earth. **g_h**--> acceleration due to gravity at a height 'h'. h--> height from the surface of earth. R--> Radius of earth. M--> Mass of earth. We have $g=\frac{GM}{R^2}$ and $g_h=\frac{GM}{(R+h)^2}$

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

For $\frac{h}{R} << 1$, using binomial expression,

$$g_h = g[1-\frac{2h}{R}]$$

Thus the acceleration due to gravity decreases with height from the surface of earth.

39 Can a person on the moon experience weight? Why?

Ans: Yes. Because there is a gravitational force of moon acting on the person. It is approximately 1/6 th of that due to earth. So the person experiences weight.

40 Why does earth impart same acceleration on all bodies?

Ans: Acceleration due to gravity $g = \frac{GM_E}{R_E^2}$

Where G--> gravitational constant.

M_E --> mass of earth

R_E --> Radius of earth.

Here Acceleration due to gravity is independent of shape, size and mass of the body. Thus earth impart same acceleration on all bodies.

41 At what height 'h' the value of 'g' will be half of that on the surface of the earth? (Radius of earth is =6400km)

Ans: At a height 'h'

$$g_h = g[\frac{R}{R+h}]^2$$

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

$$\frac{g}{2} = g[\frac{R}{R+h}]^2$$

$$\frac{1}{2} = [\frac{R}{R+h}]^2$$

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

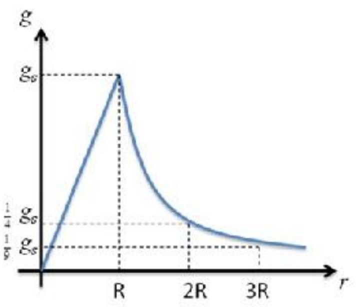
$$R+h = \sqrt{2}R$$

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

Therefore $h = (1.44-1)x\,6400 = 2650\,km$.

42 Draw a graph showing the variation of 'g' with depth and height from the surface of the earth. Assume that the density of earth is constant.

Ans:

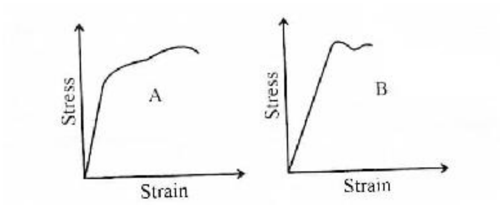


43 a)The kinetic energy of a satellite revolving around earth is 200MJ. What is its potential energy?

Ans:
a)Potential energy of the satellite = - 400 M J
b)How much energy is required for it to escape from the gravitational pull of earth?
Ans:Minimum 200MJ energy (= T.E) is required to escape from the gravitational pull of earth.

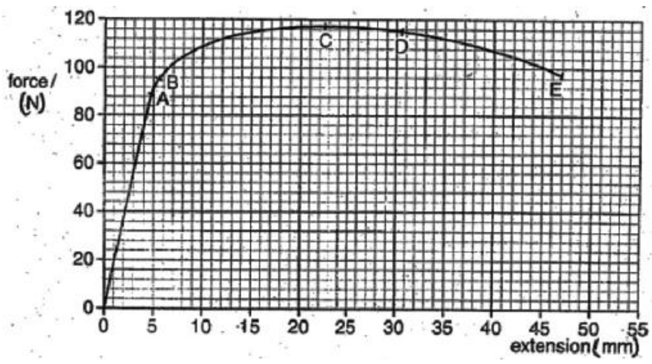
44 What is an elastomer? Give examples.
Ans: Materials for which stress-strain graph is not a straight line within elastic limit.
Do not obey Hooke’s law.
The elastic region is very large.
No plastic region.
Examples: Rubber, the elastic tissue of aorta.

45 The Stress-Strain graph of two materials A and B are shown below.
(a)State the law which relates stress with strain.
(b)Which of the two materials is more ductile?



Ans:(a) It states that “within the elastic limit stress is directly proportional to strain”.
(b) material A

46 The graph below shows how the force applied to a metal wire is related to the extent ion of the wire.



Write the letter that corresponds to:
i) Elastic limit
ii) Fracture point
Ans: i) B
ii) E

47 Which is more elastic, steel or rubber? Why?
Ans: Steel. For a given stress , strain is small for steel.

48 We can cut an apple easily with a sharp knife as compared to with a blunt knife. Explain why?

Ans: The area of a sharp edge is much less than the area of a blunt edge. For the same total force, the effective force per unit area (or pressure) is more for the sharp edge than the blunt one. Hence a sharp knife cuts easily than a blunt knife.

49 Why bullets are given cylindrical shape?
Ans:
The Magnus effect is absent if the spinning cylinder is moving linearly in the direction parallel to spin axis. That is why the bullets are made cylindrical instead of spherical. They do not deviate from the linear path.

50 In hydraulic machine, the two pistons are of area of cross section in the ratio 1:10. What force is needed on the narrow piston to overcome a force of 100N on the wider piston?

Ans: F_1 = 100N A_1 = 10m^2
F_2 =xN A_2 = 1m^2

Since pressure = constant

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

$\frac{100}{10}=\frac{x}{1}$

x= 10N

51 Why are sleepers used below the rails? Explain.

Ans: When sleepers are placed below the rails, the area of the cross section is increased. We know that P = F/A, so when the train runs on the rails, the pressure exerted on the ground due to the weight of the train is small because of a large area of cross-section of the sleeper. Hence the ground will not yield under the weight of the train.

52 Blood pressure in humans is greater at the feet than at the brain. Explain why.
Ans: According to pressure depth relationship P = hρg, h–depth, ρ–density and g–acceleration due to gravity. As per the above equation blood pressure in humans will be greater at the feet than at the brain.

53 Why do the metal utensils have wooden handles?
Ans: Wood is a bad conductor of heat. Wooden handle does not allow heat to be conducted from the hot utensil to the hand. So we can easily hold the hot utensil with its help.

54 Stainless steel cooking pans are preferred with extra copper bottom. Why?

Ans: The thermal conductivity of copper is much larger than that of steel. The copper bottom allows more heat to flow into the pan and hence helps in cooking the food faster.

55 What is the effect of pressure on melting point of a solid ?

Ans: The melting point of a solid may increase or decrease depending on the nature of solid. For solids such as ice which contracts on melting, it is lowered while for solids such as sulphur and wax which expand on melting it increases.

56 Tea gets cooled, when sugar is added to it. Why ?

Ans: When sugar is added to tea, its heat gets shared by sugar. So the temperature of the tea decreases.

57 Why do we pack ice in gunny bags?

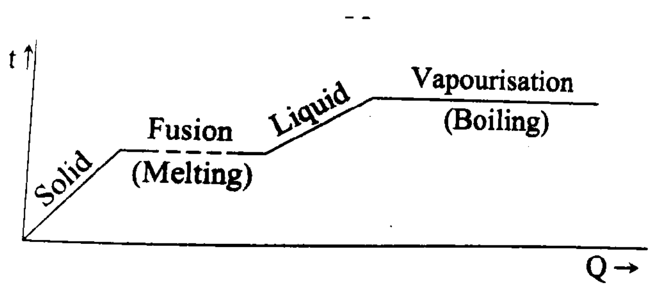
Ans: Gunny bags have a number of fine pores, which contain air in them. Air is a bad conductor of heat. Therefore, it does not allow the external heat to go in and melt the ice.

58 Why a thick glass tumbler cracks when boiling liquid is poured into it?
Ans: Its inner and outer surfaces undergo uneven expansion due to the poor conductivity of glass, hence it cracks.

59 A solid at 0°C is heated to convert it into its vapour. Draw a graph connecting temperature and the

quantity of heat supplied.

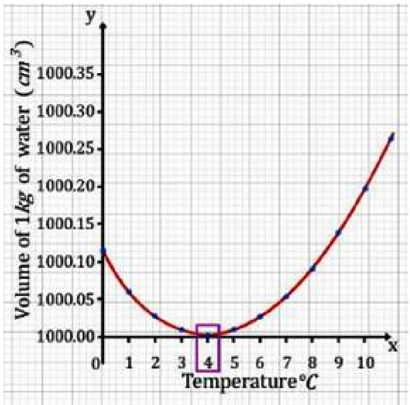
Ans:



60 During winter aquatic animals are saved under water in cold countries. Justify?

Ans:In cold countries during winter as the temperature of the atmosphere falls, the upper layer of water in the ponds, lakes etc cools and sinks to the bottom. This goes on until the whole water is cooled to $4^0 C$.When the top layer cools below $4^0 C$, it does not sink as its density is less than the water below it. Thus the top layer cools further and freezes but there is water at $4^0 C$ below the ice. Thus aquatic animals and plants are saved.

61 Draw the graph showing the variation of volume of a given mass of water with temperature from $0^0 C$. Mark the temperature at which water has maximum density.



62 State two essential requirements of an ideal heat engine.

Ans:

i)An ideal heat engine should have a source of infinite thermal capacity.

ii) It should have a sink of infinite thermal capacity.

63 State the first law of thermodynamics.

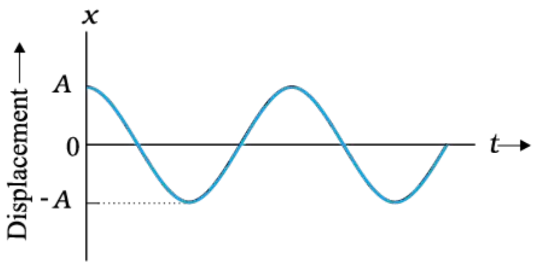
Ans: According to the first law of thermodynamics, the amount of heat ΔQ absorbed by a system capable of doing mechanical work is equal to the sum of the increase in internal energy ΔU of the system and the external work ΔW done by the system. Mathematically,

$dQ= dU+ dW=dU + PdV$.

64 Cooling is produced when a gas at high pressure suddenly expands. Why ?

Ans: During its expansion, the gas does work against high pressure. This decreases the internal energy and hence the temperature of the gas.

