Telangana State Board of
INTERMEDIATE Education

PHYSICS-I

BASIC LEARNING MATERIAL

For The Academic Year
2020-2021

TELANGANA STATE BOARD OF INTERMEDIATE EDUCATION

PHYSICS 1st YEAR (E/M)

BASIC LEARNING MATERIAL

ACADEMIC YEAR

2020-21

PREFACE

The ongoing Global Pandemic Covid-19 that has engulfed the entire world has changed every sphere of our life. Education, of course is not an exception. In the absence of Physical Classroom Teaching, Department of Intermediate Education Telangana has successfully engaged the students and imparted education through TV lessons. The actual class room teaching through physical classes was made possible only from 1st February 2021. In the back drop of the unprecedented situation due to the pandemic TSBIE has reduced the burden of curriculum load by considering only 70% syllabus for class room instruction as well as for the forthcoming Intermediate Public Examinations May 2021. It has also increased the choice of questions in the examination pattern for the convenience of the students.

To cope up with exam fear and stress and to prepare the students for annual exams in such a short span of time , TSBIE has prepared “Basic Learning Material” that serves as a primer for the students to face the examinations confidently. It must be noted here that, the Learning Material is not comprehensive and can never substitute the Textbook. At most it gives guidance as to how the students should include the essential steps in their answers and build upon them. I wish you to utilize the Basic Learning Material after you have thoroughly gone through the Text Book so that it may enable you to reinforce the concepts that you have learnt from the Textbook and Teachers. I appreciate ERTW Team, Subject Experts, Medha Charitable Trust who have involved day in and out to come out with the, Basic Learning Material in such a short span of life.

I would appreciate the feedback from all the stake holders for making it enriching and cent percent error free in all aspects.

The material can be accessed through our website www.tsbie.cgg.gov.in which is exclusively devoted to uploading the additional study material from time to time.

Commissioner &Secretary
Intermediate Education, Telangana.

Contents

UNIT I

PHYSICAL WORLD

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. What is Physics?

Ans:- Physics is a branch of science which deals wilte the study of nature and natural phenomena. It deals with Motion, energy and their consegnces.

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2. What are the fandamental forces in nature?

Ans:- Basic forces in nature are of the 4 types :

1) Gravitational forces. 2) Electromagnetic Forces.

3) Weak nuclear Forces. 4) Strong Nuclear Forces.

UNIT II

UNITS AND MEASUREMNTS

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. Distinguish between accuracy and percisions.

Ans:-

Accuracy	Precision
1) Accuracy of a measurement is a measure of how close the measured value is to the true is to the true value of guantity.	1) Whereas pricision telles us to what resolutions or what resolutions or limit the guontify is measured. It depandas on the resolutions of the measuring devices.

2. What are the different types of errors that can occur in a measurements?

Ans:- Mainly there are three types of errors :

1) Systematic errors 2) Random error 3) Gross error.

3. How can systematic errors can be minimised or eliminated?

Ans:- Systematic, selecting bettes instrumuts and removing persond bias as far as possible.

4. Illastrate how the result of a measurement is to be reported indicating the error involved?

Ans:- Errors are uncertiainties that are present in the measuremnt made with any measuring instrument, heast count of instrument is minimum error in the measurement.

5. What are significant figures and what do they represant when peporting the result of a measurent?

Ans:- The digits of numbers that the definitely known plas one more digit that is esstimated are called signaificat digit.

Example : The time period of a simple pendulum is 1.62 the digit and 6 are reliable while the digit 2 is uncertain. They measured value has three signifi cant figures.

6. Distinguish between fundamental units and derived units?

Ans:- a) Units of fundamental physical quanties. such as length, mass, time, etc, are known as fundamantal units.

b) Units of the derived physical quantities, such as velocity. force energy etc, are known derivel units.

7. Why do we have different units for the same physicall quantities?

Ans:- The result of a measument of a physical quantity is experssed by a number accompained by a unit.

8. What is dimensional analysis?

Ans:- 1) Dimasional analysis is the representation of derived physical quantities interms of units of fundamental quantities.

2) With the help of dimsional analysis to cheik the correctness of the equation. Convert one system of units into ther system and derive certain equation relating physical quantities.

9. How many orders of magnitude greater is the radius of the atom as compared to that of the nucleus?

Ans:- Size of nucleus $= 10^{-14}$, size of atom $= 10^{-10}$ m

Hence size of atom is 10^{-4} m greater the size of the nucleus.

10. Express mified atomic mass unit in Kg.

Ans:- 1 unified atomic mass unit = $\frac{1}{2}$ of the mass of carbon - 12 atom.

1 amer $= 1.66 \times 10^{-27}$ Kg

SHORT QUESTION & ANSWERS (4 MARKS)

1. The verinier scale of an instrument has 50 division which coincide with 49 main scale divisions. If each main scale divisions is 0.5mm, then using this instrument that would be the minimum in accuracy in the measuremnt of distance?

Ans:- Value of each main scale division = 0.5mm

No. of ernier scale division = 50

In vernier callipers $L.C. = \frac{S}{N} = \frac{\text{Value of one main scale divisions}}{\text{No. of vernier scale division}}$

$$L.C. = \frac{0.5}{50} = 0.01\text{mm}$$

The minium in accuray in the measurment of distance is 0.1 mm.

2. In a system of units, the unit of force is 100N unit of length is 10m and the unit of time is 100S. What is the unit of mass in this system?

Ans:- Force = 100N, length = 10m Time = 100 sec.

F= ma

$$m = \frac{F}{a} = \frac{F}{LT^{-2}} = \frac{F.T^2}{L} = \frac{100 \times 100 \times 100}{10} = 10^5 kg$$

3. The distance of a galaxy from Earth is of the order of 10^{-25}m . Calculated the order of magintude of the tim taken by light to reach us from the galaxy?

Ans:- Distance of galaxy from earth = 10^{25}m

Velocity of light $= 3 \times 10^8 m/s$

Time taken by the light $= \frac{\text{Velocity of light}}{\text{Dis tan ce of galaxy from earth}}$

$$= \frac{d}{e} = \frac{10^{25}}{3 \times 10^8} = 0.33 \times 10^7 = 3.3 \times 10^{16} \sec$$

4. The Earth moon distance is about 60 Earth radius. What will be the approximate diameter of the earth as seen from the moon?

Ans:- Distance between earth moonr = 60 R

Radius of earth = R

r = 60 R = 60 x 6400 x 10^3 (R=6400 km)

$$\theta = 1\sec = \frac{1}{60}\min = \frac{1}{60 \times 60} \text{deg ree}$$

$$= \frac{1}{60 \times 60} \times \frac{\pi}{1800} \text{radiam}$$

$$r = \frac{1}{\theta} \Rightarrow 1 = r \times \theta = 60 \times 6400 \times 10^3 \times 60 \times 60 \times \frac{\pi}{180}$$

$$\ell = 11.16 \times 10^3 km \Rightarrow \text{Diametn } \ell = 11.16 \times 10^3 km$$

5. Three mcasurements of the time for 20 oscillations of a pendulum give $t_1 = 39.6s, t_2 = 39.9s$ and $t_3 = 39.5s$ what is the pricision in the measurements? What is the accuraiy of the measuremtns?

Ans:- No. of oscillations = 20

$t_1 = 39.6 sec, t_2 = 39.9 sec, t_3 = 39.5 sec$

Mean value $= \frac{t_1 + t_2 + t_3}{3} = \frac{39.6 + 39.9 + 39.5}{3}$

$$= 39.66 \cong 39.7 sec$$

Precisim = 0.1sec

Accurary is the closess of mesured value with true value

Hnece 39.6 sec is accurary.

6. 1 Caloric = 4.2 where 1J = 1Kg m^2s^{-2} suppose we amploy a systom of units in which the euit of mass is â kg the unit of length is â m and and the unit of time is as, show that a caloric has a magnitude $4.2\ \hat{a}^{-1}\ \hat{a}^{-2}\ \hat{a}^{-2}$ in the new system?

Ans:- 1 caloric = 4.2J $\Rightarrow$ 1J=1kg m^2s^{-2}

1 caloric = $4.2\ Kg.m^2s^{-2}$

In a new system 1 caloric $= 4.2\ \hat{a}\ \ \hat{a}^2\ \hat{a}^{-2}$

7. A new unit of length is choose so that the speed of light in vallum is $1ms^{-2}$. If light takes 8 min and 20S to cover this distance, what is the distance between the sun and earth in terms of the new unit?

Ans:- V=speed of light in vaccum = 1m/s

Time taken (t) = 8 min 20 sec = 500 sec.

Distance between the sun and earth $= \frac{V}{t} = \frac{1}{500} = 0.002m$.

8. A student mcasured the thickness of a human hari using a micro scope of maginification 100. He makes 20 obserations. and find that the average thicknees (as rievred in the microscope) is 3.5mm, what is the cstimate of the thickness of hair?

Ans:- Magnification of microscope = m = 100

observed thickness = 3.5 mm

magnification $= \frac{\text{observed thickness}}{\text{Real thickness}}$

$$100 = \frac{3.5}{\text{Real thickness (t)}}$$

$$t = \frac{3.5}{100} = 0.035mm$$

9. A physicall quantity x is related to four measurable quantities a,b,c and d as follows. $x = a^2\ b^3\ c^{5/2}\ d^{-2}$ the percentage eraor in the measurment of a,b,c,d are 1%, 2%, 3%, 4% respectively, what is the percentage of error in x?

Ans:- x = $x = a^2\ b^3\ c^{5/2}\ d^{-2}$

$$\frac{\Delta a}{a} \times 100 = 1\%,\quad \frac{\Delta b}{b} \times 100 = 2\%,\quad \frac{\Delta c}{c} \times 100 = 3\%,\quad \frac{\Delta d}{d} \times 100 = 4\%$$

Percentage error in x is

$$\left(\frac{\Delta x}{x}\right) \times 100 = 2\left(\frac{\Delta a}{a} \times 100\right) + 3\left(\frac{\Delta b}{b} \times 100\right) + \frac{5}{2}\left(\frac{\Delta c}{c} \times 100\right) + 2\,\frac{\Delta d}{d} \times 100$$

$$= 2 \times 1 + 3 \times 2 + \frac{5}{2} \times 3 + 2 \times 4 = 2 + 6 + \frac{15}{2} + 8$$

$$= 23.5\ \%$$

10. The velocity of a body is given by $v = A^{+2} + B^{+} + C$. If v and t are expressed in SI what are the units of A, B and C?

Ans:- Given $V = At^2 + Bt + C$

According to principle of hormoguty

i) $V = At^2 \Rightarrow A = \frac{V}{t^2} = \frac{LT^{-1}}{T^2} = LT^{-3} = ms^{-3}$

ii) $V = Bt \Rightarrow B = \frac{V}{t} = \frac{LT^{-1}}{T^1} = LT^{-2} = ms^{-2}$

iii) $V = C \Rightarrow C = LT^{-1} = ms^{-1}$

Problems :

1. In the expression $p = EL^2m^{-5}G^{-2}$ the quantities. E, L m and G denote energy, angular momentam, mass and gravitagional constant respectively. Show that p is a dimensionaless guanting.

Sol. $P = EL^2 m^{-5} G^{-2}$

$P = \left[ML^2T^{-2}\right]\left[ML^2T^{-1}\right]^2\left[M^5\right]\left[M^{-1}L^3T^{-2}\right]$

$P = M^{1+2-5+2}\ L^{2+4-6}\ T^{-2-2+4}$

$P = \left[M^0\ L^0\ T^0\right]$

$\therefore$ Hnece P is dimensionaless guautity.

$E = \left[M\ L^2\ T^{-2}\right]$

$L = \left[M\,L^2\ T^{-1}\right]$

$M = [M]$

$M = [M]$

2. An artificial stelite is revolving around a planet of Mass M and radims R_1 in a circular orbit of radius t using dimensional analysis show that the period of the satelite? $T = \frac{K}{R}\sqrt{\frac{r^3}{g}}$ when K is a dimesionaless censtant and g is acceteration due to gravity.

Sol. $T = \frac{K}{R}\sqrt{\frac{r^3}{g}}$

L.H.S = Time period = T,

R.H.S $= \frac{K}{R}\sqrt{\frac{r^3}{g}} = \frac{1}{L}\sqrt{\frac{L^3}{LT^{-2}}} = T$

$\therefore$ L.H.S = R.H.S

above egecations is correct.

3. The error in measurement of radius of as phere is 1% what is the error in the measurement of volume?

Sol. Radious of sphere $\frac{\Delta r}{r} \times 100 = 1\%$

Volume $V = \frac{4}{3}\pi r^3$

$$\frac{\Delta V}{V} \times 100 = 3 \times \frac{\Delta r}{r} \times 100 = 3 \times 1\% = 3\%$$

UNIT III

MOTION IN A STRAIGHT LINE

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. The states of motion and rest are relative. Explain.

Ans:- Rest and motion are relative. They are not absolute. A body can be in the rest or in motion with respect to reference frame. A main in a moving frain is a rest with respect to a co-passenger but he is in motion with respect to a man on the gorund.

2. How is average velocity different from instantameous velocity?

Ans:- The average velocity does not give any detail of the motion of the particle. It gives only the result of the motion. The instantaneous velocity defines how fast the particle moves at a particular instant of time.

In uniform motion the instaneous velocity is egeeal to the average velocity.

3. Give an example where the velocity of an objects is zero but its acceleration is not zero?

Ans:- When the body is projected vertically upwards at the highest priut its velocity is zero. But acceleration. (a=g) is not egeeal to zero.

4. A vehicle travels half the distance L with speed V_1 and the other half with speed V_2, what is the average speed?

Ans:- Average speed $= \dfrac{\text{Total length of the path}}{\text{Total time taken}}$

$$= \frac{L}{\frac{\left(\frac{L}{2}\right)}{V_1} + \frac{\left(\frac{L}{2}\right)}{V_2}} = \frac{2V_1V_2}{V_1 + V_2}$$

5. A lift coning down is just about to reach the ground floor. taking the ground floor as origin and +ve direction upwards for all quantities, which one of the following is correct.

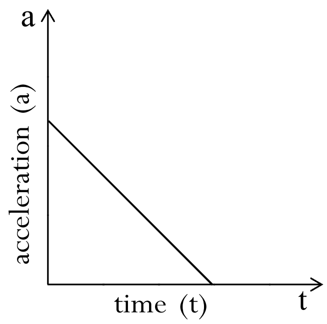
(a) $x<0, \ v<0, \ a>0$ **(b) $x>0, \ v<0, \ a<0$**

(c) $x>0, \ v<0, \ a>0$ **(d) $x>0, \ v>0, \ a>0$**

Ans:- While lift is moving towards ground floor. Conigin +ve x decresses velocity decneases. Hence $x<0$, $v<0$, but $a>0$ so (a) is correcet option.

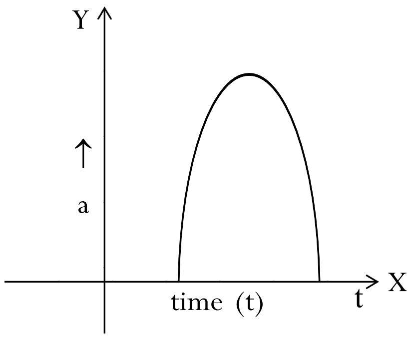
6. A uniformly moving cricket ball is lit with a bt for a very short fime and is turned back. Show the variation of its acceleration with time taking the accelpration in the backward direction as positive.

Ans:-



7. Give an example of one dimensions motion where a particle moving along the positive x-direction. comes to rest periodically and moves for ward?

Ans:-



8. An object falling through a flnid is observed to have an acceleration given by a = g - bv where g is the gravitional acceleration and b is a constant. After a long time it is observed to fall with a constant velocity. What would be the value of this constant velocity?

Ans:- $a = g - br$

$$\frac{dv}{dt} = g - br$$

$$0 = g - br \qquad \Rightarrow \boxed{v = \frac{g}{b}}$$

9. If the rajectory of abody is parabotic in one framy can it be purabolic in another frame that moves with a constant velocity with respect to the first fram? It not what can it be?

Ans:- No, the trajeectory is vertical stright line.

10. A Spring with one end attached to a mass and the other to a rigid support is streectched and released when is the magnitude of a acceleration a maximum?

Ans:- The magnitude of acceleration is maximum at Extree positions.

SHORT QUESTION & ANSWERS (4MARKS)

1. Can the equations of kinematics be used when the acceleration varies with time? If not, what form would these equation take?

Ans:- No, the equation of Kinematics be used when the acceleration varies with time.

If an object moves along a stright line with uniform acceleration (a) equations of Kinematics are.

(1) $V = V_0 + at$ (2) $X = V_0 t + \frac{1}{2} at^2$ (3) $V^2 = V_0^2 + 2ax$

Where X is displacement, V_0 is velocity at $t = 0$, V is velocity at time t, a is acceleration these are Kinematic equations of rectilinear for constant acceleration.

2. A particle moves in a stright line with uniform acceleration. Its velocity at time t=0 is V_1 and at time t = t is V_2. The average velocity of the particles in this time intuval is $\left(\frac{V_1 + V_2}{2}\right)$. Is this correct? Substaintiate your ausares?

Ans:- Let us consider particle moving with uniform acceleration "a"

at $t = 0$, initial velocity $= V_1$

$t = t$, final velocity $= V_2$

time $= t$

From (1) eq. to $V_2 = V_1 + at$

$$\Rightarrow a = \frac{V_2 - V_1}{t}$$

and (2) eq. to $S = V_1 t + \frac{1}{2} at^2$

$$S = V_1 t + \frac{1}{2}\left(\frac{V_2 - V_1}{t}\right) \times t^2$$

$$S = t\left[V_1 + \frac{V_2 - V_1}{2}\right]$$

$$S = t\left[\frac{V_1 + V_2}{2}\right]$$

$$\frac{S}{t} = \frac{V_1 + V_2}{2}$$

∴ The given statment is correct.

3. Can the velocity of an object be in a direction other than the direction of acceleration of the object? If so, given an example?

Ans:- Yes, the velocity of an object be in a direction other than the direction of acceleration of the object.

Example : In the case of the upward motion of a projectiles the angle between velocity and acceleration is 180^0. During it's journy the direction of velocity is in upwards and the direction of acceleration. is in down wards.

4. A purachutist flying in an aeroplane jumps when it is at a height of 3 Km above ground. He opens his parachutiste when he is about 1 Km above ground. Desirive his motion?

Ans:- Consider that the aeroplane is flying hoizontally. The penson jumping from the aeroplane is treated as freely falling body because his initial velocity in the vertically down ward direction is zero at a height of about 1km the person get a uniformvelocity called fermihal velocity due to air friction. Hence the acceleration becomes zero. Hence the person falls with a constant velocity stright line from 1 km onurards.

5. A bird holds a fruit in its beak and flies parallel to the ground. It lets go of the fruit at sonce height. Describes the frajectory of the frmit as it falls to the ground as seen by (a) the bird (b) a person on the ground?

Ans:- Let a horizantally flying bird drop a fruit.

1) The frajectory of the fruit with respect to the bird is a straight line.

2) The trajectory of the fruit with respect to the person on the ground is a parabola.

6. A man runs aitoss the roof of a tall building and jumps horizontally on the (lowes) roof of an adjacent building. It his speed is a m/s and the horizonatal distance between the buildings is 10m and the height diffrence between the roofs is 9m, will be able to land on the next building?

Ans:- $u = 9\ m/s,\ \ g = 10m/s^2,\ \ h = 9m$

Range = 4 x t

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

$$R = u \cdot \sqrt{\frac{2h}{g}} = 9 \times \sqrt{\frac{2 \times 9}{10}}$$

$$= 9 \times \sqrt{\frac{18}{10}}$$

$$= 9 \times 1.4 \cong 12.6m$$

Range is greath than distance between two buildings

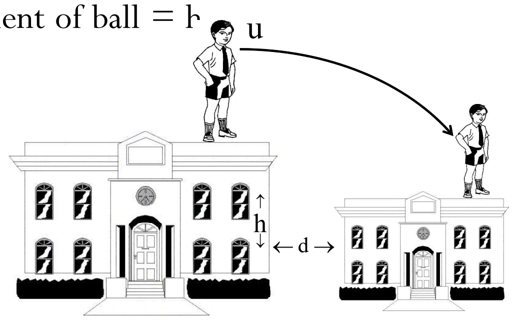
R > S

∴ The man safely land on the next building.

7. A ball dropped from the roof of a full building and stimultaneously anothen ball is thrown horizontally with som veloity from the same roof which ball lands first? Explain your answer?

Ans:- Let height of the building = Dishplacement of ball = h

For frist ball u=0, s=h, a =g, t=t



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

$$n = 0 + \frac{1}{2} gt_1^2$$

$$t_1 = \sqrt{\frac{2h}{g}} \quad \text{------}\rightarrow (1)$$

For second ball

$u_x = u_1, u_x = 0, ay = g, ay = h, t = t_2$

$$s_y = Lit_y + \frac{1}{2} ay^{+2}$$

$$h = 0 + \frac{1}{2} gt_2^2$$

$$t_2 = \sqrt{\frac{2h}{g}}$$

∴ From eq'n. (1) & (2) are equal.

$$t_1 = t_2$$

∴ Two balls will reach the ground in same time.

8. A ball is dropped from a building and simeltameo usly another ball is projected up ward with some velocity. Describes the change in relative velocities of the ball as a function of time?

Ans:- Case (i) For the 1st body

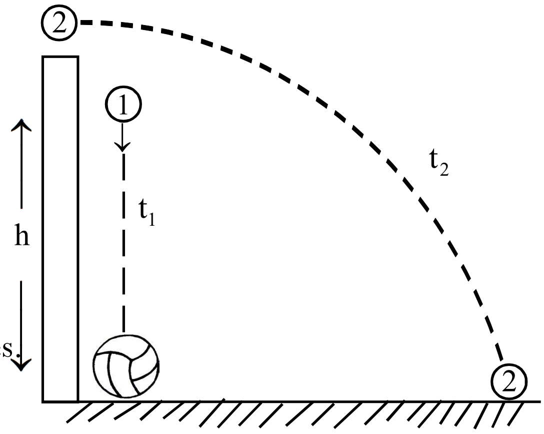
$$V_1 = u + gt$$

(or)

$$V_1 = gt \quad \text{-----(1).}$$

For the 2nd body

$$V_2 = u - gt \quad \text{------(2)}$$



Relative velocity between (1) & (2) bodies

$$V_2 + V_1 = u - gt + gt = 4$$

$$V_2 + V_1 = 4$$

The relative velocities of the body is always constanst.

Hence the change in the relative velocity is zero.

9. A typical raindrop is about 4mm is diametes. If a randrop falls from a cloud which is at 1 km above the group estimate its momentum when it hits the ground?

Ans:- Density of water $P_w = 1000 kg/m^3$

Radius of rain drop $r = 2mm = 2 \times 10^{-3} m$

Heisht $h = 1km = 10^3 m$

$V^2 - u^2 = 2as$ (or) $V = \sqrt{2gh}$

$$\therefore \; V = \sqrt{2 \times 9.8 \times 10^3} = 140 \; m/s$$

$$P = MV = \frac{4}{3} \pi r^3 \delta V$$

$$= \frac{4}{3} \times 3.14 \times (2 \times 10^{-3})^3 \times 1000 \times 140$$

$$\therefore P = 0.00469 \; kg \; m/sec$$

10. Show that the maximum height reacued by a projectile lanched at an angle of 45^0 is on quata of its range?

Ans:- $\theta = 45^0$ Range $= \frac{4^2 \sin^2\theta}{g} = \frac{4^2 \sin 90^0}{g} = \frac{4^2}{g}$ -----(1)

Maximum height $H = \frac{4^2 \sin^2\theta}{2g} = \frac{4^2 \sin^2(45)}{2g} = \frac{1}{4}\frac{4^2}{g}$ ------(2)

$\therefore \boxed{H = \frac{R}{4}}$

Problems :

1. A bullet moving with a speed of 150 m/sec strikes a tree and penetrates 3.5cm before stopping what is the magnitude of its vetardation in the tree and the time taken for it to stop after striking the tree?

Ans:- $u = 150\text{m/s}$ $S = 3.5\text{cm}$ $= 0.035,\ V = 0$

$V^2 - u^2 = 2as$

$0^2 - 150^2 = 2 \times 9 \times 0.035 \Rightarrow a = \left|\frac{-150 \times 150}{2 \times 0.035}\right|$

$a = -3.214 \times 10^5 \text{m/s}^2$

$t = \frac{V-u}{a} = \frac{0-150}{-3.24 \times 10^5} = 4.67 \times 10^4 \text{sec}$

2. A food packet is ropped from an aeroplane moving with a speed of 360 Knysh in a horizontal direction, trom a hight of 500m. Find (1) its time of descent (2) the horizonatal distance between the point at which the food packet reaches the ground and the point above which it was dropped? $(g = 10\text{m/s}^2)$

Ans:- Velocity of aeroplane V = 360 knysh = $360 \times \frac{5}{18}$ $h = 100\text{m/s}$

$h = 500\text{m}$

i) Time of decent $= + = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 500}{10}}$

$= 10 \text{ sec}$

ii) Horizontal range $R = 4 \times \sqrt{\frac{2h}{g}} = 100 \times 10 = 1000 \text{ sec}$

3. A ball is tossed from the window of a building with an inital velocity of 8 m/s, at an angle of 20^0 below the horizontal. It strikes the ground 3 sec lates. From what heisht was the ball thround? How far from the base of the building does the ball strickes the ground.