65 Carnot engine cannot have 100% efficiency. Explain, why ?

	Ans: Efficiency, n=1- $\frac{T_2}{T_1}$ The efficiency will be 100% or 1, if T_2, = 0 K. Since, temperature equal to 0 K cannot be realised, a heat engine with 100% efficiency cannot be designed.
66	Write the 4 steps of operation in the Carnot cycle. **Ans:** The Carnot cycle consists of two isothermal processes and two adiabatic processes. 1)Isothermal expansion 2)Isothermal compression 3)Adiabatic expansion 4) Adiabatic compression
67	How does the average kinetic energy of each gas in a mixture compare? Ans. The average kinetic energies are equal because they are at the same temperature.
68	Explain with the help of kinetic theory, why the pressure of a gas on its container walls rises when the volume is reduced. Ans. When the volume of gas is reduced, its pressure increases on account of the fact that: (i) the molecules have to travel a shorter distance between impacts on the container walls and (ii) these impacts are now distributed over a smaller area.
69	Is it possible to increase the temperature of a gas without adding heat to it? If yes, explain how? Ans. The temperature of a gas can be increased by compressing it. The work done in compressing the gas is converted into its internal energy which results in an increase in its temperature.
70	Define Simple Harmonic motion (SHM). Ans: Simple harmonic motion (SHM) is defined as such an oscillatory motion about a fixed point (mean position) in which the restoring force is always proportional to the displacement from that point and is always directed towards that point.
71	List any two conditions for a motion of a body to be simple harmonic. Ans; i. The restoring force is always proportional to the displacement from the mean position. ii. The restoring force is always directed towards the mean position.
72	Name two examples for simple harmonic motion. Ans: i. Oscillation of a loaded spring. ii. Oscillation of a simple pendulum.
73	A girl is swinging on a swing in the sitting position. How will the period of swing be affected if she stands up? Ans; Time period decreases, as the length of the pendulum decreases when she stands up.
74	Represent Simple Harmonic Motion graphically. Ans: 

75	A woman is hearing a sound of 680 Hz. Calculate the wave length of sound heard by her (speed of sound in air 340 m/s) Ans :- v = ν λ $\lambda = \frac{v}{\nu}$ $\lambda = \frac{340}{680}$ = 0.5m
76	A travelling wave in +X direction is representing as Y(x,t) = A sin (kx-ωt+ϕ).What are terms A,k,ω,ϕ in it ? Ans :- A→ amplitude k → wave number $k = \frac{2\pi}{\lambda}$ ω → Angular frequency $\omega = \frac{2\pi}{T} = 2\pi f$. ϕ is the Initial phase
77	If the tension of a string increases four times, how many times will the velocity increase? Ans:- $v \propto \sqrt{T}$ $v' \propto \sqrt{4T}$ $\frac{v'}{v} = 2$ $v' = 2v$
78	What is the temperature at which the velocity of sound in air is twice the velocity at 0ºC? Ans:- v ∝√T Case (I) = T=T_0 =0ºC = 273K $v \propto \sqrt{273}$ --------- (1) Case (II) T =? Velocity = 2v $2v \propto \sqrt{T}$ ----------- (2) $\frac{2v}{v} = \sqrt{\frac{T}{273}}$ $2 = \sqrt{\frac{T}{273}}$ $4 = \frac{T}{273}$ T = 4 x 273 K
79	Write newton–laplace equation Ans :- $V_{(\text{sound in gas})} = \sqrt{\frac{\gamma P}{\rho}}$ Where $\gamma \rightarrow$ *specific heat ratio* P→ pressure ρ → Density of medium
80	How pressure is effected on velocity of sound Ans :- We know that $V_{(\text{sound in gas})} = \sqrt{\frac{\gamma P}{\rho}}$ At constant temperature $\frac{P}{\rho}$ = constant So velocity of sound is independent on pressure
81	Given below are some functions of x and t to represent the displacement (transverse or longitudinal) of an elastic wave. State which of these represent (i) a travelling wave, (ii) a stationary wave or (iii) none at all

(a) $y = 2\cos(3x)\sin(10t)$

(b) $y = 2\sqrt{x - vt}$

(c) $y = 3\sin(5x - 0.5t) + 4\cos(5x - 0.5t)$

(d) $y = \cos x \sin t + \cos 2x \sin 2t$

Ans:

a) The given equation represents stationary wave because the harmonic therms *kx* and ωt appear separately in the equation

b) The given equation does not contain any harmonic term. Therefore,it does not represent either a travelling wave or a stationary wave

c) The given equation represents a travelling wave as the harmonic terms *kx* and ωt are in the combination of *kx*-ωt

d) The given equation represents a stationary wave because the harmonic terms *kx* and ωt appear separately in the equation. This equation actually represents the superposition of two stationary waves

82 The equation of a transverse wave travelling on a rope is given by y=10sinπ × (0.01x - 2.00t) where y and x are in cm and t in seconds. Calculate The maximum transverse speed of a particle in the rope

Ans: given A = 10 cm

ω = 2π

Maximum particle Speed = A ω

= 10 x 2 π

= 62.8 cm/s

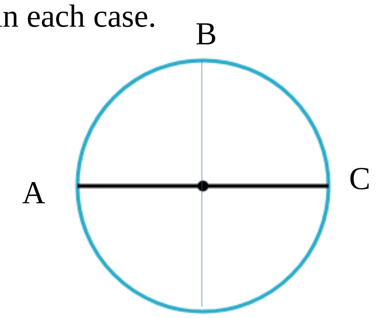
Each question scores Three

1 A particle moves along a circle of radius 'R'. It starts from 'A' and moves in clockwise direction. Calculate the distance and displacement of the particle in each case.

a) From 'A' to 'C'

b) From 'A' to 'B'

c) In one complete revolution.



Ans: a) From 'A' to 'C'

Distance = πR (2πR /2)

Displacement = 2R

b) From 'A' to 'B'

Distance = $\frac{2\pi R}{4} = \frac{\pi R}{2}$

Displacement = $\sqrt{R^2+R^2}=\sqrt{2R^2}=\sqrt{2}R$

c) For one complete revolution

Distance =2πR Displacement =0

2 Velocity is defined as the rate of change of displacement.

a) Distinguish between average velocity and instantaneous velocity.

b) When does the average velocity becomes equal to the instantaneous velocity?

Ans: a) Average velocity: It is the ratio of total displacement travelled to the total time taken.

Instantaneous velocity: The velocity at any instant. $\vec{V}_i=\frac{d\vec{x}}{dt}$

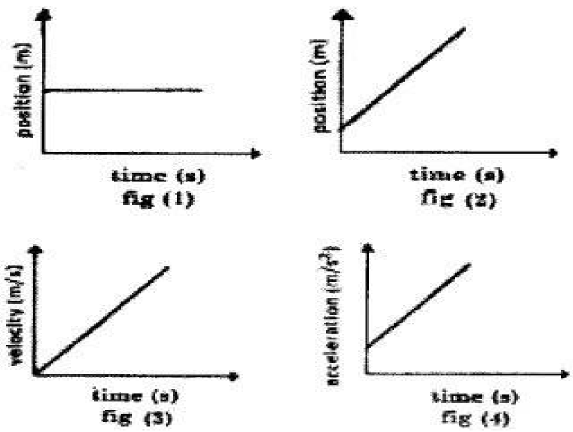
b) When the velocity is uniform or constant.

3 A body falling under the effect of gravity is said to be in free fall.

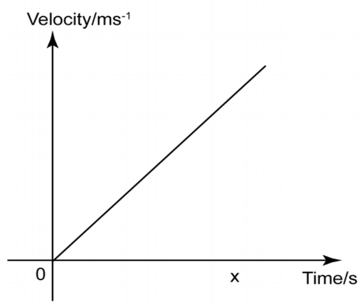
a. Draw the velocity-time graph for a freely falling object.

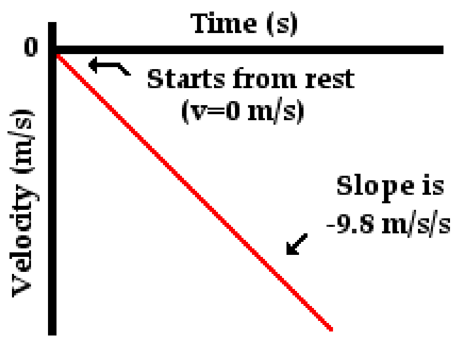
b. Define uniform acceleration.

c. From the given figures, identify the figure which represents uniformly accelerated motion.



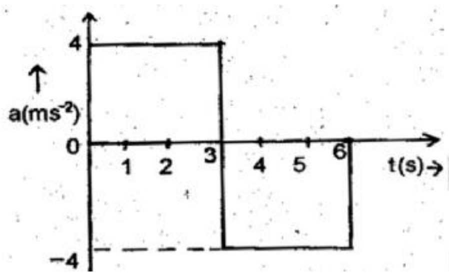
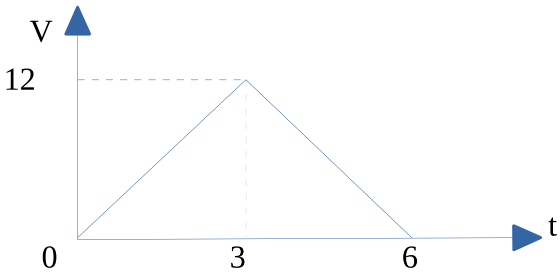
Ans: (a)





(b) If a body travels with equal change in velocity in equal intervals of time then it is said to be in uniform acceleration.

(c) Fig 3

4	Acceleration – time graph of a body starts from rest as shown below:  a)What is the use of the acceleration-time graph? b)Draw the velocity – time graph using the above graph. c)Find the displacement in the given interval of time from 0 to 3 seconds. Ans: a) Uses of acceleration-time graph: (i) To find acceleration at any instant. (ii) To find velocity. b)  c)Displacement = Area under the graph. = $\frac{1}{2} x 12 x 3 = 18 m$.
5	When breaks are applied on a moving vehicle, it stops after travelling a distance. This distance is called stopping distance. a) Derive an expression for stopping distance in terms of initial velocity (u) and retardation (a). b) If the initial speed is doubled keeping the retardation same, by how much will the stopping distance change? Ans: a) By the equation of motion, $v^2 = u^2 + 2as$ Here v=0 a=-a retardation , S--> Stopping distances Therefore $0 = u^2 - 2as$ Stopping distance $S = \frac{u^2}{2a}$ b) Stopping distance $S = \frac{u^2}{2a}$ If u = 2u, then $S' = \frac{(2u)^2}{2a} = \frac{4u^2}{2a} = 4S$ That is Stopping distance becomes four times.
6	(a) Give the expression to find the unit vector of a given vector $\vec{A}$ (b) Find the unit vector of $\vec{A}$ = $4\hat{i} - 3\hat{j} + \hat{k}$ Ans: (a) The unit vector of $\vec{A}$,

$$\hat{A}=\frac{\vec{A}}{|\vec{A}|}$$

(b) $\vec{A} = 4\hat{i}-3\hat{j}+\hat{k}$

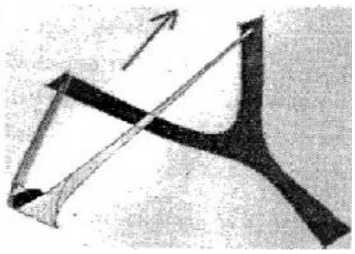
Here $|\vec{A}|=\sqrt{A_x^2+A_y^2+A_z^2}$

$$|\vec{A}|=\sqrt{4^2+(-3)^2+1^2}$$

$$|\vec{A}|=\sqrt{16+9+1}=\sqrt{26}$$

There fore $\hat{A}=\frac{\vec{A}}{|\vec{A}|} = \frac{4\hat{i}-3\hat{j}+\hat{k}}{\sqrt{26}}$

7 A stone is thrown with the help of a sling with initial velocity 'u' at an angle 'θ' from the horizontal.



a) Working of sling is based on........... law of vector addition.

b) Derive the expression for the maximum height reached by the stone.

Ans:

a)Parallelogram law of vector addition.

b) **Expression for Maximum height(H):**

We have $V^2=u^2+2as$

Taking the vertical components;

$$V_y^2=u_y^2+2a_y s_y$$

Here Vy=0, u_y=usinθ , a_y=-g and S_y =H

Therefore $0=(u\sin\theta)^2-2gH$

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

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

8 A gun moves backward when a shot is fired from it.

(a) Choose the correct statement.

(i)The momentum of the gun is greater than that of the shot.

(ii)The momentum acquired by the gun and shot have the same magnitude.

(iii)Gun and shot acquire the same amount of kinetic energy.