Ans:- $4 = 8m/s \quad \theta = 20^0, \quad t = 3sec$

(a) Horizontal distance $= 4\cos\theta \times t = 8\cos 20^0 \times 3$

$$= 8 \times 0.9397 \times 3$$

$$= 22.6m$$

(b) Hisht h $= (4\sin\theta)\, t + \frac{1}{2}gt^2$

$$= 8 \times \sin 20 + \frac{1}{2} \times 9.8 \times 9$$

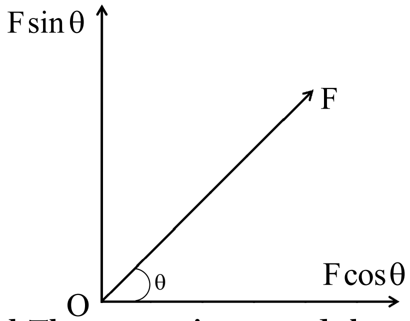
$$= 8.208 + 44.1 = 52.31m$$

UNIT IV

MOTION IN A PLANE

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. The vertical component of a vector is equal to its horizontal components. What is the angle made by the vector with x - axis.



Ans:- The lorizontal component is equal to the vertical component of avector

$F\cos\theta = F\sin\theta$

$\tan\theta = 1 \Rightarrow \theta = \tan^{-1}(1) = 45^0$

$\boxed{\theta = 45^0}$

2. A vector V makes an angle ewite the horizontal. The vector is rotated through an angle $\hat{e}$. Does this rotation change the vector V?

Ans:- Yes it changes the vector.

3. Two forces of magnitude 3 units and 5 units al + at 60^0 with each 0 times. What is the magnitude of their resultant?

Ans:- P = 3 unit Q = 5 unit $\theta = 60^0$

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta} = \sqrt{3^2 + 5^2 + 2\times3\times5\times\frac{1}{2}}$$

$$= \sqrt{9 + 25 + 15}$$

$$= \sqrt{49}$$

= 7 units

4. $A = \vec{i} + \vec{j}$ what is the angle between the vector and x - axis?

Ans:- $A = \vec{i} + \vec{j}$

$$\cos\alpha = \frac{Ax}{|A|} \quad (\therefore A\times = 1)$$

$$= \frac{1}{\sqrt{1^2+1^2}} = \frac{1}{\sqrt{2}}$$

$$\alpha = \cos^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^0$$

$\boxed{\alpha = 45^0}$

5. When two right angled vectors of magnitude 7 units and 24 units combine, what is the magmitude of their resultant?

Ans:- $\theta = 90^0$, $P = 7$ units, $Q = 24$ units

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta} = \sqrt{7^2 + 24^2 + 2 \times 7 \times 24 \times 0}$$

$$= \sqrt{49 + 576 + 0}$$

$$= \sqrt{625}$$

= 25 units.

6. If $P = 2i + 4j + 14k$, and $Q = 4i + 4j + 10k$ find the magnitude of P + Q

Ans:- $P = 2i + 4j + 14k$, $Q = 4i + 4j + 10k$

$$\vec{P} + \vec{Q} = 2i + 4j + 14k + 4i + 4j + 10k = 6i + 8j + 24k$$

$$\left|\vec{P} + \vec{Q}\right| = \sqrt{6^2 + 8^2 + 24^2} = \sqrt{36 + 64 + 576} = \sqrt{676}$$

= 26

7. Can a vector of magnitude zero have non zero components?

Ans:- No, the components of a vector of magnitude zero have non-zero components.

8. What is the acceleration of projectile at the top of its frajectory.

Ans:- The acceleration of a projecties at the top of its trajectory is vertically down wards.

9. Can two vectors of unegual magnitude add up to give the zero vector? Can three un equal vectors add up to give the zero vector?

Ans:- No, two vectors of enegual magnitude cannot be equal to zero. According to tringle law, three unequal vectors in equilli brium can be zero.

SHORT QUESTION & ANSWERS (4MARKS)

1. State parallebgram law of vectors. Derive an expressions for the magnitude and direction of the resultant vectors?

Ans:- Statement : If two vectors acting at a point are represented by the adjacent sides of a parallelogram in magnitude and direction then their resultant is vepresmted by the diagonal of the parallelogram in magnitude and direction drawn from the same point.

Explanation :

$$\overrightarrow{OA} = BC = \vec{P}$$

$$\overrightarrow{OB} = AC = \vec{Q}$$

$$\overrightarrow{OC} = \vec{R}$$

Resultant magnitude : From Δ COD

$$OC^2 = OD^2 + CD^2$$

$$OC^2 = (OA + AD)^2 + CD^2$$

$$OC^2 = OA^2 + AD^2 + 2OA.AD + CD^2$$

But $\Delta CAD \Rightarrow AD^2 + CD^2 = AC^2$

$$\Rightarrow OC^2 = OA^2 + AC^2 + 2OA\,.\,AD \;------\to (1)$$

From $\Delta CAD \;\cos\theta = \dfrac{AD}{AC}$

$$AD = Q\cos\theta \quad ------(2)$$

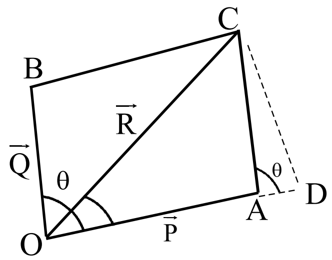
$$\Delta CAD \;\sin\theta = \frac{CD}{AC}$$

$$CD = Q\sin\theta \quad ----(3)$$

(2) eqn substute in (1) eqn

$$R^2 = P^2 + Q^2 + 2P\,Q\cos\theta$$

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$



Resultant Direction : $\quad \text{Tan}\,\alpha = \dfrac{CD}{OD}$

$$\text{Tan}\,\alpha = \frac{CD}{OA + AD}$$

From (2) & (3) eq.n to

$$\text{Tan}\,\alpha = \frac{Q\sin\theta}{OA + Q\cos\theta}$$

$$\text{Tan}\,\alpha = \frac{Q\sin\theta}{P + Q\cos\theta}$$

$$\alpha = \text{Tan}^{-1}\left(\frac{Q\sin\theta}{P + Q\cos\theta}\right)$$

2. What is relative motion? Explain it?

Ans:- **Relative Motions :** The motion of body with respect to another body is called the relative motion. The corresponding velocity is called the relative velocity.

Explanaion : Let us consider two persons A & B moving with nelocifics $\overrightarrow{V_A}$ and $\overrightarrow{V_B}$ in two diffant direction making an angle with each other.

1) The velative velocity of body A with respect to B is given by $\overrightarrow{V_R} = \overrightarrow{V_A} - \overrightarrow{V_B}$

2) The velative veleritr of body B with respect to A is given by $\overrightarrow{V_R} = \overrightarrow{V_B} - \overrightarrow{V_A}$

3) $\overrightarrow{V_R}$, $\overrightarrow{V_R}$ are equal magnitudes and opposite in directions.

4) $\left|\overrightarrow{V_R}\right| = \left|\overrightarrow{V_A} - \overrightarrow{V_B}\right| = \sqrt{V_A^2 + V_B^2 - 2\, V_A\, V_B \cos\theta}$

5) For two bodies moving in the sane directions relative velocity is equal to the diffrent of velocities $(a = 0^0,\ \cos 0^0 = 1) \Rightarrow \left|\overrightarrow{V_R}\right| = \left|\overrightarrow{V_A} - \overrightarrow{V_B}\right|$

6) For two bodies moving in the opposite divetions relative velocity is equal to the sum of their velocity $(a = 180^0,\ \cos 180^0 = -1)$

$$\Rightarrow \left|\overline{V_R}\right| = \overline{V_A} + \overline{V_B}$$

7) If they move at right angle to each orher then the relative velocity = $\sqrt{V_1^2 + V_2^2}$

8) If $\overline{V_A} = \overline{V_B}$ =V then $V_{Rcl} = 2V \sin \frac{\theta}{2}$

3. Show that a boat must move at angle with respect to given water in order to cross the river in minimum time?

Ans:- The boat is directed making an angle "θ" with direction of water cursent. The angle between $\overrightarrow{V_b}$ and $\overrightarrow{V_w}$ as shown in fig.

→ The component of $\overrightarrow{V_b}$ across the riun is given as $V_{by} = V_b \sin \theta$

→ When the boat reaches the other bacuse displacement of boat=width of the river = d

Time taken to cross the river = $\frac{\text{Displanment of boat across the river}}{\text{Coneponent of velocity of boat across the river}}$

$$t = \frac{d}{V_{by}} = \frac{d}{V_b \sin\theta}$$

When θ is maximum then time becomes minimum.

$\sin\theta = 1 \quad \Rightarrow \theta = 90^0$

$\therefore$ Miximum time taken to cross the river, $t = \frac{d}{V_b}$

4. Define unit vector, null vector and position vector?

Ans:- Unit vector : A vector having unit magnitude is called unit nutor.

$\hat{A} = \frac{A}{(A)}$ where $\hat{A}$ is unit vector.

Null vector : A vector having zero magnitude is called null vector.

Position vectors : The position of a particle is described by a position vector which is drawn from the origin of a referance frame. The position vector helps to locate the particle in space.

$\overrightarrow{OP} = \vec{r} = \overrightarrow{xi} + \overrightarrow{yi} + \overrightarrow{zk}$

5. If $\vec{a}+\vec{b} = |\vec{a}-\vec{b}|$ prove that the angle between $\vec{a}$ and $\vec{b}$ is 90^0.

Ans:- $|\vec{a}+\vec{b}| = \sqrt{a^2 + b^2 + 2ab\cos\theta}$

$|\vec{a}-\vec{b}| = \sqrt{a^2 + b^2 - 2ab\cos\theta}$

$\therefore |\vec{a} + \vec{b}| = |\vec{a} - \vec{b}|$

$\sqrt{a^2+b^2+2ab\cos\theta} = \sqrt{a^2+b^2-2ab\cos\theta}$

$2ab\cos\theta - 2ab\cos\theta$

$4ab\cos\theta = 0$

$\cos\theta = 0$ but $4ab \neq 0$

$\theta = 90^0$

Hence angle butween $\vec{a}$ and $\vec{b}$ is 90^0.

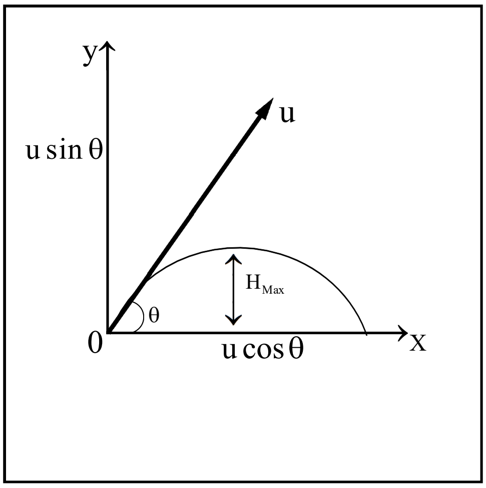
6. Show that the trajectiory of an object thrown at cestin anyle with the horizantal is a parabola.

Ans:- Consider a body is projected with an initial velocity (u) making an angle θ with the horizontal. The velocity of the projectiles. x-disation $u\cos\theta$ and y-direction $u\sin\theta$.

The distance fravelled along ox in time 't' is give by

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

$$t = \frac{x}{u\cos\theta} \quad ------(1)$$



along with y - direction in time 't' is given by

$$y = u\cos\theta\ xt + \frac{1}{2}(-g)\ x\ (+)^2$$

but (1) eq'n $t = \frac{x}{u\cos\theta}$ then

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

$$= \mathrm{Tan}\,\theta\ x - \left(\frac{g}{2u^2\cos^2\theta}\right) x^2 \quad \text{Let } A = \mathrm{Tan}\,\theta$$

$y = Ax - Bx^2$ $\qquad B = \frac{g}{2u^2 \cos^2 \theta}$

This is the equation of parabola.

$\therefore$ The trajectiony of a projectiles is parabola.

7. Explain the terms the average velocity and instananeous velocity. When are they equal?

Ans:- **Average Velocity :** The average velocity of the particles is defined as the ration of displacement (Δx) to the time intnral Δt

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

Instantaneous velocity : A velocity of the particle at any instant of time is called instanneous velocity.

$$V_{Insta} = \underset{\Delta t \to 0}{Lt} \frac{\Delta x}{\Delta t} = \frac{ds}{dt}$$

For a body moving with uniform velocity its averige velocity is equal to the instantaneous velocity.

8. Show that the maxium height and range of a projectite are $\frac{u^2 \sin^2\theta}{2g}$ and $\frac{u^2 \sin 2\theta}{g}$ respectively whese the tums have their regular meaings.

Ans:- **Maximum luight :** when the projectile is at the maximum height, its vertical component of velocity $V_y = 0$.

initial velocity (u) = u sinθ

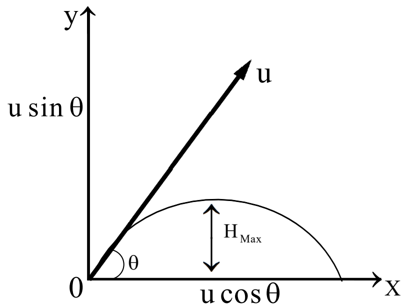
S=H=maximum height

a = - g

$$V^2 - u^2 = 2as$$

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

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



Horizontal ranges (R) : The horizonatal distance travelled by the projectile from the point of projection during the time of flight is called range.

Range (R) = Horizonatal velocity x time

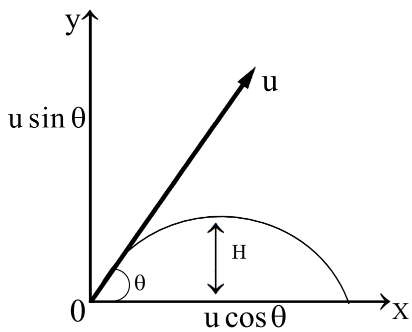
$$R = u \cos\theta \text{ x } t = u \cos \theta \times \frac{2u \sin \theta}{g}$$

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

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

if $\theta = 45$

$$\boxed{R_{max} = \frac{u^2}{8}}$$



9. If the trajectory of a body is parabolic in one reference france, can it be parabolic in auother reference frame that moves at constant velocity with respect to the first reference from? If the trajectory can be other than parabolic what else can it be?

Ans:- No, when a store is thrown from a moving bus, the trajectory of the store is parabolic in one reference frame. That is when a man observes out side footpath. In another frame of reference the trajectory is a vertical straight live.

10. A force 2i + j - k newton acts on a body which is initially at rest. At time ends of 20 sec. The velocity of the body is 4i+2j+-2k m/s what is the mass of the body?

Ans:- F = (2i + j + k)N t=20 sec, u=0, V=4i+2j-2k

$$a = \frac{V-u}{t} = \frac{4i+2j-2k}{20} = \frac{2(2i+2j-k)}{2\times 10} = \frac{2i+j-k}{10}\ \text{m/sec}$$

But $F = ma \Rightarrow m = \frac{F}{a} = \frac{2i+j-k}{\frac{2i+j-k}{10}}$

$$\boxed{m = 10\ \text{kg}}$$

Problems :

1. A projectiles is tired at an angle of 60^0 to the horizontal with aninial velocity of 800m/s

i) Find the time of flight of the projectile betore it hits the ground.

ii) Find the distance is travels berore it bits the ground (Range)

iii) Find the time of flisht for the projectiles to reach its maximum height.

Sol:- $\theta = 60^0,\ u = 800\ \text{m/sec}$

i) $T = \frac{2u\sin\theta}{g} = \frac{2\times 800\times \sin 60^0}{9.8}$

$$= \frac{2\times 800\times\sqrt{3}}{9.8\times 2}$$

$$T = 141.4\ \text{sec}$$

(ii) Range $= \frac{u^2 \sin 2\theta}{g} = \frac{(800)^2 \times \sqrt{3}}{9.8 \times 2} = 56.57$ km

iii) $t_a = \frac{u \sin\theta}{g} = \frac{800 \times \sin 60^0}{g} = \frac{800 \times \sqrt{3}}{9.8 \times 2}$

$t_a = 70.7$ sec

2. **For a particle projected slantwise from the round, the magnitude of its position vector with respect to the point of projection, when its is the highest point of the path is found to be $\sqrt{2}$ times the maximum height reached it show that the angle of projection is $\tan^{-1}(2)$.**

Sol:- Range (R) $= \frac{u^2 \sin 2\theta}{g}$, $H_{max} = \frac{u^2 \sin^2\theta}{2g}$

Give $R = \sqrt{2}\ H$

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

$$\tan\theta = 2\sqrt{2}$$

$$\boxed{\theta = \tan^{-1}(2\sqrt{2})}$$

3. **An object is luched from a cliff 20m above the ground at an angle of 30 above the norizontal with an initial speed of 30m/s. How horizontally does the object travel before leading on the ground? ($g = 10 m/s^2$)**

Sol:- $h = 20m,\ \theta = 30^0,\ u = 30\ m/s\quad g = 10\ m/s^2$

$$h = -(u \sin\theta)t + \frac{1}{2}gt^2$$

$$20 = -30 \sin 30^0 \times t + \frac{1}{2} \times 10t^2$$

$$20 = -30 \times \frac{1}{2} \times t + \frac{1}{2}10t^2$$

$4 = -3t + t^2$

$t^2 - 3t - 4 = 0$

$(t-4)(t+1) = 0$

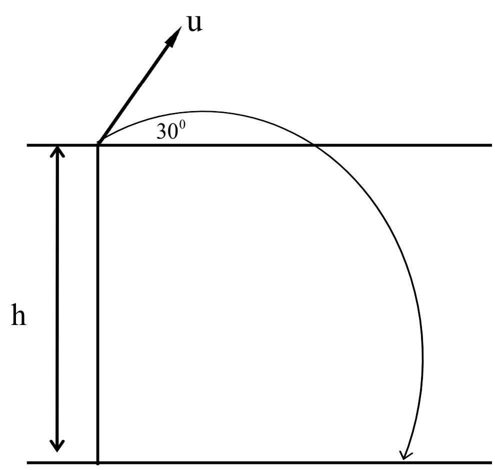
$t = 4$sec (or) $t = -1$ sec

Range R = 4 $\cos\theta$ x t

$$= 30 \cos 30^0 \times 4$$

$$= 30 \times \frac{\sqrt{3}}{2} \times 4$$

$$\boxed{R = 60\sqrt{3}\ m}$$



4. A particle is projected from the ground with some initial velocity making anangle of 45^0 with the horizontal. It reaches a heisht of 7.5m above the ground while it travels a horizontal distance of 10m from the point of projection. Find the initial speed of projection. ($g=10m/s^2$)

Ans:- $\theta = 45^0, \; g = 10m/s^2$ Hd (x) = 10

Yd (y) = 7.5m

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

$$7.5 = \tan 45^0 \times 10 - \frac{10}{2u^2 \cos^2 45^0} \times 10^2$$

$$7.5 = 10 - \frac{1000}{2u^2 \times \frac{1}{2}}$$

$$\frac{1000}{u^2} = 2.5 \Rightarrow u^2 = \frac{1000}{2.5}$$

$$u^2 = 400$$

$$\boxed{u = 20 \; m/s}$$

UNIT V

LAWS OF MOTION

VERY SHORT QUESTION & ANSWERS (2 MARKS)

3. When abullet is fired from a gun, the gun gives, a kick in the backward direction? Explain?

Ans:- According to law of coroservation of momentum when a bullet is fired from a gun, the momentum of the gun is equal and opposite to that of bullet. As the bullet moves forward on firing, the gun moves back.

4. Why does a heavy rifle not recoil as strongly as a light rifle unling the same catridges?

Ans:- As the mass of the rifle is more its acceleration is less. Therefore, a heavey rifle doesn't recoil as stronely as a light rifle.

5 . If a bomb at rest explodes in two pieckes the pieces must travel in opposite direction. Explain?

Ans:- According to law of conservation of momentum.

$Mu = m_1u_1 + m_2u_2$

initially $u = 0$

$m_1u_1 + m_2u_2 = 0$ or $m_1v_1 = m_2v_2$

(-ve sign indicates that the pieces must travel in opposite direction)

6 . Define force. Whate are the basic forces in nature?

Ans:- It is that which changes or tries to change the state of body.

Basic forces : 1) Gravitational forces 2) Electromagnetic forces
3) Strong nuelear forces 4) weak nulear

7. Can the coefficient of friction be greater then one?

Ans:- Yes, coefficient of friction may be greater than one. In some particular cases it is possible. They are

1) Due to in crease the inner molucular attractive forces between surfaces when the contact surfaces are highly polished.

2) When the contact surfaces of the bodies are inrer locking the coefficient friction may be greater than one.

8. Why does the car with a flatlened type stop sooner than the oue with in flated tyres?

Ans:- In case of flathened tyres more deformation occurs. when compared to that of in flattened tyres. Since rolling friction is directly proportional to the area of contact. Flatlened tyres stop sooner than of inflattened tyres.

9. A horse has to pull harder during the starts of the mation than later. Explain?

Ans:- Inifially the cart has to overcom the limiting friction. Once motion has started the frictional forces deducer. Hence the horse has to pull cart harder during start.

10. What happends to the coefficient of friction if the weight of the body is doubled?

Ans:- Cofficient of friction is independent of mass of the body. Hence it remains.

SHORT QUESTION & ANSWERS (4MARKS)

1. A stone of mass 0.1kg is thrown vertically up ward. Give the magnitude and direction of the net force on the stone (a) during its upward motion (b) duning its downward motion, (c) at the highest point, where it moncentarily comes to rest.

Ans:- (a) during upward motion : Magnitud of the bet force of the stone.

$F = |-mg| \; : \; = 0.1 \times 9.8 = 0.98N$

(b) During downward motion : Magnitude of the net force of the store.

$F = |-mg| \; : \; = 0.1 \times 9.8 = 0.98N$

(c) At the highest point : Magnitude of the net force

$F = mg = 0.1 \times 9.8 = 0.98N$

4. Explain the terms limiting friction, dynamic friction and rolling friction.

Ans:- **Limitting friction :** The maximum frictional force developed between the bodies at rest is called limiting friction.

Dynanic friction : Frictional force between bodies in motion is called dynamic (or) kinitic friction.

Rolling friction : When one body rolls on the surface of the other body, then the friction in between the furfaces is called rolling friction.

5. Explain advantages and disadvantages of friction?

Ans:- **Advantages of friction :**

1) Walking on the floor, motion of vehicles etc. are possible only due to friction.

2) Nails, serews etc. are driver into walls, wooden surfaces etc. due to friction.

3) Writing with pens, pencils, holding objects with hands etc, is possible due to friction.

4) A match stick is lightened due to friction.

Disadvantages of friction :

1) Wear and tear of machine parts are due to friction.

2) Energy is wasted as heat due to friction.

6. Mention the methods used to decreases friction?

Ans:- Methods to reduce friction.

(a) Polishing : Polishing the surfaces in contact decrease the inter locking and there by friction can be reuces.

(b) Ball bearings : Ball bearings can reduce the friction since rolling fricton is less than the sliding friction.

(c) Lubricants : Lubricants cike grease forms a thin layer between surfaces in contact. It reduces the friction.

(d) Streamlining : Automobiles and aeroplans are strenliing to reduce the air friction.

7. State the laws of rolling friction?

Ans:- Laws of friction - rolling friction :

1) The smalla the area of contact, the leeser will be the rolling friction.

2) The larger the radius of the rolling body the lesses will be the rolling friction

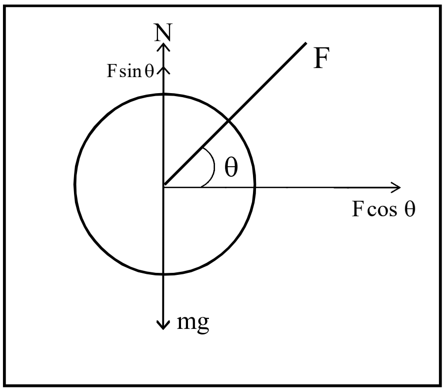
3) The rolling friction is directly proportional to the normal reaction.

If F_r is the rolling friction and "N" is the normal reaction at the contant then $F_r \alpha$ N.

$\Rightarrow F_r = \mu_r N$ Where μ_r is the coefficient of rolling friction.

8. Why is pulling the lawn roller perfered in pushing it?

Ans:- **Pulling :** Consider a lawn roller of weight mg acting on the horizontal surface. It is pulled by a force F making an angle θ with horizontal. The force F can be resolved in to two components (i) F cos θ, horizontally along the road and (ii) F sinθ, rertically up wards.