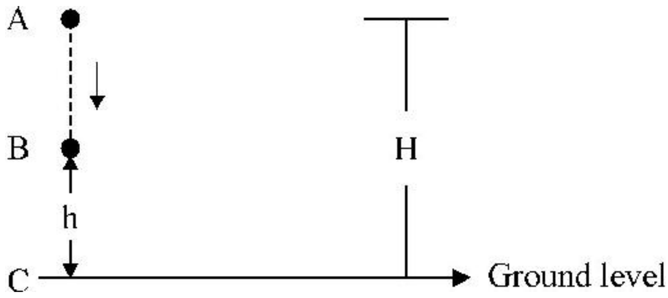
(b)A shell of mass 0.020 kg is fired by a gun of mass 100 kg. If the muzzle speed of the shell is 80 m/s, what is the recoil speed of the gun?

Ans: (a)(ii) The momentum acquired by the gun and shot have the same magnitude.

(b) Recoil speed of the gun , $V=\frac{-mv}{M}$

9 A machine gun fires bullets of mass 40 g each with a speed of 1200 ms $^{-1}$.The person can hold the gun with a maximum force of 144 N. What is the maximum number of bullets that can be fired per second from the gun?

Ans:

	By Newton's second law of motion $F = \frac{dp}{dt} = \frac{n(mv)}{dt}$ Where 'n' is the number of bullets per second. Therefore $144 = \frac{n(40\,x\,10^{-3}\,x\,1200)}{1}$ $n = \frac{144}{48}$ =3 bullets.
10	An object is dropped from a height H as shown below :  Show that total energy is conserved at the points A, B and C. Ans: **At the point 'A':-** Kinetic Energy , KE =0 (because velocity u=0) Potential Energy , PE =mgH Therefore, Total Energy , TE = KE+PE =**mgH**.-------(1) **At the point 'B' :-** Kinetic energy , KE = $\frac{1}{2}mv_1^2$ But $v_1^2 = 2g(H-h)$ (because u=0, a=g) Therefore , KE =mg(H-h) and PE = mgh Therefore TE = KE +PE =mg(H-h)+ mgh =**mgH** --------(2) **At the point 'C':-** Kinetic energy , KE = $\frac{1}{2}mv^2$ But $v^2 = 2gH$ (because u=0, a=g) Therefore , KE =mgH and PE = 0 Therefore TE = KE +PE =mgH+ 0 =**mgH** --------(3) Thus Equation (1) , (2) and (3) shows that the total energy of a freely falling body is constant at every point along its path.
11	a. State and explain the work done in the following situations: i) A person carrying a heavy load walks on a level road. ii) A man spending his energy by pushing on a concrete wall. b. A constant force of 200 N displaces a body through 5m in the direction of the force. Find the work done on the body.

Ans: a) i) Zero ii) Zero.

b) Work done W= F.S=200×5 =1000J

12 a)Write the equation for potential energy of a spring.

b)A spring extended to a length x the energy stored is E. If it is extended a distance 2x, find the energy developed in the spring in terms of E.

Ans:

a) $E=\frac{1}{2}kx^2$

b) $E^1=\frac{1}{2}k(2x)^2=4E$

13 Moment of inertia of a uniform disc about an axis passing through the centre and perpendicular to the plane is $MR^2/2$

a) State Perpendicular axes theorem (1 score)

b) Derive the expression for moment of inertia of a uniform disc about an axis passing through the diameter. (2 score)

Ans: a) Statement $I_z=I_x+I_y$

b) $I_x=I_y=I_d$

$I_z=2I_d$

$I_d=\frac{I_z}{2}$ $\quad I_d=\frac{\frac{MR^2}{2}}{2}$ $\quad I_d=\frac{MR^2}{4}$

14 A girl rotates on a swivel chair as shown below.

a.)What happens to her angular speed when she stretches her arms?

b.) Name and state the conservation law applied for your justification.

Ans:(a) Angular speed decreases.

(b) 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.

15 Acceleration due to gravity decreases with depth.

(a). Prove the above statement by deriving the proper equation.

(b). Using the equation, show that acceleration due to gravity is maximum at the surface and zero at the centre of the earth.

Ans: (a) Let g--> acceleration due to gravity on the surface of earth.

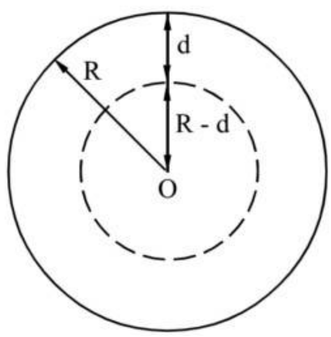
g_d--> acceleration due to gravity at a depth ‘d’.

d--> depth from the surface of earth.

R--> Radius of earth.

M--> Mass of earth.

ρ-->density of earth.



We have $g=\frac{GM}{R^2}$

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

Therefore $g=\frac{4}{3}\pi R\rho G$

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

Therefore $g_d = g[1 - \frac{d}{R}]$

Thus the acceleration due to gravity decreases with depth from the surface of earth.

(b) At the surface of earth d=0, therefore acceleration due to gravity is maximum. At the centre of earth d=R, therefore acceleration due to gravity is equal to zero.

16 Find the percentage change in g at a height 3200 Km from the surface of earth? (Radius of earth is =6400km)

Ans:

g' = $\frac{gR^2}{(R+h)^2}$

g'= $\frac{gR^2}{(R+\frac{R}{2})^2}$

g'= $\frac{gR^2}{\frac{(9R^2)}{4}}$

g'=4g/9

Percentage change

=(g-g')*100/g

=5*100/9

=55%

17 Hooke's law states that stress α strain.

a) What is the necessary condition for the above law to be valid?

b) Explain with the help of a graph, the relation between stress and strain for a given solid material under increasing tensile stress.

Ans: (a)The law is valid only for small deformation and it is obeyed only with in the elastic limit.

(b)

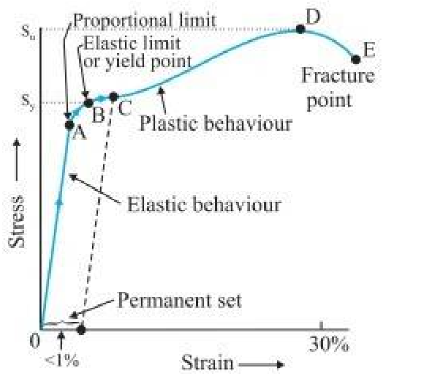
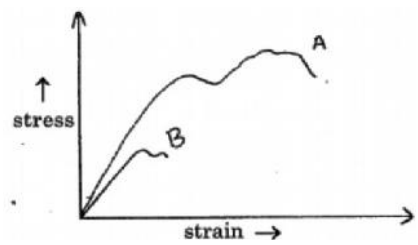
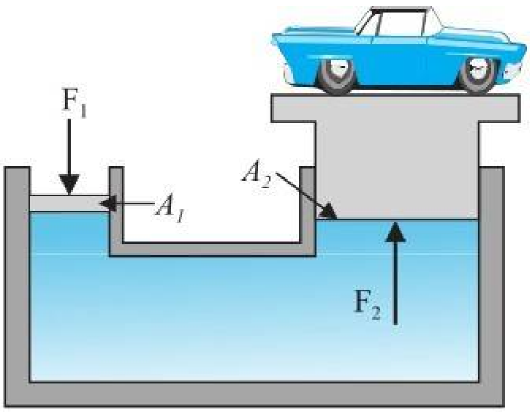


Fig. 2

18 The stress-strain graph for wires of two materials A and B are given below.



	a) Which material is more ductile? b) When a spring balances are continuously used for long time, they show wrong reading. Explain why. Ans: (a) Material 'A' (b) Due to elastic fatigue the spring temporarily losses its elasticity and the balance shows wrong reading.
19	Why it is dangerous to stand near the edge of the platform when a fast train is crossing it? Ans: When a fast train crosses the platform, the air dragged along with the train also moves with a high velocity. In accordance with Bernoulli's equation, the pressure in the region of high velocity gets decreased. If a person stands near the edge of the platform he may be pushed towards the train due to high pressures outside.
20	Hydraulic lift is a device used to lift heavy loads. State the principle behind the working of this device. Ans:Pascal's law When force is applied on a liquids the pressure is transmitted equally in all directions inside the liquids there fore the hydrostatic pressure has no fixed direction and hence it is a scalar quantity  Let, F_1 --> force on smaller piston. F_2 -->force developed on larger piston. A_1 --> area of smaller piston, A_2 --> area of larger piston. According to Pascal's law, the pressure applied on smaller piston is transmitted with out change at all points in the liquid. Thus $\frac{F_1}{A_1}=\frac{F_2}{A_2}$ Therefore $F_2=\frac{F_1}{A_1}A_2$ as $A_2 >> A_1$, $F_2 >> F_1$ This shows that the small force applied on the smaller piston will be appearing as a very large force on the large piston. As a result of which a heavy load placed on the larger piston is easily lifted upwards.
21	Two accidents happen. The first one with water at 100° C and the second one with steam at 100°C. (a) Which is more dangerous; burn due to water at 100°C or burn due to steam at 100° C? Why?

	(b) Latent heat of vaporisation of water is 536 cal/g. Explain the idea of latent heat of vaporisation. (c) Find the heat required to convert 1 g of ice at 0°C to steam at 100°C [Latent Heat of ice = 80 cal/g: specific heat of water =1 cal/g°C] Ans: (a) Burn due to steam is more dangerous because heat content in steam at 100°C is very high compared to that in water at 100° C. b) Quantity of heat required to convert 1g of water at its boiling point into steam at the same temperature is 536 cal. (c) Q= mL + mcΔθ +mL, Q =1x 80 +1x 1 x 100 +1 x 536 = 716 cal =3007 J.
22	The coefficient of thermal expansion in solids are mainly i) Coefficient of Linear Expansion α ii) Coefficient of Area Expansion β iii) Coefficient of Volume Expansion γ a. What is the ratio of α, β and γ? b. Invar is used for making pendulum of clocks. Why? Ans.. a. 1:2:3 b. Invar has extremely small coefficient of linear expansion. Therefore the length of the clock pendulum doesn't change appreciably with the change of season so the clock keeps correct time

23 Temperature is the degree of ‘hotness ‘of the body.

a) Temperature of a normal human body is 98.6^0F. What is the corresponding temperature shown in the Celsius scale?

Ans: 37 ^{0}C

Note: $tc = \frac{t_f - 32}{1.8} = \frac{98.6 - 32}{1.8}$

b) Complete the table.

Temperature	Kelvin scale	Celsius scale	Fahrenheit scale
Steam point	373.15 K		212.00^0F
Ice point		0.00^0C	32^0F.
Absolute zero	0.00K		459.69^0F

Ans:

Temperature	Kelvin scale	Celsius scale	Fahrenheit scale
Steam point	373.15 K	...100^0c.....	212.00^0F
Ice point	273.15	0.00^0C	32^0F.
Absolute zero	0.00K	- 273.15 ^{0}C	459.69^0F

24 a. When you are about to make tea from hot tea and cold milk, your phone is ringing.

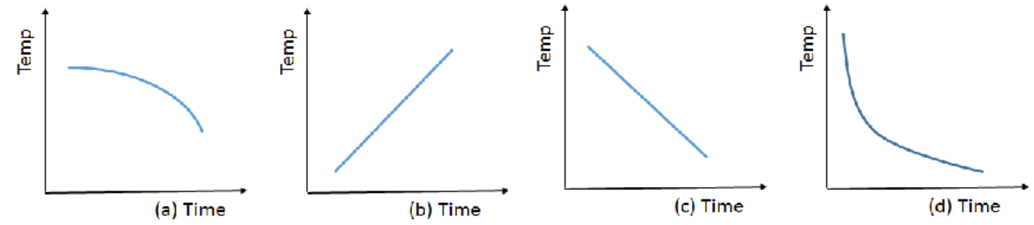
Which of the following can be done to keep the cup of tea hotter when you return after attending the phone call?