Total upward force = Total downward force

N + Fsin θ = mg

N = mg - F sin θ

The frictional force fr = μ_r.N θ

fr = μ_r [mg-Fsinθ]

The net force on the pulling of roller P = Fcosθ - fr.

$$P = F[\cos\theta + \mu_r \sin\theta] - \mu_r mg \quad ------(1)$$

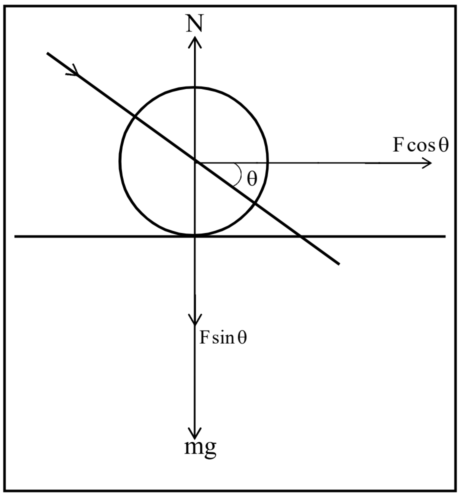
Pushing : when a lawn roller is pushed by a force.

F which makes an angle θ with the horizontal, F sinθ acts vertically down ward and F cos θ pushes the roller to the right. The weight mg acts vertically down wards.

N = mg + F sinθ

The frictional force (fr) = μ_rN

$$= \mu_r (mg + F\sin\theta)$$



The net force on the pushing of roller P = F cosθ - fr.

$$P = F[\cos\theta - \mu\sin\theta] - \mu_r mg --------(2)$$

From equation (1) and (2) that it is easier to pull than push a lawn roller.

1. A boyd is moving along a circular path such that its speed always remains constant. Should there be a force aeting on the body?

Ans:- **Force on a body moving in a circular path :** Due to the change in direction of velocity in circular path the body experiences certripetal force, eventhough magnitude of velocity always remains constant.

Problems :

1. The linear momuntum of a particle as a funtion of time t is given by p= a+ b+, where and b are positive constants, what is the force acting on the particle?

Ans:- Lincear momentum of a particle P = a+ b+

Force $F = \frac{dp}{dt} = \frac{d}{dt}(a + b+) = 0 + b$ $\boxed{F = b}$

2. Calculate the time needed for a net force of 5N to change the velocity of a 10 Kg mass by = m/sec^2

Ans:- F = 5N, m=10Kg (V-u) = 2m/sec t=?

$$F = m\frac{(v-u)}{t} \Rightarrow 5 = \frac{10\ (2)}{t} = 4\sec$$

$\boxed{t = 4\ \sec}$

3. A constant force acting on a body of mass 3Kg changes its speed from 2 in m/sec to 3.5 m/s in 25 sec, The direction of motion of the body reamaing unchanged. What is the magnitude and aircetion of the force.

Ans:- m = 3kg u=2m/sec v=3.5m/sec, t=25sec.

$$F = m\left(\frac{v-u}{t}\right) = \frac{3\,(1.5)}{25} = \frac{4.5}{25} = 0.18N$$

4. A container of mass 200 kg rests on the back of an open trusk. If the truck accelerates at 1.5 m/s2 what is the minimum cafficient of static, friction between the container and the bed of the truck reguired to prevent the container from sliding of the back of the truck?

Ans:- m = 200Kg a=1.5 m/s2 g=9.8m/s2

$F = \mu_s.N$ $N = mg$

$ma = \mu_s\ mg$ $F = ma$

$$\mu_s = \frac{9}{8} = \frac{1.5}{9.8} = 0.153$$

UNIT VI

WORK, ENERGY AND POWER

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. State the condition under which a force does no work?

Ans:- 1) When the displacement is zero.

2) When the displancement is perpenducular to the direction of the force.

3) When the body moves under the action of a conservative force over a closed path.

2. Define, work, power and Energy. State their S.I units?

Ans:- Work : The product of magnitude of displacement and component of force along the direction of displacement is called work.

$$W = \bar{F}.\bar{S} = F.S\cos\theta$$

Unit : Joyle.

Power : The rate of doing work by a force is called power.

$$P = \frac{w}{t}$$ Units : Watt or J/sec

Energy : The capality to do work is called energy.

Unit : Joyle.

3. State the relation between the kinetic energy and momentum of a body?

Ans:- Kinetic energy $E_K = \frac{P^2}{zm}$

P = momentum of the body

m = mass of the body.

4. State the sign of work done boy a force in the following

(a) Work done by a man in lifting a bucket out of a well by means of rope tied to the bucket.

(b) Work done gravitational force in the above case.

Ans:- (a) Work done is +Ve, because the bucket displaces in the direction of force.

(b) Work done is -Ve, because the displacement is opposite to the gravitational force.

$W = F.S\cos\theta = F.S\cos 180^0 = - F.S$

5. **State the sign of work done by a force in the following.**

(a) Work done by friction on a body sliding down an inclined plaine.

(b) Work done by gravitational force in the above case?

Ans:- (a) Work done is -Ve, because friction always opposite to the direction of the motion.

(b) The work done is +Ve.

6. **State the sign of work done by a force in the following.**

(a) Work done by an applied force on a body moving on a rough horizontal place with uniform velocity.

(b) Work done by the resistive force of air on a vibrating pendulum in bringing it to rest?

Ans:- (a) The workdone is +Ve, because the applied force and displancement are in the same direction.

(b) The work done is -Ve, because the direction of resistive force is opposite to the direction motion of the pendulun.

7. **State if each of the following statement is true or false. Give realons for gour answer, (a) Total energy of a system is always conserval, no matter wahat internal and external forces on the body are present.**

(b) The work done by earth's gravitational force in keeping the moon in its orbits one revolution is zero.

Ans:- a) False b) True. Because gravitation force is conservative force.

8. **Which physical quantity regnains constant.**

i) in an elastic collision ii) in an inelastic collision.

Ans:- **i) in elastic collision :** Both momatum and kinetic energy is constant.

ii) in an inelastic collision : Only momemetum renaing constant.

9. **A body freely falling from a certain height "h" after striking a smooth floor rebounds and an rises to heisht h/2 what is the coefficient of restitution between the floor and the body?**

Ans:- Given $h_1 = h, \quad h_2 = \frac{h}{2}$

$$\therefore e = \sqrt{\frac{h_2}{h_1}} = \sqrt{\frac{\frac{h}{2}}{h}} = \frac{1}{\sqrt{2}} = 1.414$$

10. **What is the total displacement of a freely folling body after successive re bounds from the place of ground before it comes to stop? Assume that "e" is the coefficient of restitution between the body and the ground?**

Ans:- The total displacement of the freely talling body after successive rebounds from the sround before it comes to stop is "h".

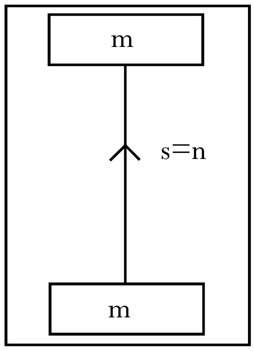
SHORT QUESTION & ANSWERS (4MARKS)

1. What is potential energy? Derive and expression for the gravitational potantial energy?

Ans:- **Potential energy :** The energy possessed by a body by virture of its position is called potential energy.

Examples : i) A stretched rubber cord

ii) The stone lifted above the ground.



Expression for potential energy :

A body of mass m is on the ground. It is lifted vertically up words through a height h.

Gravitational force on the body F = mg

Displacements = h

Workdone = W = F.S

$$W = mgh$$

This work done is stored in the form of potuntial energy.

$$\boxed{P.E\ (U) = mgh}$$

2. A Lorry and a Car moving with the same momentum are brought to rest by the application of brakes, which provide equal retarding forces. Which of them will come to rest in shorten time? Which will come to rest in less distance?

Ans:- Given momentam of the lorry = momentam of the car.

$$P_L = P_C$$

and same retareling force $F_L = F_C$

From Newton's second law $F = \frac{m(v-u)}{t} = \frac{\Delta P}{t}$

W=F.S = charge in K.E $= \frac{P^2}{2m}$

$\therefore$ Both lorry and car comes to rest at the same time.

$F.S = \frac{P^2}{2m}$ (Here F,P are constant)

$$S \ \alpha \ \frac{1}{m}$$

Hence lorry comes to rest in less distance.

3. Distinguish between conservative and non-conservative forces with one example each?

Ans:- **Conservative Forces :** A force is conservative if the work done by the force on a body along any closed path is zero.

Example : Gravitational force. Work done independent of the path.

Non-conservative force : A force is called non-conservative force, is the work done by the force on a body along a closed path is not zero.

Example : Frictional force work done depends on the path.

4. Show that in the case of one dimensional elastic collision the relative velocity of approach of two colliding bodies before collision is equal to the relative velocity of separation after collision?

Ans:- Consider two bodies of masses m_1 and m_2 moving with velocities u_1 and u_2 collids elastically. Assume $m_1 > m_2$ and $u_1 > u_2$. Let v_1 and v_2 velocities of the two bodies after collision.

From the law of conservation of conear momentam

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$m_1(u_1 - v_1) = m_2(v_2 - u_2) \quad ------(1)$$

From the law of consorvation of kinetic energy.

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$m_1(u_1^2 - v_1^2) = m_2(v_2^2 - u_2^2) \quad -----(2)$$

equation 2/1 then we get

$$u_1 + v_1 = v_2 + u_2$$

$$u_1 - u_2 = v_2 + v_1 \quad -------(3)$$

Relative velocity of approach from the above equation before collision = Ralative velocity of separation after collision.

5. Show that two equal masses undergo obligue elastic collision will move at right angles after collision, if the second body initially at rest.

Ans:- **Oblique elastic collision :** If the center of mass of the colliding bodies are not initially moving along the line of impact then the impact is called oblique collision.

Two equal masses undergo oblique elastic collision will move at right angles after collision, is the second body initially at rest.

Consider two smooth and perfectly elastic spheres of masses m_1 and m_2. Let u_1 and u_2 be their initial velocity before collision. Let v_1 and v_2 be their final velocities after collision (α,β) and (θ,ϕ) are the angles, the direction of motion make with the line of impact before collision and after collision.

$v_1 \sin\theta = v_2 \sin\alpha \quad ----(1)$

and $v_2 \sin\phi = u_2 \sin\beta \quad ----(2)$

From the conservation of momentum and kineticenergy to.

$\therefore m_1u_1 \cos\alpha + m_2u_2\cos\beta = m_1v_1\cos\theta + m_2v_2\cos\phi$

$\Rightarrow m_1 (u_1\cos\alpha - v_1\cos\theta) = m_2(v_2\cos\phi - u_2\cos\phi) \quad -----(3)$

and $\frac{1}{2}m_1u_1^2 \cos\alpha^2\alpha \frac{1}{2}m_2u_2^2\cos^2\beta = \frac{1}{2}m_1v_1^2\cos^2\theta + \frac{1}{2}m_2v_2^2\cos^2\phi$

$\Rightarrow m_1(u_1^2\cos^2\alpha - v_1^2\cos^2\theta) = m_2(v_2^2\cos^2\phi - u_2^2\cos^2\beta) \quad -----(4)$

equation 4/3 we will get

$\frac{4}{3} \Rightarrow (u_1\cos\alpha + v_1\cos\theta) = (v_2\cos\phi + u_2\cos\beta)$.

$v_1\cos\theta = v_2\cos\phi + u_2\cos\beta - u_1\cos\alpha \quad ----(5)$

and $v_2\cos\phi = v_1\cos\theta + u_1\cos\alpha - u_2\cos\beta \quad ------(6)$

sub. equation (5) in equation (3) we get

$$v_1\cos\theta = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) u_1\cos\alpha + \frac{2m_1u_2}{m_1+m_2}\cos\beta \quad -----(7)$$

and $$v_2\cos\phi = \frac{2m_1u_1}{m_1+m_2}\cos\alpha + \left(\frac{m_1 - m_2}{m_1 + m_2}\right) u_2\cos\beta \quad -----(8)$$

If $u_2 = 0$ and $m_1 = m_2$ then equation (2) we get $\phi = 0$ and from equation (7), $\theta = 90^0$. This meanes that if a sphere of mass "m" collides obliguely on another perfiectly elastic sphere of the same mass at rest. The directions of motions of the sphere after impact will be at right angles.