1) Pour hot tea and cold milk in your cup and leave it to attend phone call.

2) Mix the two after attending the call

Ans: Pour hot tea and cold milk in your cup and leave it to attend phone call.

b. Also indicate which among the curves below represents a cooling curve.



Ans: curve (d)

25 The time taken by a hot body to cool from 70^0c to 60^0c is 6 minutes. The surrounding temperature is 25^0c. What will be the time taken by the body to cool from 60^0c to 50^0c?

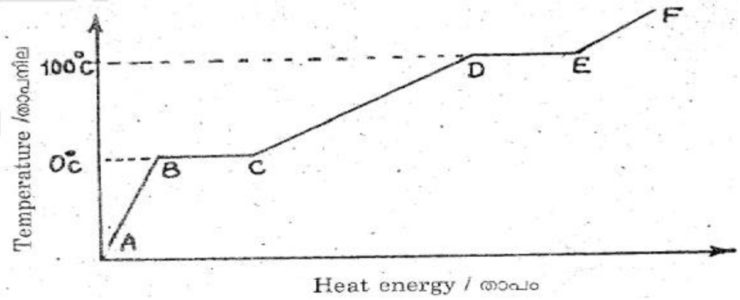
Ans: According to Newton's law of cooling $\frac{T_1 - T_2}{t} = K \left\{ \frac{T_1 + T_2}{2} - T_0 \right\}$

$\frac{70-60}{6} = K \left\{ \frac{70+60}{2} - 25 \right\}$ ------- (1)

$\frac{60-50}{t} = K \left\{ \frac{60+50}{2} - 25 \right\}$ --------(2)

$\frac{eq(1)}{eq(2)}$ --> $t = 6 \times \frac{40}{30}$ = <u>8 minutes</u>

26 The below graph represents temperature versus heat for water at 1 atm. pressure.



(a) Match the following using the above graph.

Graph	Process	State
i) BC	b) Sublimation	p) Water
ii) DE	a) Melting	q) Ice
	c) Regelation	r)Partially Solid and liquid
	d) Vaporisation	s) Partially liquid and vapour

Ans:

Graph	Process	State
i) BC	a) Melting	r)Partially Solid and liquid
ii) DE	d) Vaporisation	s) Partially liquid and vapour

b) The slopes of AB and CD are different. Why?

Ans: Specific heat capacity of ice and water are different (specific heat of ice < specific heat of water)

27 Derive the relation between coefficient of linear expansion and coefficient of area expansion

Consider a thin square plate of side 1m.

Original Area = $1 \times 1 = 1\,m^2$

Let the plate be heated so that its temperature increases by $1^0 C$

New area = = $(1+\alpha_l)(1+\alpha_l)$ $(1+\alpha_l)^2$

Increase in area = $(1+\alpha_l)^2 - 1$

$= \alpha_l^2 + 2\alpha_l$

$\cong 2\alpha_l$ (higher powers neglected)

$$\alpha_a = \frac{\Delta A}{A \Delta T} = \frac{2\alpha_l}{1 \times 1} = 2\alpha_l$$

28 Derive the relation connecting α_l and α_v .

Ans: $V = l^3$ $V_1 = l_1^3$

$V_1 = V(1+\alpha_v \Delta T)$....................(1)

$V_1 = [\ l\ ((1+\alpha_l \Delta T)\ ]^3$

$V_1 = [\ l^3\ (1+\alpha_l \Delta T)^3]$

$V_1 \approx [\ V\ (1+3\alpha_l \Delta T]$...............(2)

From (1) and (2)

$V(1+\alpha_v \Delta T) = V(1+3\alpha_l \Delta T)$

$\alpha_v = 3\alpha_l$

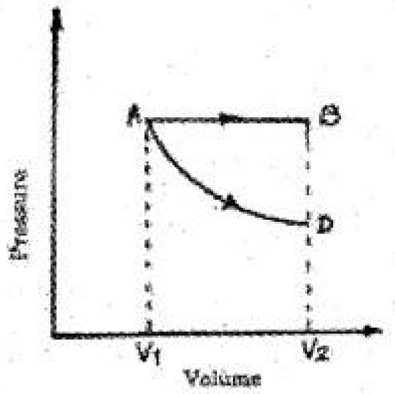
29 Calculate the efficiency of an engine working between steam point and ice point.

Efficiency $\eta = \frac{T_1 - T_2}{T_1} = \frac{373 - 273}{373}$

$\eta = 0.268$

$\eta = \underline{26.8\%}$

30 P-V diagram of a gas is shown in the figure. In this figure AB represents isobaric process and AD represents isothermal process.



a) Explain isobaric process and isothermal process.
b) Using the above graph, find the process in which the work done is maximum. Give the reason.

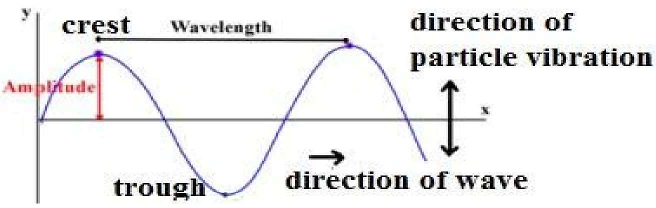
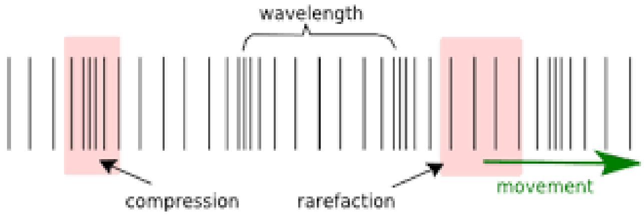
Ans:

a) The thermodynamic process at constant pressure is called isobaric process. Thermodynamic process at constant temperature is called isothermal process

b) The work done is maximum for AB because area under AB is more than that of AD

31 If an inflated tyre bursts, the air escaping out is cooled, why?

Ans: When the tyre bursts, there is an adiabatic expansion of air because the pressure of the air inside is sufficiently greater than the atmospheric pressure. During the expansion, the air does some

	work against the surroundings, therefore, its internal energy decreases, and as such temperature falls
32	Is it possible that there is no increase in the temperature of a body despite being heated ? **Ans:** Yes, for example, during a change of state (from solid to liquid or from liquid to gas), the system takes heat, but there is no rise in temperature. Internal energy of the system increases in each case
33	How does the ideal gas model explain the rise in pressure of a gas as its temperature is raised without changing its volume? Ans. Raising the temperature of the gas increases the kinetic energies of its molecules and as a result of that their speeds increase. The increased speeds of the particles not only means that they have larger momenta, but they also hit the walls more frequently.
34	A simple pendulum has a bob of mass m is suspended from the ceiling of a lift which is lying at the ground floor of a multi storied building. a) Find the period of oscillation of pendulum when the lift is stationary. b)What is the tension of the string of the pendulum when it is ascending with an acceleration 'a'? c) What is the period of oscillation of the pendulum while the lift is ascending? Ans: a) $T=2\pi\sqrt{\frac{l}{g}}$ b) Tension T = m(g+a) c) $T=2\pi\sqrt{\frac{l}{g+a}}$
35	Distinguish between longitudinal wave and transverse wave ? Ans :- **Transverse wave** A wave in which particles vibrate in perpendicular direction of its propagation They produce crest and trough as shown below.  Region with positive displacement of particles is called crest and region with negative displacement of particles is called trough They can be polarized Eg: a wave through a string, light wave **Longitudinal wave** A wave in which particle vibrate in parallel of its propagation They produces compressions and rarefactions as shown below 

Region with high pressure in medium is called compressions and Region with low pressure in medium is called rarefaction They can't be polarized
Eg: a wave through a spring, sound wave

36 A transverse harmonic wave on a string is described by y(x,t) = 3.0 sin (36t + 0.018x + π/4) where x and y are in cm. and t in s. The positive direction of x is from left to right.

a)Is it is travelling or stationary wave?
b)What is the initial phase at the origin?
c)What are its amplitude and frequency?
d)If it is a travelling wave, what are the speed and direction of its propagation?
Ans :-

a) Travelling

b) $\frac{\pi}{4}$

c) Amplitude of the wave, A = 3 cm
and frequency, $\omega = 2\pi f$

f = $\frac{\omega}{2\pi}$ = $\frac{36}{2\pi}$ = 5.73 Hz

d) v = f λ   k=0.018

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

λ = $\frac{2\pi}{k}$ = = $\frac{2 \times 3.14}{0.018}$ = 348.88 cm =3.48 m

v = f λ   v = 5.73 × 3.48 = 19.94 m/s

37 A wave travelling along a string is described by, $y_{(x,t)} = 0.005 \sin(80.0x - 3.0t)$ in which all the numerical constants are in SI units. Calculate the wavelength and frequency of the wave.

Ans :- k= 80

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

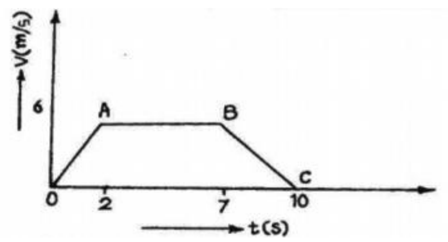
λ = $\frac{2\pi}{k}$ = $\frac{2 \times 3.14}{80}$ = 0.078m

$\omega = 3$ $\omega = 2\pi f$

$3 = 2\pi f$ f = $\frac{3}{2\pi}$ = 0.477 Hz

Each question scores Four

1 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.

Ans: a) BC

b) Displacement = Area under the line AB(from 2s to 7s);

= 6 x 5 =30 m.

c) We have $S=ut+\frac{1}{2}at^2$

Here S=-h u=0 a=-g

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

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

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

2 Acceleration is defined as the rate of change of velocity.

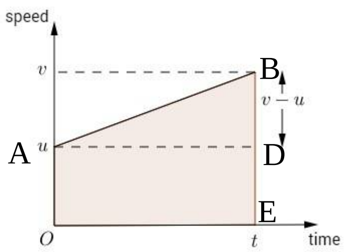
a) Is it possible for a body to have acceleration without velocity? Explain.

b) Draw the velocity–time graph of a body moving with uniform acceleration ‘a’ and initial velocity V_0

c) Using the above graph, obtain the equation for displacement in time ‘t’.

Ans: a)Yes. For example if a body is thrown up , at the highest point the velocity is zero but there is an acceleration downwards.

b)



c)Second equation of motion OR Displacement time relation:

From the graph

Displacement S = Area under the graph AB

= Area of rectangle OADE + Area of triangle ADB

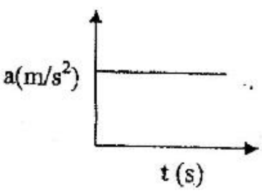
= $OA\times OE+\frac{1}{2}DB\times AD$

= $u\times t+\frac{1}{2}(v-u)\times t$

= $ut+\frac{1}{2}at\times t$

$S=ut+\frac{1}{2}at^2$ This is the displacement – time relation.