6. Derive an expression for the hight attained by a freely falling body after "n" number of rebounds from the floor?

Ans:- Let a sphere is dropped freely from a height "h" on to the floor. It strikes the floor with a velocity u_1 so that $u_1 = \sqrt{2gh_1} \quad -----(1)$

Let v_1 be the final velocity of the sphere with which the sphere rebounds to a hight h_1 and $v_1 = \sqrt{2gh_1}$ since the snitial and the final velocities of the floor are zero

$u_2 = 0, \; v_2 = 0$

Co-efficient of restitution $e = \frac{v_2 - v_1}{u_1 - u_2} = \frac{0 - \left(-\sqrt{2gh_1}\right)}{\sqrt{2gh} - 0}$

$$e = \sqrt{\frac{2gh_1}{2gh}}$$

$$e = \sqrt{\frac{h_1}{h}} \text{ (or) } h_1 = e^2 h$$

Similarly for the second bounce $h_2 (e^2)^2 h$ and "h" bounce $\boxed{h_n = (e^2)^h \ h}$

7. Explain the law of conservation of energy?

Ans:- **Law of conservaton enery :** Energycan be neither created nor destroyed one form of energy can be converted into another form.

Explanation : The total mechonical energy is constant if the forces are conservative. If some of the forces are non-conservative a part of mechanical energy may be convertied into another forms like sound, heat etc. But to sum of all kinds of enegies as constant for the system.

The energy of the universe as a whole is canstant. If one part of the universe loses energy another part must gain an equal amount of energy.

LONG QUESTION & ANSWERS (8MARKS)

1. Develop the notions of work and kinetic energy and show that it leads to work - energy theorem?

Ans:- Kinetic energy : Kinetic energy of a body is a measured of work done by it by virture of its motion.

$\therefore K_f - K_i = W$

Proof : Consider a particle of mass "m" is moving with initial speed "u" to final speed "v". Let "a" be its comstant acceleration and s be its distonce traveased. The kinematic relation given by.

$v^2 - u^2 = 2as \quad ----(1)$

multiplying both sides by $\frac{m}{2}$ we have to get

$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mas$

$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = F.S \quad -----(2)$

We can generalised equation (1) to there dimension by employing vectors.

$v^2 - u^2 = 2\vec{a}.\vec{d}$

Once again multiplaying both sides by $\frac{m}{2}$ we get

$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = m\,\vec{a}.\vec{d} = \vec{F}.\vec{d} \quad ------(3)$$

The above eq'n provides amotivation for the definition of work and K.E.

in eq'n (3) $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = K_f - K_i$

where K_f, K_i are initial and final K.E. and $\vec{F}.\vec{d} = w$

Where wrefers to work done bya force on the body over a certain displacement.

$\therefore K_f - K_i = W \quad -----(4)$

$\therefore$ This is work - energy therorem.

2. What are collisions? Explain the possible types of collisions? Develop the theory of one-dimensional elastic motion?

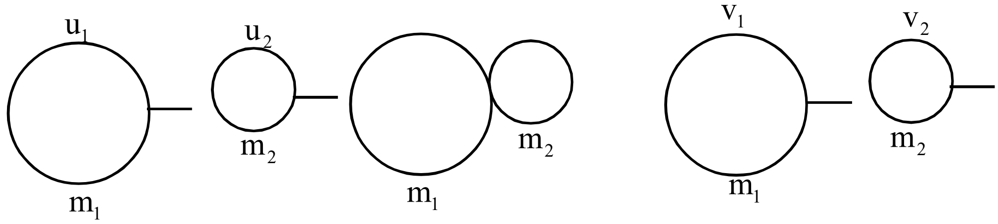
Ans:- **Collision :** A collision is a strong interaction between the particles with (or) with out contact when there are no other external forces.

Collision two types : 1) elastic collision (2) In elastic collisions.

(1) Elastic collision : The collision in which both momentum and kinctic energy are conserved then is called elastic collisions.

(2) In elastic collisions : The collision in which kinetic energy is not conservet but momentum is conserved, is called inelastic collision.

One-dimentional elastic collision : Consider two bodies of masses m_1 and m_2 moving with velocities u_1 and u_2 collide elastically. Assume $m_1 > m_2$ and $u_1 > u_2$. Let v_1 and v_2 be the velocities of the two bodies after collision.



From the law of consorvation of momentum.

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$m_1(u_1 - v_1) = m_2(u_2 - v_2) \quad ------(1)$$

From the law of conservation of K.E.

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$m_1\left(u_1^2 - v_1^2\right) = m_2\left(v_2^2 - u_2^2\right) \quad ------(2)$$

Dividing equation (2) and (1) then wayet

$$\frac{(u_1 - v_1)\ (u_1 + v_1)}{(u_1 - v_1)} = \frac{(v_2 - u_2)\ (v_2 + u_2)}{(v_2 - u_2)}$$

$u_1 + v_1 \quad = v_2 + u_2$

$u_1 - u_2 \quad = v_2 - v_1 \qquad ------(3)$

Velocity of first body

From eq'n (3) $v_2 = u_2 + v_1 - u_2$

Substiting eq'n (4) in eq'n (1) and simplyfing, weget

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) u_1 + \left(\frac{2m_2}{m_1 + m_2}\right) u_2 \qquad ------(5)$$

Velocity of second body

Again from equation (3) $v_1 = v_2 + u_2 - u_1$

Substituting this in eq'n (1) and simpliting, we get

$$v_2 = \left(\frac{2m_1}{m_1 + m_2}\right) u_1 + \left(\frac{m_2 - m_1}{m_1 + m_2}\right) u_2 \qquad ------(6)$$

3. State and prove law of conservation of energy in case of a freely falling body?

Ans:- **Law of conservation of energy :**

Energy can neither be created nor be destroyed. But it can be changed from one form to another form.

Proof : Consider abody of mass "m" dropped from a height "n" above the ground. At thepoint "A"

initial velocity = 0

$\therefore$ Kinetic energy $K.E_A = \frac{1}{2} mu^2 = 0$

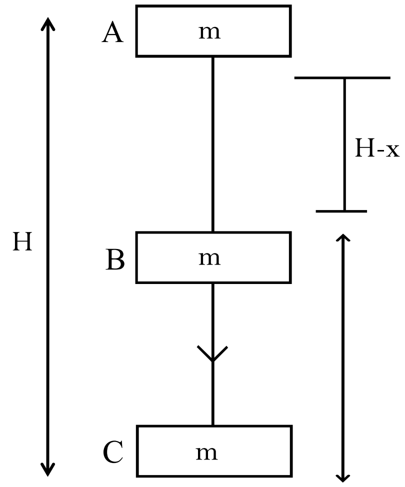
$P.E_A = mgh$

$(h = H) \Rightarrow P.E_A = mgH$

$\therefore$ Total Energy $= P.E_A + K.E_A$

$= mgH + 0$

$\boxed{T.E_A = mgH} \qquad ------(1)$



At the point "B" : Kinetitic relation (3) eqn'n

$v^2 - u^2 = 2as \qquad \mu = a$

$v_B^2 - o^2 = 2(+g)\ (H - x) \qquad v = v_B$

$v_B^2 = 2g(H - x) \qquad a = +g$

$S = H - x$

$$K.E_B = \frac{1}{2}mv_B^2 = \boxed{\frac{1}{2}m(u^2 - 2gh)}$$

$$= \frac{1}{2}m(2g(H-x) \quad \boxed{\frac{1}{2}mu^2 - mgh}$$

$$K.E_B = mgH - mg\,x$$

$$PE_B = mgh$$

$$h = x$$

$$P.E_B = mg\,x$$

$$T.E_B = mgH - mgx + mgx = mgH$$

$$\boxed{T.E_B = mgH} \quad ------(2)$$

At the point "C" : Kinematic relation to

$$v^2 - u^2 = 2as \qquad v = v_c$$

$$v_c^2 = 2gH \qquad u = 0$$

$$K.E_c = \frac{1}{2}mv_c^2 \qquad a = g$$

$$= \frac{1}{2}m\ (2gH) \qquad S = H$$

$$K.E_c = mg\ H$$

$$P.E_c = mg\,h$$

$$h = 0$$

$$P.E_c = 0$$

$$T.E_c = mgH + 0 = mgH$$

$$\boxed{T.E_c = mgH} \quad ----(3)$$

$\therefore$ en'n (1), (2) and (3) total mechanical energy remains constant. Hence law of consawation of energy is verified in the case of a frelly falling body.

Problems :

1. A machine gun fires 360 bullets per minutes each bullet trawels with a velocity of 600 m/s. If the mass of each bullet is 5 gr, find the power of the machine gun?

Ans:- n=360, t=600m/sec m=5gr = 5 x 10^{-3} kg

$$P = \frac{\frac{1}{2}mnv^2}{t} = \frac{\frac{1}{2}\times 5\times 10^{-3}\times 360\times 600\times 600}{60}$$

P = 5400 W = 5.4 K.W

2. **Find the useful power used in pumping 3425m^3 of water per hour from a well 8m deep to the surface. Supposing 40% of the horse power during pumping is wasted. What is the horse power of the engine?**

Ans:- $V = 3425\ m^3 = d = 103\ Kg/m^3$ h=8m g=9.8m/s^2

t = 1 hour = 60 x 60 sec.

$$\text{Power} = \frac{mgh}{t} \Rightarrow 60\%\ \text{power} = \frac{mgh}{t}$$

$$\Rightarrow 60\%\ \text{power} = \frac{vdgh}{t}$$

$$\Rightarrow \frac{60}{100} \times P = \frac{3425 \times 10^3 \times 9.8 \times 8}{60 \times 60}$$

$$P = \frac{3425 \times 10^3 \times 10^2 \times 9.8 \times 8}{60 \times 60 \times 60}$$

$$P = 1243.14 \quad \text{watt}$$

$$\boxed{P = 1.666\ \text{h.P}} \qquad [\text{Thp} = 746\ \text{watt}]$$

3. **A pump is required to lift 600kg of water per minute from a well 25m deep and to eject it with a speed of 50 m/sec. Calculate the power reguirted to perform the above task?**

Ans:- m = 60 kg h=25m, v = 50m/sec t=60sec

$$p = \frac{mgh + \frac{1}{2}mv^2}{t} = \frac{m\left[gh + \frac{1}{2}v^2\right]}{t}$$

$$= \frac{600}{60}\left[9.8 \times 25 + \frac{50 \times 50}{2}\right] = 10\ [245 + 1250]$$

$$= 14950 \text{ watt}$$

$$\boxed{P = 14.95\ \text{kw}}$$

4. **From a height of 20m above a horizontal floor, a boll is thrown down with inifial velocity 20 m/sec. After striking the floor, the ball bourkes to the same height from which it was thrown. Find the coefficient of restitution for the collision between the ball and the floor?**

Ans:- u = 20 m/sec, h = 20m, g=10m/s2

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

$$u_1^2 - 20^2 = 2 \times 10 \times 10$$

$$u_1^2 = 20^2 + 400$$

$u_1^2 = 400 + 400$

$\therefore u_1 = \sqrt{800}$

5. **A ball fall from a height of 10m on to a hard horizontal floor and repeatedly bounces. If the coefficient of restitution is $\frac{1}{\sqrt{2}}$, what is the total distance travelled by the ball before it ceases to rebounds?**

Ans:- $e = \frac{1}{\sqrt{2}},\ h = 10\text{m}$

$$S = h\left[\frac{1 + e^2}{1 - e^2}\right]$$

$$= 10\left[\frac{1 + \frac{1}{2}}{1 - \frac{1}{2}}\right]$$

$$= 10 \times \frac{3}{2} \times \frac{2}{1}$$

$$\boxed{S = 30\text{ m}}$$

UNIT VII

SYSTEMS OF PARTICLES AND ROTATIONAL MOTION

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. Is it necessary that a mass should be present at the center of mass of any system?

Ans:- No, any mass need not be present at the center of mass of a system.

Ex : a hollow sphere, center of mass liesatits center.

2. What is the difference in the positions of girl, carrying a bag in one of her hands and another girl carrying a bag in each of her two hands?

Ans:- For a girl with one bag in her hand the center of mass shifts (girl-bag system) to wards the hand with the bag. For a girl with two bags in either of hands the position of center of mass system does not change.

3. Two rigid bodies have same moment of inertia about their axes of symmetry or the two, which body will have greater kinetic energy?

Ans:- $E = \frac{1}{2} Iw^2 = \frac{1}{2} \frac{L^2}{I}, \ E \ \alpha \ \frac{1}{I}$ $(\because \ L = \text{constant})$

The rigid body having less moment of inertia will have gretater K.E.

4. Why are spokes provided in a bicycle wheel?

Ans:- By conneeting to the rim of wheel to the axle through the spokes the mass of the wheel gets concentrated at its rim. This increases its moment of inertia. This ensures its uniform speed.

5. We cannot open or close the door by applying force at the hinges. Why?

Ans:- When the force is applied at the hinges, the line of the force passes. Through the axis of rotation. i.e r = 0, So we can not open or close the door by pushing or pulling it at the hinges.

6. Why do we preter a spanner of longer arm as compared to the spanner of shorter arm?

Ans:- The torque applied on the nut by the spanner is equal to the force multiplied by the perpendicular distance from the axis or rotation. A spanner with longer arm provides more torque compared to a spanner with shorter arm. Hence longer arm spanner is preferred.

7. By spining egg on a table top, how will you disting wish a hard boiled egg from a raw egg?

Ans:- A raw egg has som fluid in it and a hard boiled egg is solid form inside. Both eggs are spvining on a table top. The fluid is thrown out wards. Therefore $I_r > I_b$. That means M. I of raw egg is greater than boiled egg. As $I \times w$ constant.

$\therefore\ w_r < w_b$ That means anglar velocity of raw egg

is less than angular velocity of boiled egg.

8. Why should a helicopted necessarily have two propellers?

Ans:- If there were only one propeller in the hellicopter then, due to conservation of angular momentum, the helicopter it self would have turned in the opposite direction.

9. It the polar ice caps of the earth were to melt, what would the effect of the length of the day be?

Ans:- Earth rotates about its polar axis when ice of polar caps of earth melts, mass concesr frated near the axis or potation spreads out. There fore, monutum of inertia. I increases. As no external forgue acts

$\therefore L = I \times w = I\left(\frac{2\pi}{T}\right)$ = constant with increases of I, T will in creases i.e length of the day will increase.

10. Why is it easies to because a bicycle in motion?

Ans:- When bycycle is in motion, it is easy to balance because the principle of conservation of angular momentum is involved.

SHORT QUESTION & ANSWERS (4MARKS)

1. Distinguish between center of mass and center of grawity?

Ans:-

Center of mass	Center of gravity
1. Point at which entire mass of the body is supposed to be concentrated and the motion of the point represents motion of the body	1. Fixed point through which the weight of the body act.
2. It refers mass of to body.	2. It refers to the weight acting on all particles of the body.
3. In a uniform grawitational field center of mass and gravity conincide.	3. In a non-unform gravitational field, center of gravity and CM do not coincide.
4. CM of the body is defined to dercibe the nature of motion of` a body as a whole.	4. Center of gravity of body is defined to know the amount of stabillity of stabillity of the body when supported.

2. Show that a system of particle moving under the influence of an extenal force, moves as if the force is applied at its center of mass?

Ans:- Let us consider position vector's $x_1, x_2, -----x_n$ are and massos $m_1, m_2, -----m_n$ particles system.

According to defination of center of mass

$$\vec{X} = \frac{m_1\vec{x_1} + m_2\vec{x_2} + ------+ m_n\vec{x_n}}{m_1 + m_2 + ------+m_n}$$

Consider $m_1 + m_2 + ---------+mn = M$

$$\vec{X} = \frac{m_1\vec{x_1} + m_2\vec{x_2} +------+ m_n\vec{x_n}}{M}$$

$$M\vec{X} = m_1\vec{x_1} + m_2\vec{x_2} +------+mn\,\vec{x_n}$$

Differentating on both sides above eq'n.

$$M\frac{dx}{dt} = m,\frac{dx_1}{dt} + m_2\frac{mx_2}{dt} + ------+ mn\frac{dx_n}{dt}$$

$$M\vec{v} = m_1\vec{v_1} + m_2\vec{v_2} +-------+ mn\vec{v_n}$$

Differentating on both saids above eq'n.

$$M.\frac{dv}{dt} = m_1\frac{dv_1}{dt} + m_2\frac{dv_2}{dt} +-----+ mn\frac{dv_n}{dt}$$

But $m_1a_1 = F_1,\ m_2a_2 = F_2 ------mna_n = F_n$ and

Ma = F than

$$F = F_1 + F_2 + ------+ F_n$$

Where Fext represents the sum of all external forces acting on the particles of the system. This eq'n states that the C.M. of a system of particles moves as if all the mass of the system was concentrated at the center of mass and all extenal forces were applied at that point.

3. Explain about the center of mass of earth moon system and potation around the sun.

Ans:- The earth moon system rotates about the common center of mass. The mass of the earth is about 81 times that of the moon. Hence the center of mass of the earth moon system is relatively close to the earth. The gravitational attraction of the sun is an extegnal force that acts on the earth moon system. The center of mass of the earth-moon system moves in an elliptical path arround the sun.

4. Define vector product. Explain the properties of a vector product with two Examples?

Ans:- **Vector product :** The cross product of two vectors is given by $\vec{C} = \vec{A} \times \vec{B}$ the magnitude of vector detined from cross product of two vectors is equal to product of magnitudes of the vectors and sine of angle between the vectors.

$\bar{a} \times \bar{b} = ab\sin\theta.\ \hat{n}$ where $\hat{n}$ is a unit vector a long $\bar{a} \times \bar{b}$

Propertics :

i) Cross product of vectors do not obey commutative law.

$\bar{A} \times \bar{B} \neq \bar{B} \times \bar{A}$ and $\bar{A} \times \bar{B} = \bar{B} \times \bar{A}$

ii) Cross product obey distributive law.

$\bar{A} \times \left(\bar{B} \times \bar{C}\right) = \bar{A} \times \bar{B} = -\bar{B} \times \bar{A}$

iii) The cross product of two parallel vectors is a null vector. If $\theta = 0^0$, then $\bar{A} \times \bar{B} = 0$

iv) The area of the triangle formed by $\bar{A}$ and $\bar{B}$ as adjacet sides is $\frac{1}{2}|\bar{A} \times \bar{B}|$

Examples :

1) Torque is cross product of position vector and force i.e. $\tau = r \times F$

2) Angular momutum is cross product of position vector and momentum.

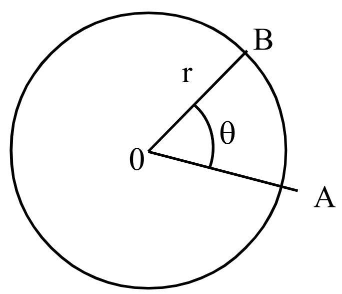
$\vec{L} = \vec{r} \times \vec{P}$

5. Define angular velocity (u) Derive =V = rw.

Ans:- **Angular velocity :** The rate of change of angular displacement of a body is called angular velocity $\boxed{\omega = \frac{d\theta}{dt}}$

Equation : Consider a rigid body be moving with uniform speed (v) along the circumberence of a circle of radius r. Let the body be displaced from A to B in a small interval of time Δt making an angle $\Delta\theta$ at the center. Let the linear displacement be Δx from A to B.

From the proputy length of are = radius x angle.



$\Delta x = rx\ \Delta\theta$

This equation is divided by Δt, and taking Limit $\Delta t \to \theta$ on both sides.

$$\Rightarrow \underset{\Delta t \to 0}{Lt} \frac{\Delta x}{\Delta t} = r \underset{\Delta t \to 0}{Lt} \frac{\Delta\theta}{\Delta t} \quad -----(1)$$

But $\underset{\Delta t \to 0}{Lt} \frac{\Delta x}{\Delta t} = v$ -------(2) and $\underset{\Delta t \to 0}{Lt} \frac{\Delta\theta}{\Delta t} = w$ -------(3)

eq'n (2) & (3) in (1) weget $\boxed{r = v.\ w}$

6. Define angular acceleration and torque. Establish the relation between angular acceleration and torque?

Ans:- **Angular acceleation :** The rate of change of angular velocity is called angular accelexation

$$\text{i.e } \alpha = \frac{dw}{dt}$$

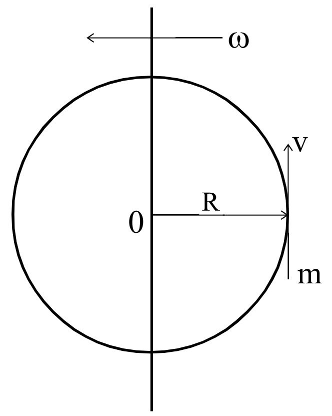
Torque : The rate of change of angular momentum is called torque or the moment of force is called torque.

Relation between angular acceleration and Torque :

Consider a rigid of mass "M"

rotating in a eircular path of radius "R"

with angular velocity about fixed axis.



By defination, $\tau = \frac{dL}{dt} = \frac{d}{dt}(Iw)$

Where $I = MR^2$ = Momentum of inertia of a body.

$$\tau = I\frac{dw}{dt} \qquad \left(\because \frac{dw}{dt} = \propto\right)$$

$$\boxed{\tau = I \propto}$$

7. Write the equations of motion for a particuler rotating about a fixed axis?

Ans:- Equations of motion for a particle rotating about a fixed axis:

1) $\omega_f = \omega_i + \alpha t$ $\qquad [\because \text{like } v = u + at]$

2) $\theta = \left(\frac{\omega_i + \omega_f}{2}\right)t$ $\qquad \left[\because \text{like } \vec{v} = \left(\frac{v_1 + v_2}{2}\right)t\right]$

3) $\theta = \omega_i t + \frac{1}{2}\propto t^2$ $\qquad \left[\because \text{like } S = ut + \frac{1}{2}at^2\right]$

4) $\omega_f^2 - \omega_i^2 = 2\,\alpha\,\theta$ $\qquad [\because \text{like } \omega^2 - u^2 = 2as]$

8. Derive expressions for the final velocity and total energy of a body rolling with out slopping?

Ans:- **Expression of velocity of abody Rolling down an inclined place :** Consider a rigid body of mass M and radius R rolling down an linclined place from a height h. Let v the linear speed acquired by the body when it realhes the bottom of the place and K is its radius of gyration.

According to law of conservation of energy we have P.E of body on top θ, f inelined plane.

P.E. at the top = K.E of transiation + K.E. of rotation Mgh = $\frac{1}{2}mv^2 + \frac{1}{2}Iw^2$

$$Mgh = \frac{1}{2}mv^2 + \frac{1}{2}mk^2\frac{V^2}{R^2}\begin{pmatrix} I = MK^2 \\ \&\omega = \frac{V}{R}\end{pmatrix}$$

$$Mgh = \frac{1}{2}MV^2\left(1 + \frac{K^2}{R^2}\right)$$

$$\therefore \boxed{V = \sqrt{\frac{2gh}{\left(1+\frac{K^2}{R^2}\right)}}}$$

Expression of total energy of a body rolling down or an inclined place : Supposre a body is rolling on a surface. Its motion can be treated as a combination of the franslation of the center of mass and rotation about a axis passing through the center of mass. The total K.E can written as.

$$E = E_T + E_R = \frac{1}{2}MV^2 + \frac{1}{2}IW^2 = \frac{1}{2}MR^2W^2 + \frac{1}{2}MK^2W^2$$

$$E = \frac{1}{2}MW^2(R^2 + K^2)$$

$$E = \frac{1}{2}MW^2\left(1+\frac{K^2}{R^2}\right) \text{ qyration } \left[\therefore w = \frac{V}{R}\right]$$

LONG QUESTION & ANSWERS (8MARKS)

1. (a) State and prove parallel axes the orem.

(b) For a the in flat circular disk, the radius of gyration about a diameter as axis is K. If the disk is cut a long adiameter AB a shown into two equal pieces, then find the radius of gyration of each pieces about AB.

Ans:- **Statement :** The moment of inertia of a plane lamina about an axis is equal to the sum of the moment of ineration about a parallel axis passing through the center of mass and product of its mass and square of the distance between the two axes

i.e $I_0 = I_G + MR^2$

Let I_G is the moment of inortia of the plane lamina about the axis Z_2 passing through the centre of mass.

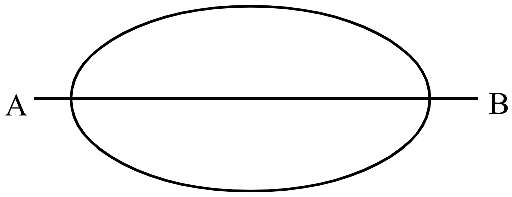
I_0 is the moment of inertia of the lamina about an axis Z_1.

Proof : Let aparticle of mass mis situated at P. Moment of inutiw about the axis pass in through join with line extending from OG.

From the trainagle Δ POQ

$OP^2 = OQ^2 + PQ^2$

$OP^2 = (OG + GQ)^2 + PQ^2$



$[\because OQ = OG + GQ]$

$OP^2 = OG^2 + 2OG \, . \, GQ + G.Q^2 + PQ^2$

$OP^2 - OG^2 + GP^2 + 2OG \, . \, GQ$

Multiplying with $\sum m$ on both sides.

$\sum m \; OP^2 = \sum m \, OG^2 + \sum M \, GP^2 + \sum m \, OG \, . \, GQ$

But $\sum m \, OG^2 = M \, r^2$

($\because$ OG is constant and $\sum = M$ total mass of the body)

$\sum m \, GP^2 = I_G, \sum m \, OP^2 = I_0$

$I_0 = M \, r^2 + I_G + 2r \sum m \, GQ$

$\sum m. \, G \, Q = 0$

($\because$ The moment of all the particles about the enter of mass is always zero)

$$\boxed{I_0 = I_G + M \, r^2}$$

(b) For the in circular disk, the radius of gyration about a diamentes AB is $K = \sqrt{\frac{I}{M}}$

The disk is cut in to two halves about AB.