3 Acceleration – time graph of a body is shown below:

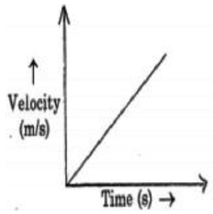


a)Draw the corresponding velocity-time graph.

b)What does the area under the velocity – time graph represent?

c)Arrive at a relation connecting velocity (v) and time (t) for a uniformly accelerated body.

Ans: a)



b) Displacement.

c)Velocity -time relation: $v = u + at$

Let u--> initial velocity v-->final velocity

a-->acceleration t-->time.

We have $acceleration = \frac{Change\ in\ velocity}{time}$

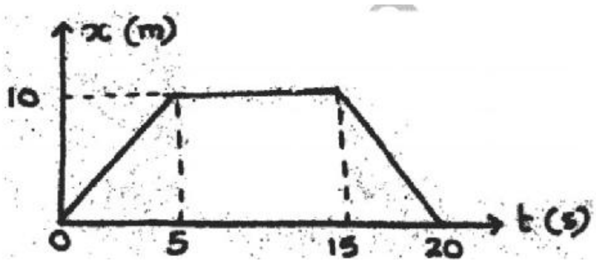
$$a = \frac{v-u}{t}$$

$$v - u = at$$

$$v = u + at$$

This is the velocity -time relation.

4 a) The figure shown the position – time graph of a body moving along a straight line.

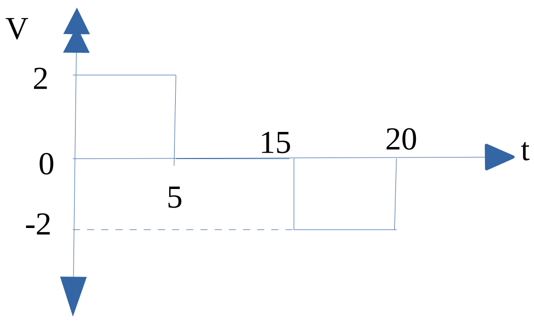


i) Draw the velocity-time graph of the body.

ii) From the graph, find the displacement in 20 seconds.

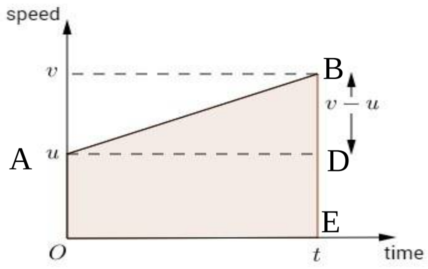
b) From the velocity-time graph of a body moving with uniform acceleration, deduce the velocity-time relation and the velocity-displacement relation.

Ans: a) (i)



(ii) Displacement = Area under the graph
=2 x 5 + (-2x5)
=0

b)



First equation of motion (velocity-time relation)

From the graph ,

Acceleration a = Slope of velocity time graph AB.

$$a=\frac{DB}{AD}=\frac{(v-u)}{t}$$

v – u = at

v=u+at

This is the first equation of motion or velocity-time relation.

Third equation of motion OR Velocity-Displacement relation:

From the graph

Displacement travelled S = Area of trapezium OABE

$$= \frac{1}{2}(EB+OA)\times OE=\frac{1}{2}(EB+ED)\times OE \quad \text{-------(1)}$$

acceleration a = slope of the graph AB

$$a=\frac{DB}{AD}=\frac{EB-ED}{OE}$$

Therefore $OE=\frac{EB-ED}{a}$ -----------(2)

Substituting eqn (2) in eqn (1)

$$S=\frac{1}{2}(EB+ED)\times\frac{(EB-ED)}{a}$$

$$S=\frac{1}{2}\frac{(EB^2-ED^2)}{a}$$

$$(EB^2-ED^2)=2as$$

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

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

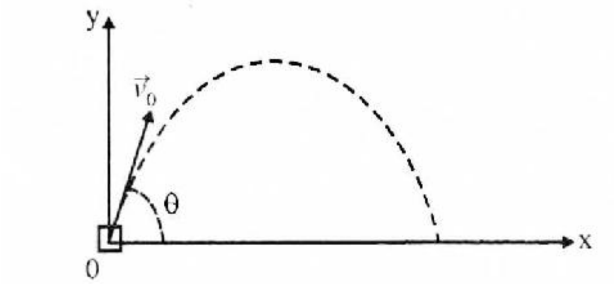
This is the velocity -Displacement relation.

5 If v is the velocity and a is the acceleration, give an example of a physical situation for each of the following cases.

a) $V \neq 0, a = 0$
b) $V = 0, a \neq 0$
c) $V > 0, a < 0$
d) $V < 0, a > 0$

Ans: a)A ball moving with uniform velocity.
b)A ball thrown up to reach the highest point.
c)A ball moving upward.
d)A ball dropped from height , moving down ward.

6 The figure below shows the path of a projectile motion.



a)Obtain the expressions for maximum height and time of flight.
b)What is the angle of projection for maximum horizontal range?

Ans: a)**Expression for Maximum height(H):**

We have $V^2 = u^2 + 2as$

Taking the vertical components;

$$V_y^2 = u_y^2 + 2a_y s_y$$

Here Vy=0, u_y=usinθ , a_y=-g and S_y =H

Therefore $0 = (usin\theta)^2 - 2gH$

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

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

Expression for Time of flight (T):

We have $S = ut + \frac{1}{2}at^2$

Taking vertical components;

$$S_y = u_y t + \frac{1}{2} a_y t^2$$

Here S_y=0, u_y=usinθ , a_y=-g and t=T, time of flight.

Therefore $0 = u \sin\theta T - \frac{1}{2} g T^2$

$$\frac{1}{2} g T^2 = usin\,\theta T$$

$$\frac{1}{2} g T = usin\,\theta$$

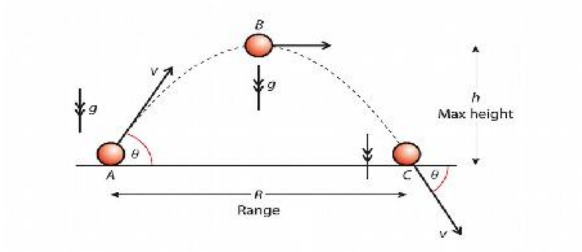
Time of flight $T = \frac{2u \sin\theta}{g}$

b) For Maximum horizontal range , angle of projection θ=45^0

7 a)A man throws a stone up into air at an angle 'θ' with the horizontal. Draw the path of the projectile and mark directions of velocity and acceleration at the highest position.

b) Derive an expression for the maximum height reached by the stone.

Ans: a)



b)**Expression for Maximum height(H):**

We have $V^2 = u^2 + 2as$

Taking the vertical components;

$$V_y^2 = u_y^2 + 2a_y s_y$$

Here Vy=0, u_y=usinθ , a_y=-g and S_y =H

Therefore $0 = (u\sin\theta)^2 - 2gH$

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

Maximum Height , $H = \dfrac{u^2 \sin^2\theta}{2g}$

8 To reduce friction and accident by skidding the roads are banked at curves.

(a)What is meant by banking of roads?

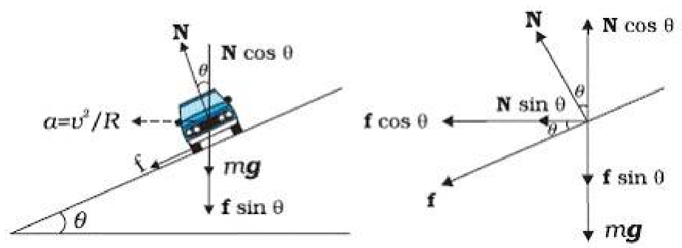
(b)Sketch the schematic diagram of a vehicle on a banked road with friction and mark the various forces.

(c) Derive an expression for maximum safe speed of a vehicle on a banked road with friction.

Ans: (a) The process of raising the outer edge than the inner edge for a curved road is called Banking of road.

The angle through which the outer edge is raised is called **angle of banking**.

(b)



(c)

Let

R--> radius of circular path

θ--> angle of banking

μ_S -->Coefficient of friction.

From the diagram

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

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

$$N\cos\theta - \mu_S N\sin\theta = mg$$

$$N(\cos\theta - \mu_S \sin\theta) = mg$$

Therefore $N=\frac{mg}{\cos\theta-\mu_S\sin\theta}$ ------------------(1)

Similarly $\frac{mv^2}{R}=N\sin\theta+f\cos\theta$

$$\frac{mv^2}{R}=N\sin\theta+\mu_S N\cos\theta$$

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

Substituting (1) in (2)

$$\frac{mv^2}{R}=\frac{mg}{\cos\theta-\mu_S\sin\theta}(\sin\theta+\mu_S\cos\theta)$$

$$\frac{v^2}{R}=\frac{g(\sin\theta+\mu_S\cos\theta)}{(\cos\theta-\mu_S\sin\theta)}$$

$$v^2=\frac{Rg(\sin\theta+\mu_S\cos\theta)}{(\cos\theta-\mu_S\sin\theta)}$$

Therefore $v=\sqrt{\frac{Rg(\sin\theta+\mu_S\cos\theta)}{(\cos\theta-\mu_S\sin\theta)}}$

Dividing by cos θ,

$$v=\sqrt{\frac{Rg(\tan\theta+\mu_S)}{(1-\mu_S\tan\theta)}}$$

This is the safe velocity (maximum possible speed) for a vehicle on a banked road.

9 According to Newton's law of motion, the force depends on the rate of change of momentum.

a)State whether the force is external or internal? Justify your answer.

b)What happens to the linear momentum when the force is absent?

c)The motion of a particle of mass m is described y = ut + 1⁄2 gt ^{2} . find the force acting on the particle.

Ans: (a)External force. Because to change the state of body the force must be external.

(b) Momentum becomes constant.

(c) We have $y=ut+\frac{1}{2}gt^2$

$$v=\frac{dy}{dt}=u+gt$$

$$a=\frac{dv}{dt}=g$$

Therefore F=ma =mg

10 Power is the rate at which work is done.

a) Express power in terms of force and velocity.

b) An elevator carrying the maximum load of 1800 kg is moving up with a constant speed of 2 ms^{-1} The frictional force opposing the motion is 4000 N. Determine the minimum power delivered by the motor to the elevator.

c) Express your above answer in horse power?

Ans:

a) Power P= F v

b) The total down ward force , F=mg+Frictional force

= (1800×10) +4000=22000N

Thus minimum power to be supplied by the motor

$P = F.V$
$= 22000 \times 2 = 44000W$

c) 59 hp

11 a) State the work energy theorem.

b) Show that the potential energy of a body is completely converted into kinetic energy during its free fall under the gravity.

c) A man carefully brings down a glass sheet from a height 2 m to the ground. The work done by him is ....

(i) negative (ii) zero

(iii) positive (iv) unpredictable

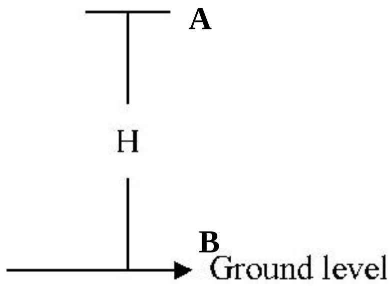
Ans: a) Work -Energy theorem states that "Work done is equal to change in Kinetic energy".

b)**At the point 'A':-**

Kinetic Energy , KE =0 (because velocity u=0)

Potential Energy , PE =mgH

At the point 'B':-



Kinetic energy , KE = $\frac{1}{2} m v^2$

But $v^2 = 2gH$ (because u=0, a=g)

Therefore , KE =mgH

and PE = 0

This shows that the potential energy of a body is completely converted into kinetic energy during its free fall under the gravity.

c) negative.

a.

12 a)Write down the equation for Moment of inertia of a disc passing through its centre of mass and perpendicular to the disc? (1 score)

b) Find the Moment of inertia of the disc tangential to the surface and parallel to the disc? (3 score)

Ans:

a) $MR^2/2$.

b) Moment of inertia of the disc through its diameter is = $MR^2/4$.

According to parallel axes theorem.

$I' = I_{cm} + Ma^2$

$I' = MR^2/4 + MR^2$

$I' = 5/4\ MR^2$

13 State theorem of perpendicular axes on moment of inertia. Derive an expression to find the moment of inertia of a disc about one of its diameters with the help of a neat diagram.

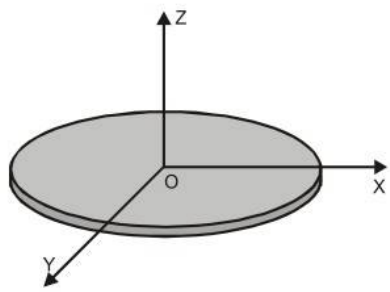
Ans: Theorem of Perpendicular axes states that "The moment of inertia of a planar body (lamina) about an axis perpendicular to its plane is equal to the sum of its moments of inertia about two perpendicular axes concurrent with perpendicular axis and lying in the plane of the body."

Here $I_Z = I_X + I_Y$

Where I_Z --> Moment of Inertia about Z-axis.

I_X --> Moment of Inertia about X-axis.

I_Y --> Moment of Inertia about Y-axis.



Moment of inertia of a thin circular disc of radius 'R' and mass 'M' about an axis passing through diameter:

We have $I_{disc} = \frac{MR^2}{2}$

By Perpendicular axes theorem

$$I_d + I_d = \frac{MR^2}{2}$$

$$2I_d = \frac{MR^2}{2}$$

$$I_d = \frac{MR^2}{4}$$

This is the Moment of inertia of a thin circular disc of radius ‘R’ and mass ‘M’ about an axis passing through diameter.

14 (a)Show that $\tau = \frac{dl}{dt}$ for rotational motion.

(b) State the law of conservation of angular momentum.

(c) Write an example for the motion in which angular momentum is conserved.

Ans: (a) We have $\vec{l} = \vec{r}\, x\, \vec{P}$

Therefore $\frac{d\vec{l}}{dt} = \frac{d(\vec{r}\, x\, \vec{P})}{dt}$

$$\frac{d\vec{l}}{dt} = \vec{r}\, x \frac{d\vec{P}}{dt} + \frac{d\vec{r}}{dt}\, x\, \vec{P}$$

$$\frac{d\vec{l}}{dt} = \vec{r}\, x\, \vec{F} + \vec{v}\, x (m\vec{v})$$

Therefore $\frac{d\vec{l}}{dt} = \vec{\tau}$ (Because $\vec{r}\, x\, \vec{F} = \tau$ and $\vec{v}\, x\, \vec{v} = 0$)

Thus Torque is equal to the rate of change of angular momentum.

(b)**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.

(c)Planetary motion.

15 The value of acceleration due to gravity (g) is same for all objects at a given place.

(a) Derive an equation for the acceleration due to gravity in terms of radius (R) and mass (M) of the earth.

(b)Arrive at mathematical expressions for variation of g below and above the surface of the earth.

Ans: (a)If the mass m is situated on the surface of earth, then

$$F = mg = \frac{GmM_E}{R_E^2}$$

Therefore

Acceleration due to gravity $g = \frac{GM_E}{R_E^2}$

Where G--> gravitational constant.

M_E --> mass of earth

R_E --> Radius of earth.

(b)**Variation of acceleration due to gravity with depth from the surface of earth:**

Let g--> acceleration due to gravity on the surface of earth.

g_d--> acceleration due to gravity at a depth ‘d’.

d--> depth from the surface of earth.

R--> Radius of earth.

M--> Mass of earth.

ρ-->density of earth.

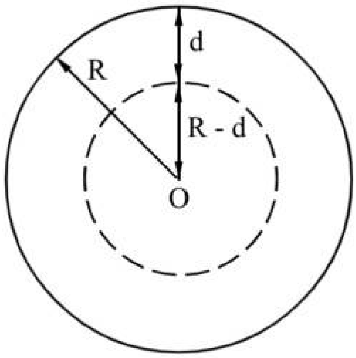
We have $g = \frac{GM}{R^2}$

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

Therefore $g = \frac{4}{3}\pi R \rho G$

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

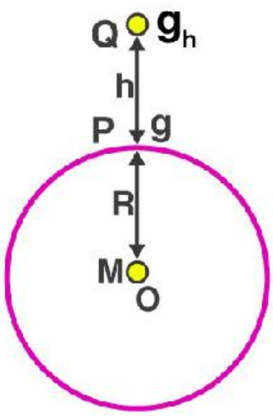
Therefore $g_d = g[1 - \frac{d}{R}]$



Thus the acceleration due to gravity decreases with depth from the surface of earth.

Variation of acceleration due to gravity with altitude (height) from the surface of earth:

Let g--> acceleration due to gravity on the surface of earth.
g_h--> acceleration due to gravity at a height 'h'.
h--> height from the surface of earth.
R--> Radius of earth.
M--> Mass of earth.



We have $g = \frac{GM}{R^2}$ and $g_h = \frac{GM}{(R+h)^2}$

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

For $\frac{h}{R}$ << 1 , using binomial expression,

$g_h = g[1 - \frac{2h}{R}]$

Thus the acceleration due to gravity decreases with height from the surface of earth.

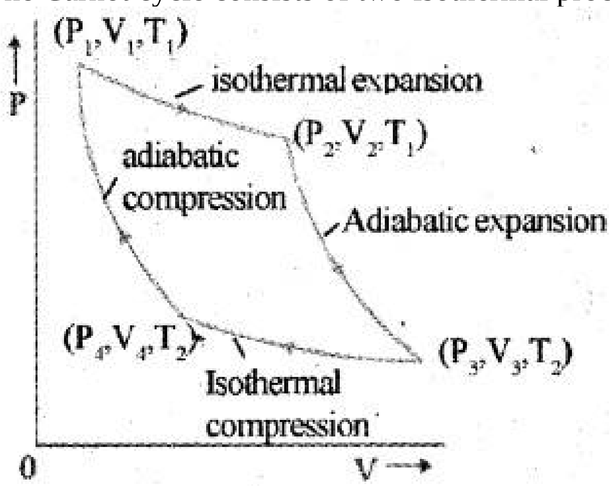
16 Thermodynamics deals with the concept of heat and the exchange of heat energy.
a) Which law of thermodynamics is used to explain the working of heat engine?
b) Explain briefly, the operations of a Carnot's engine, draw the Carnot's cycle and deduce the expression for its efficiency.

Ans:

a) Second law of thermodynamics

b) Carnot's cycle

The Carnot cycle consists of two isothermal processes and two adiabatic processes.



Let the working substance in Carnot's engine be the ideal gas.

Step 1 : The gas absorbs heat Q_1 from hot reservoir at T, and undergoes isothermal expansion from (P_1, V_1 ,T_1) to (P_2, V_2, T_1).
Step 2 : Gas undergoes adiabatic expansion from (P_2, V_2, T_1) to (P_3,V_3, T_2)
Step 3 : The gas release heat Q_2 to cold reservoir at T_2, by isothermal compression from (P_3,V_3,T_2)to(P_4,V_4,T_2).
Step 4: To take gas into initial state, work is done on gas adiabatically (P_4, V_4, T_2) to (P_1, V_1, T_1)
Efficiency of Carnot's engine

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

17 A perfect Carnot engine utilizes an ideal gas. The temperature of the source is 500 K and that of the sink is 375 K. If the k engine takes 600 Kcal per cycle from the source, then calculate:
(i) the efficiency of the engine.
(ii) work done per cycle in Joule.
(iii) heat rejected to the sink per cycle.

Ans:

Here, T_1 = temp, of source = 500 K
T_2 = temp, of sink = 375 K
Q_1 = heat absorbed from the source per cycle
= 600 Kcal
(i) the efficiency of the engine.
Let η = thermal efficiency of the Carnot engine,
then η = T1−T2 T1=500−375500
= 125500 = 0.25
∴ η = 0.25 × 100 = 25%

(ii) work done per cycle in Joule.
Let W be the work done/cycle, then
η =Work done per cycle Heat absorbed per cycle =WQ1
or
25100=W600
or
W = 25 × 6 = 150 K cal
= 150×10^3 cal
= $150 \times 10^3 \times 4.2$ J
= 6.3×10^5 J.

(iii) heat rejected to the sink per cycle.
Let Q_2 = heat rejected to the sink per cycle, then
$Q_1 = W + Q_2$
or
$Q_2 = Q_1 - W$
= 600 – 150
= 450 K cal.

18 Give any four postulates of Kinetic theory of ideal gas.

Ans:

1. Molecules of a gas are alike and different for different molecules.
2. Molecules of a gas are very small compared to distance between them.
3. Molecules of a gas behaves as perfectly elastic spheres.
4. Molecules of a gas are in random motion in all direction with all possible velocities.

19 Write any three postulates of kinetic theory of an ideal gas.

Derive the expression for pressure exerted by an ideal gas.

20 A particle executes simple harmonic motion according to the equation x = 5 sin$\left(\frac{2\pi}{3} t\right)$

a)Find the period of the oscillation

b)What is the minimum time required for the particle to move between two points 2.5cm on either side of the mean position?

Ans: a)We have x= a sin ωt

Given x=5 sin ($\frac{2\pi}{3}$ t)

Comparing $\omega = \frac{2\pi}{3}$ But $\omega = \frac{2\pi}{T}$

Therefore , Time period T=3 s

b)We have x= 5 sin ($\frac{2\pi}{3}$ t)

When the particle moves 2.5 cm from the mean position,

2.5=5 sin ($\frac{2\pi}{3}$ t)

sin ($\frac{2\pi}{3}$ t)= $\frac{1}{2}$ =sin ($\frac{\pi}{6}$)

Therefore , t=0.25 s

Time taken to travel 2.5 from the mean position is 0.25 sec. Hence time taken to travel 2.5 cm on either side of the mean position is 0.5 sec.

Each question scores Five

1 Derive the following equations of motion for a body moving with uniform acceleration in a straight line.

a) $v = u + at$

b) $S = ut + \frac{1}{2} at^2$

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

Ans: a) <u>Velocity -time relation:</u> $v = u + at$

Let u--> initial velocity

v-->final velocity

a-->acceleration

t-->time.

We have $acceleration = \frac{Change\, in\, velocity}{time}$

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

$$v-u = at$$

$$v = u + at$$

This is the velocity -time relation.

b) Displacement-time relation: $S = ut + \frac{1}{2}at^2$

Let S--> Displacement u-->initial velocity v--> final velocity a-->acceleration t-->time.

We have $Average\, velocity = \frac{Total\, displacement}{Time}$

$$V_{av} = \frac{S}{t}$$

Also $V_{av} = \frac{v+u}{2}$

Therefore $\frac{s}{t} = \frac{v+u}{2}$

$$S = \frac{(v+u)t}{2}$$

$$S = \frac{(u+at+u)t}{2}$$

$$S = \frac{(2u+at)t}{2}$$

$$S = \frac{2ut}{2} + \frac{at^2}{2}$$

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

This is the displacement-time relation.

c) Velocity -Displacement relation: $v^2 = u^2 + 2as$

Let S--> Displacement u-->initial velocity v--> final velocity a-->acceleration t-->time.

We have $Average\, velocity = \frac{Total\, displacement}{Time}$

$$V_{av} = \frac{S}{t}$$

Also $V_{av} = \frac{v+u}{2}$

Therefore $\frac{s}{t} = \frac{v+u}{2}$

That is $v + u = \frac{2S}{t}$ ---------(1)

But $v - u = at$ ---------(2)

Multiplying (1) and (2) $(v+u)(v-u)=\frac{2S}{t}at$

$v^2-u^2=2aS$

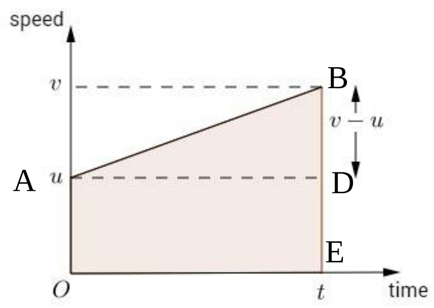
$V^2=u^2+2as$

This is the velocity-displacement relation.

2 Derive the equations of motion for a uniformly accelerating body from velocity-time graph.

Ans: <u>a)First equation of motion (velocity-time relation)</u>

From the graph ,



Acceleration a = Slope of velocity time graph AB.

$$a=\frac{DB}{AD}=\frac{(v-u)}{t}$$

v – u = at

v=u+at

This is the first equation of motion or velocity-time relation.

b) Second equation of motion OR Displacement time relation:

From the graph

Displacement S = Area under the graph AB

= Area of rectangle OADE + Area of triangle ADB

$$= OA\times OE+\frac{1}{2}DB\times AD$$

$$= u\times t+\frac{1}{2}(v-u)\times t$$

$$= ut+\frac{1}{2}at\times t$$

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

This is the displacement – time relation.

c) Third equation of motion OR Velocity-Displacement relation:

From the graph

Displacement travelled S = Area of trapezium OABE

$$= \frac{1}{2}(EB+OA)\times OE = \frac{1}{2}(EB+ED)\times OE \quad \text{-------(1)}$$

acceleration a = slope of the graph AB

$$a = \frac{DB}{AD} = \frac{EB-ED}{OE}$$

Therefore $$OE = \frac{EB-ED}{a} \quad \text{-----------(2)}$$

Substituting eqn (2) in eqn (1)

$$S = \frac{1}{2}(EB+ED)\times\frac{(EB-ED)}{a}$$

$$S = \frac{1}{2}\frac{(EB^2-ED^2)}{a}$$

$$(EB^2-ED^2) = 2as$$

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

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

This is the velocity -Displacement relation.

3 A projectile is any body that is given an initial velocity and then follows a path determined entirely by the effects of gravitational acceleration and air resistance.

a) The path of a projectile is.........

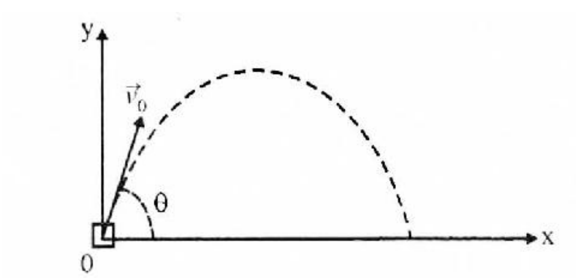
i) straight line
ii) parabola
iii) circle
iv) semi circle

b) Derive an expression for time to reach maximum height and hence the time of flight of a projectile.

c) A baseball leaves a bat with an initial speed of 37 m/s at an angle of 53.1° . Find the position of the ball when t = 2s (treat baseball as a projectile and g = 9.8 m/s ^{2})

Ans: a)(ii) parabola.

b)**Expression for time to reach maximum height:**



At the maximum height , $V_y=0$, $u_y=u\sin\theta$ and $a_y=-g$

We have $v_y=u_y-gt$

$0=u\sin\theta-gt$

Therefore time to reach maximum height , $t=\frac{u\sin\theta}{g}$

Expression for Time of flight (T):

We have $S=ut+\frac{1}{2}at^2$

Taking vertical components;

$$S_y=u_y t+\frac{1}{2}a_y t^2$$

Here $S_y=0$, $u_y=u\sin\theta$, $a_y=-g$ and t=T, time of flight.

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

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

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

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

c) Here u= 37 m/s θ= 53.1° g=9.8 m/s²

u_x = ucos θ=37 cos (53.1)=37x 0.6=22.2m/s

u_y=usin θ=37 sin (53.1)=37x0.79=29.59 m/s.

The x-coordinate is given by

$$S_x=u_x t+\frac{1}{2}a_x t^2=u_x t \quad (a_x=0)$$

Therefore at t=2s, x=22.2 x 2=44.4 m

The y-coordinate is given by

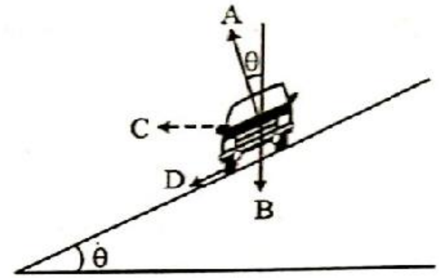
$$S_y=u_y t+\frac{1}{2}a_y t^2$$

$$y=29.59x2-\frac{1}{2}9.8x2^2 \quad (a_y=-g=-9.8\ m/s^2)$$

y=39.6m

Therefore the position of the ball when t = 2s is given by (44.4, 39.6)

4 Circular motion of a car on a banked road is shown in figure.



(a) Write the names of the forces A,B,C and D in figure.

(b) Write the equation which equate forces on the car along horizontal and vertical direction.

(c) State the Laws of static friction.

Ans: (a) A--> Normal Reaction (N).

B--> Weight (mg).

C--> Centripetal force ($\frac{mv^2}{R}$)

D--> Frictional force.(f_S)

(b)On the Vertical direction

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

and

On the horizontal direction

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

(c)The law of static friction may be written as

$$f_S \leqslant \mu_S N$$

5 A vehicle of mass m is moving on a banked road of radius r.

(a) What are various forces acting on the vehicle ?

(b) Obtain an expression for maximum safe speed of the vehicle on a banked road.

(c) A circular road of radius 300 m is banked at an angle of 15°. If the coefficient of friction between the wheels of a car and the road is 0.2, what is the optimum speed of the car ? (g = 9.8 m/s 2)

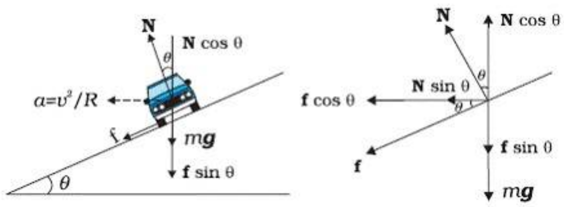
Ans: (a) Normal Reaction (N).

Weight (mg).

Centripetal force ($\frac{mv^2}{R}$)

Frictional force.(f_S)

(b)



Let

R--> radius of circular path

θ--> angle of banking

μ_S -->Coefficient of friction.

From the diagram

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

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

$$N\cos\theta - \mu_S N\sin\theta = mg$$

$$N(\cos\theta - \mu_S\sin\theta) = mg$$

Therefore $N = \frac{mg}{\cos\theta - \mu_S\sin\theta}$ ------------------(1)

Similarly $\frac{mv^2}{R} = N\sin\theta + f\cos\theta$

$$\frac{mv^2}{R} = N\sin\theta + \mu_S N\cos\theta$$

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

Substituting (1) in (2)

$$\frac{mv^2}{R} = \frac{mg}{\cos\theta - \mu_S \sin\theta}(\sin\theta + \mu_S \cos\theta)$$

$$\frac{v^2}{R} = \frac{g(\sin\theta + \mu_S \cos\theta)}{(\cos\theta - \mu_S \sin\theta)}$$

$$v^2 = \frac{Rg(\sin\theta + \mu_S \cos\theta)}{(\cos\theta - \mu_S \sin\theta)}$$

Therefore $v = \sqrt{\frac{Rg(\sin\theta + \mu_S \cos\theta)}{(\cos\theta - \mu_S \sin\theta)}}$

Dividing by cos θ,

$$v = \sqrt{\frac{Rg(\tan\theta + \mu_S)}{(1 - \mu_S \tan\theta)}}$$

This is the safe velocity (maximum possible speed) for a vehicle on a banked road.

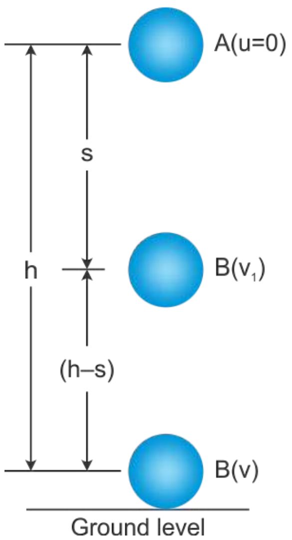
(c) Optimum speed $v = \sqrt{Rg(\tan\theta)}$

$v = \sqrt{300 \, x \, 9.8(\tan 15)}$ =28.06 m/s

6 a) State and prove that the law of conservation of energy for a freely falling body.
b) Draw graphically the variation of kinetic energy and potential energy with the height of the body in the above case.

Ans: a) 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"

Proof:



At the point 'A':-

Kinetic Energy , KE =0 (because velocity u=0)
Potential Energy , PE =mgh
Therefore,
Total Energy , TE = KE+PE
=**mgh**.-------(1)

At the point 'B' :-

Kinetic energy , KE = $\frac{1}{2}mv_1^2$

But $v_1^2 = 2gs$ (because u=0, a=g)

Therefore , KE =mgs
and PE = mg(h-s)
Therefore TE = KE +PE
=mgs+ mg(h-s)
=**mgh** --------(2)

At the point 'C':-

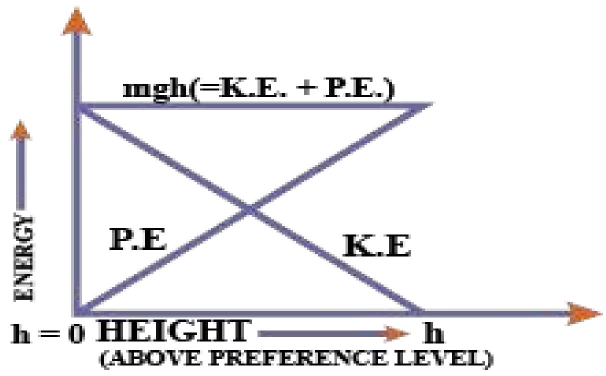
Kinetic energy , KE = $\frac{1}{2}mv^2$

But $v^2 = 2gh$ (because u=0, a=g)

Therefore , KE =mgh
and PE = 0
Therefore TE = KE +PE
=mgh+ 0
=**mgh** --------(3)

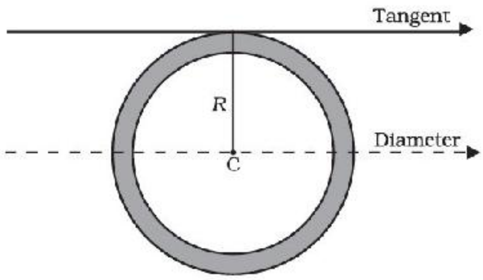
Thus Equation (1) , (2) and (3) shows that the total energy of a freely falling body is constant

at every point along its path.
b) Graph Showing the variation of KE, PE and TE with height for a freely falling body:



7 Moment of inertia about a diameter of a ring is $I_d = \frac{MR^2}{2}$

a) Name the theorem that helps to find the moment of inertia about a tangent parallel to the diameter.
b) Draw a diagram and find the moment of inertia about a tangent, parallel to the diameter of the ring.
c) The rotational analogue of mass is ....



Ans: (a) Parallel axes theorem.

(b)We have $I_{diameter} = \frac{MR^2}{2}$

By Parallel axis theorem

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

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

(c) Moment of inertia.

8 Moment of inertia is the analogue of mass in rotational motion. But unlike mass; it is not a fixed quantity.

a) Moment of inertia can be regarded as a measure of rotational inertia. Why?
b) Write any two factors on which the moment of inertia of a rigid body depends.
c) The moments of inertia of two rotating bodies A and B are I_A and I_B ($I_A > I_B$) and their angular
momentum are equal. Which one has a greater kinetic energy? Explain.

Ans: (a)The moment of interia about a given axis resists a change in its rotational motion. Thus it can be regarded as a measure of rotational inertia of the body.

(b) (i)The mass of the body, (ii) Its shape and size;

(c) We have $KE = \frac{L^2}{2I}$

Here L, the angular momentum is a constant.

Therefore $KE \, \alpha \frac{1}{I}$

Given $I_A > I_B$ Therefore $KE_B > KE_A$

9 a)State and explain Hooke's law.
b)A wire is fixed at one end is subjected to increasing load at the other end. Draw a curve between Stress and Strain and with the help of the curve, explain the terms
a)proportional limit b)yield point c) permanent set d)fracture point

c)How does this curve may be used to distinguish between ductile and brittle substances?

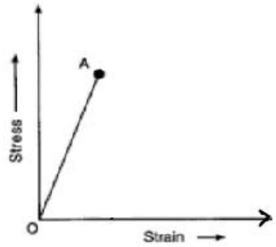
Ans: a)Hooke’s law states that within the elastic limit stress is directly proportional to strain.

Stress α Strain

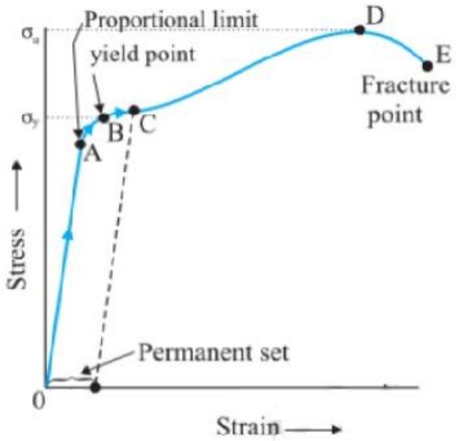
Stress = K x Strain

Where K is known as modulus of elasticity.

If a material obey Hooke’s law, the graph connecting stress and strain will be a straight line.



b)



c) If the points D and E are very close to each other the material is brittle and if they are far apart, the material is ductile.

10 In case of fluids law of conservation of energy can be explained with Bernoulli’s principle

(a) With a neat diagram State and prove Bernoulli’s principle.

Ans:

(a) Bernoulli’s theorem:

It states that “for the stream line flow of an ideal liquid, the total energy (sum of pressure energy, potential energy, and kinetic energy) per unit mass remains constant at every cross section through out the flow”

$$\frac{P}{\rho}+\frac{V^2}{2}+gh \quad \text{or} \quad P+\frac{\rho v^2}{2}+\rho gh$$

This is the conservation law of energy for a flowing liquid.

Proof:

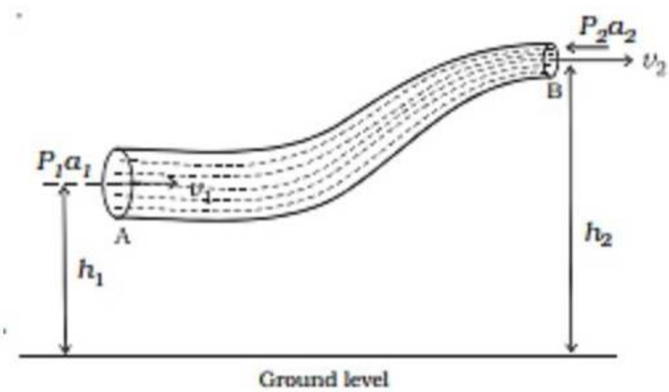


Fig. Bernoulli's theorem

Let

P 1 --> pressure applied at A,
P 2 --> pressure at B,
a 1 --> area of cross section at A,
a 2 --> area of cross section at B,
h 1 --> mean height of section A
h 2 --> mean height of section B,
v 1 --> normal velocity of liquid at A
v 2 --> normal velocity of liquid at B.
ρ--> density of liquid.

Net work done per second on the liquid by the pressure energy in moving the liquid from section A to B = $P_1 V - P_2 V$

[By equation of continuity volume of liquid 'V' flowing per second remains constant]
The increase in potential energy /second of the liquid = $mgh_2 - mgh_1$

The increase in kinetic energy /second of the liquid = $\frac{1}{2} mv_2^2 - \frac{1}{2} mv_1^2$

According to work energy principle,
work done/second by the pressure energy= increase in PE/second + increase in KE/second.

$$P_1 V - P_2 V = mgh_2 - mgh_1 + \frac{1}{2} mv_2^2 - \frac{1}{2} mv_1^2$$

$$P_1 V + mgh_1 + \frac{1}{2} mv_1^2 = P_2 V + mgh_2 + \frac{1}{2} mv_2^2$$

Dividing by 'm',

$$\frac{P_1 V}{m} + gh_1 + \frac{1}{2} v_1^2 = \frac{P_2 V}{m} + gh_2 + \frac{1}{2} v_2^2$$

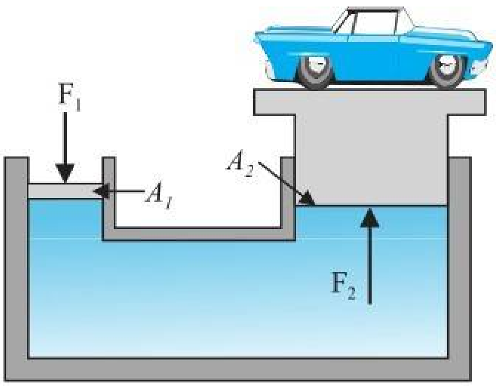
$$\frac{P_1}{\rho} + gh_1 + \frac{1}{2} v_1^2 = \frac{P_2}{\rho} + gh_2 + \frac{1}{2} v_2^2$$

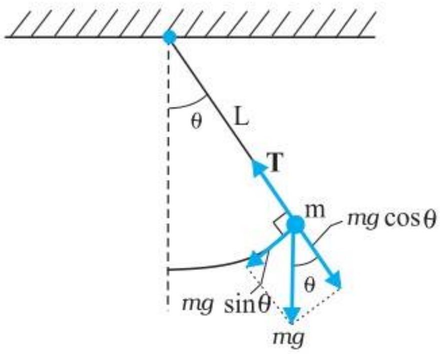
$$ie., \quad \frac{P}{\rho} + gh + \frac{1}{2} v^2 = constant.$$

$$\text{OR} \quad P + \rho gh + \frac{\rho v^2}{2} = constant$$

Thus, Pressure energy per unit mass+ PE per unit mass + KE per unit mass = a constant.
This proves Bernoulli's theorem
Additional Info : Applications of Bernoulli's theorm:
Attraction between two closely parallel moving boats (or buses)
Working of an Aeroplane (Dynamic lift)
Action of atomiser.
Blowing off roofs by wind storms:
Magnus effect
Venturimeter
When we blow in between two pith balls suspended they will attract each other.
A paper can be held stationary in air by blowing above it.
Blood flow and Heart attack can be explained by Bernoulli's theorm

(b) While travelling in aero plane, it is advisable to remove ink from fountain pen. Why?

	Ans: (b) During take off of the plane the pressure inside the plane reduces there fore the pen may leak or ink comes out
11	(a) Hydrostatic pressure is a scalar quantity even though pressure is force divided by area. Explain Why? (b) State the law associated with liquid pressure. What the SI unit of Pressure (c) Briefly explain the working of hydraulic lift Ans: (a) When force is applied on a liquids the pressure is transmitted equally in all directions inside the liquids there fore the hydrostatic pressure has no fixed direction and hence it is a scalar quantity (b) Pascal's law. SI unit for pressure is Pascal (Pa) (c)Hydraulic lift is used to lift the heavy loads. Its working is based on Pascal's law.  Let, F_1 --> force on smaller piston. F_2 -->force developed on larger piston. A_1 --> area of smaller piston, A_2 --> area of larger piston. According to Pascal's law, the pressure applied on smaller piston is transmitted with out change at all points in the liquid. Thus $\frac{F_1}{A_1}=\frac{F_2}{A_2}$ Therefore $F_2=\frac{F_1}{A_1}A_2$ as $A_2 >> A_1$, $F_2 >> F_1$ This shows that the small force applied on the smaller piston will be appearing as a very large force on the large piston. As a result of which a heavy load placed on the larger piston is easily lifted upwards. **Note**: Other applications of Pascal's law are i) Hydraulic press (or Brahma press) ii) Hydraulic brakes.
12	a) Prove that the oscillations of a simple pendulum are simple harmonic and hence derive an expression for the time period of a simple pendulum. b) What is the length of a simple pendulum, which ticks seconds?



Ans:
a)Simple pendulum consists of a bob of mass ‘m’, suspended from one end of an inextensible string of length ‘L’. The other end is fixed to a rigid support.
The length of the pendulum is the distance between the rigid support and the centre of the bob.
When the bob is pulled to one side and released the pendulum executes oscillations.
At any instant ‘θ’ be the angular displacement.
The weight of the bob ‘mg’ can be resolved into two components,
mgsin θ→ directed towards mean position,
mgcos θ→ in the direction of string.
Here, ‘mgsin θ’ gives the restoring force.

$$ie \quad F=-mg\sin\theta=-mg\theta \qquad (as \quad \theta<<)$$

$$But \qquad \theta=\frac{x}{L}$$

$$\therefore \qquad F=-\left(\frac{mg}{L}\right)x$$

Thus for small amplitude oscillations, the force is proportional to the displacement and directed towards mean position. Hence oscillations of simple pendulum is SHM.

<u>Period of oscillation of a simple pendulum:</u>

For a simple pendulum,

$$F=-\left(\frac{mg}{L}\right)x \qquad and$$

$$F=ma$$

$$\therefore \qquad ma=-\left(\frac{mg}{L}\right)x$$

$$a=-\frac{gx}{L}$$

$$But \qquad a=-\omega^2 x$$

$$\therefore \quad -\omega^2 x=-\frac{gx}{L}$$

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

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

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

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

This is the period of oscillation of a simple pendulum.
b)The length of a seconds pendulum (which ticks seconds) L=1m.