When each Mass M = $\frac{M}{2}$ and each M.I. I= $\frac{I}{2}$

Therefore radius of gyration of each pieces is

$$K' = \sqrt{\frac{I'}{M'}} = \sqrt{\frac{\frac{I}{2}}{\frac{M}{2}}} = \sqrt{\frac{I}{M}} = K$$

2. State and prove perpendicular axes theorem.

Ans:- **Statement :** The sum of momentum of inertia of a place lamina about any two perpendiuclar axes in its plane is equal to its moment of inertia passing through the point of intdr section of the first two axes.

Proof : Consider a plane lamina revolving about the zaxis. Let "O" be the origin of the axis. Imagine a particle of mass "m" hying at a distance "r" from point "O" on the plane.

Let : x, y be the coordinates of the point P.

Thus $r^2 = x^2 + y^2$

Then the moment of the body about x-axis

$$Ix = \sum my^2$$

The moment of inertia of the body about

y - axis

$$Iy = \sum mx^2$$

Then the moment of inertia of the body about Z - axis

$$Iz = \sum mr^2 = \sum m\,(x^2 + y^2)$$

$$I_2 = \sum m x^2 + \sum m y^2$$

$$\therefore I_2 = I_y + I_x$$

$$I_2 = I_x + I_y$$

Hence perpendiuclar axes theorem is proved.

(b) If a then circular ring an a thin flat circular disk of same mass have same momunt of inertia about their respective diameters as axes.Then find the ratio of their radi.

For a thin circular M.I $I_r = \dfrac{MRc^2}{2}$

For a thin flat ciruclar disk $M.I,\ I_d = \dfrac{MR_d^2}{4}$

$$I_r = I_d$$

$$\Rightarrow \frac{MR_r^2}{2} = \frac{MR_d^2}{4} \Rightarrow \frac{R_g^2}{R_d^2} = \frac{2}{4} = \frac{1}{2}$$

$$\frac{R_r}{R_d} = \frac{1}{\sqrt{2}}$$

3. State and prove the principle of conservation of angular momcutum. Explain the principle of conservation of angular momuntum with example?

Ans:- **Statement :** Angular momuntum of a body remains constat when the external torgue is zero.

L = Iw = constant K (or) $I_1 w_1 = I_2\ w_2$

If the momentum of Indrtia of a body is lowered, the angular velocity of the body ω increases.

Proof : By defination, the rate of change of angular momuntum is called Torque.

$$\tau = \frac{dL}{dt}$$

$$\text{If } \tau = 0 \Rightarrow \frac{dL}{dt} = 0 \quad (\because \text{L=constak})$$

$$L_1 = L_2$$

$$I_1 w_1 = I_2 w_2$$

Examples : 1) A balet dancer decreases or increases his angular speed of rotation by stretching the hands or bringing the hands closes to the body.

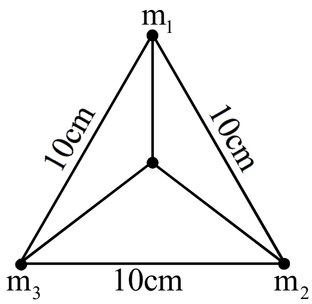
2) A diver jumps from a diving board with both the legs and hands kept far off from the body. The diver then brings the hands and legs closes to the body increasing the angular velosity. The diver makes totation in air. When the diver ncars the wath, legs and hand are stretched so that momcutum of inertia increases and ω deereases.

Problems :

1. Three particles each of mass 100g are placed at the vertices of an equilateral triangel of side length 10 cm. Find momunt of inertia of the system about an axis passing through the centroid of the friangle and perpendicular to it's place.

Ans:- m=100g, $=100 \times 10^{-3}$kg side a = 10cm

Moment of inertia = I = 3 mr^2



$$I = 3 \times 100 \times 10^{-3} x \left[\frac{10}{\sqrt{3}} \times 10^{-2}\right]^2$$

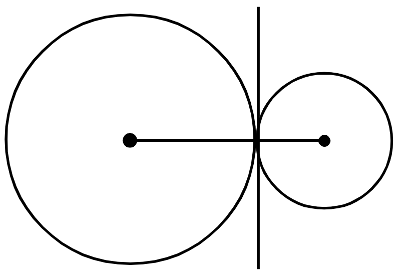
$$= \frac{3 \times 10^{-1} \times 10^{2} \times 10^{-4}}{3}$$

$$I = 10^{3} \text{ kgm}^2$$

2. Two uniform circular disks each of mass 1 kg and radius 20 cm, are kept in contact about the tangunt passing through the point of contact. Find the monut of evertia of the tangent passing throught the point of contant.

Ans:- Mass = m = 1kg r= 20 cm

$$I = I_1 + I_2 = 20 \times 10^{-2} \text{ cm}$$



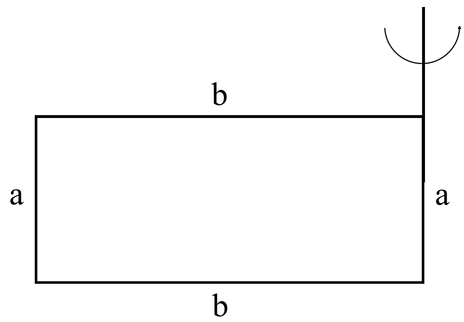
$$I_1 = \frac{MR^2}{4} + MR^2 = \frac{5MR^2}{4}$$

$$I_2 = \frac{5MR^2}{4}$$

$$I = \frac{10MR^2}{4} \frac{10 \times 1 \times (20 \times 10^{-2})^2}{4} = 0.1\text{Kgm}^2$$

3. Four spheres each diametes 2a and mass "m" are plaved with their lenth on the four corres of a spuare of the side b. Calculate the momentum of inertia of the system about any side of the square?

Ans:- $I_1 = mb^2,\ I_2 = \frac{2}{5}mb^2,\ I_3 = \frac{2}{5}mb^2,\ I_4 = mb^2$



Momantum of inertia of the

System $I = I_1 + I_2 + I_3 + I_4$

$$= mb^2 + \frac{2}{5}mb^2 + \frac{2}{5}mb^2 + mb^2$$

$$I = \frac{4}{5}mb^2 + 2mb^2$$

4. Determine the K.E of a circular disc rotating with a speed of 60 rpm about an axis passing through a point on its circumference and perpendicular to its plane.The circular disc has a mass of 5kg and radius 1m.

Ans:- Hence M = 5kg,R=1m, $W = 2\pi \times \frac{N}{t} = 2\pi \times \frac{60}{60}\text{rad/sec}$

$$= 2\pi \text{ rad/sec.}$$

The M.I of disc about paralled axis

Pasing through apoint on its circumberance.

$$I = \frac{MR^2}{2} + MR^2 = \frac{3MR^2}{2}$$

$$K.E = \frac{1}{2}Iw^2 = \frac{1}{2} \times \frac{3}{2}M^2w^2 \quad = \frac{3}{4} \times 5 \times 1^2 \times (2\pi)^2$$

$$= \frac{3}{4} \times 5 \times 4 \times (3.14)^2$$

K.E = 148.16 J

5. The momentumot incrtia of a fly wheel making 300 revolutions per minute is 0.3 kg m^{+2}. Find the torque required to bring it to rest in 20sec.

Ans:- Here I = 0.3kgm^2 $\frac{N}{t} = \frac{300 \text{ revontions}}{1 \text{ min tues}}$

$$\omega_i = \frac{2\pi N}{t} = \frac{2\pi \times 300}{60} = 10\pi \text{ rad/sec}$$

t = 20 sec, $\omega_f = 0$, $\tau = ?$

$$\tau = I\alpha = I\left(\frac{w_f - w_i}{t}\right) = 0.3\left(\frac{0 - 10\pi}{20}\right)$$

$$= \frac{-0.3\pi}{2}$$

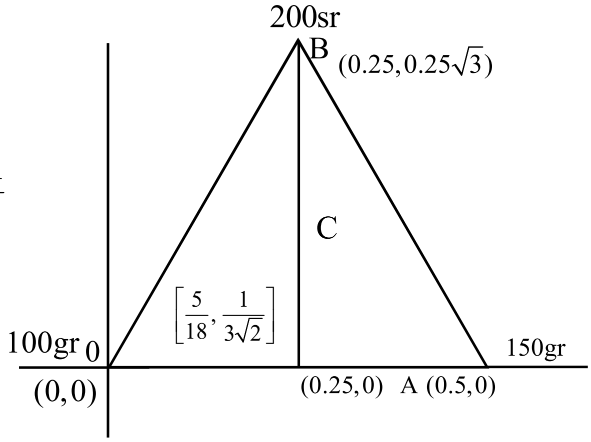
$$= -0.471 \text{ N.m}$$

6. Find the center of mass three particules at the vretices of an equilateral triangle.The masses of the particles are 100, 150 and 200 gr respectively. Each side of the equilateral triangle is 0.5 long.

Ans:- The coordinate points are O,A,B

and respectively (0,0) (0,5,0)

(0.25, 0.25$\sqrt{3}$), it following masses are 100, 150, 200g



$$X = \frac{m_1 x_1 + ma\, x\, a + m_3 x_3}{m_1 + m_2 + m_3}$$

$$= \frac{(100(0) + 150\ (0.5) + 200\ (0.25))\ gm}{[100 + 150 + 200]\ g}$$

$$= \frac{75+50}{450} m = \frac{125}{450} m = \frac{5}{18} m$$

$$Y = \frac{(100(0) + 150\ (0) + 20\ (0.25\sqrt{3})\ gm}{450g}$$

$$= \frac{50\sqrt{3}\ 8m}{450g} = \frac{\sqrt{3}}{9} m = \frac{1}{3\sqrt{3}} m$$

7. Find the scalar and vector product of two vector?

$a = 3\vec{i} - 4\vec{j} + 5\vec{k}$ and $b = 2\vec{i} + \vec{j} - 3\vec{k}$

Ans:- $a.b = (3\vec{i} - 4\vec{j} + 5\vec{k})(2\vec{i} + \vec{j} - 3\vec{k}) = -6 - 4 - 15$

$= -25$

$$a \times b = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 3 & -4 & 5 \\ -2 & 1 & -3 \end{vmatrix} = 7\vec{i} - \vec{j} - 5\vec{k}$$

8. Find the torque of a force about the origin.The force acts on a particle whose position vector is $\vec{i} - \vec{j} + \vec{k}$.

Ans:- Here $r = \vec{i} - \vec{j} + \vec{k}, \quad F = 7\vec{i} - 3\vec{j} + 5\vec{k}$

$$\tau = r \times F = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 1 & -1 & 1 \\ 7 & 3 & -5 \end{vmatrix} = (5-3)\vec{i} - (-5-7)\vec{j} + (3-(-7))\vec{k}$$

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

UNIT VIII

OSCILLATIONS

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. Give two examples of periodic motion are not oscillatony?

Ans:- (i) The motion of planet around the sun (ii) Revolution of electrons around the nuelus.

2. The displacement in S.H.M is given by y = asin (20t+4) what is the displacement when it is increased by $\frac{2\pi}{w}$?

Ans:- Y = asin (20t + 4)

$T = \frac{2\pi}{w}$ is increased, the displacement of the particle remains the same.

3. A girl is swinging seated in a jwing. What is the effect on the frequency of osciflation if she stands?

Ans:- Frequency $n = \frac{1}{2\pi}\sqrt{\frac{g}{\ell}} \quad \alpha \frac{1}{\sqrt{\ell}}$

A girl swinging in standing position location of center of masses shifts upwards *l* decreases, frequency of oscillation increases.

4. The bob of a simple pendulum is a hollow sphere filled with water, how will the period of oscillation change, if the water begins to drainout of the hollow sphere?

Ans:- The time period will increase at first, the decreases until the sphere is empty, finally the period will be the same as when the sphere was full of water.

5. The bob of a simple pendulum is made of wood. What will be the effect on the time period if the wooden bob is replaced by an identical bob of aluminum?

Ans:- Time period $T = 2\pi\sqrt{\frac{L}{g}}$ Time period is independent of mass of the bob. Hence wooden bob is replaced by an idential aluminium bob, time period remains constant.

6. Will a pendulum clock gain or lose time when taken to the top of mountain?

Ans:- At higher altituding i.e. on mountain the acceleration due to grevity is less compaired to the ground. the time period increases. The pendulum clock loses time on mountain.

7. A pendulum clock gives correct time at the equation will it gain or lose time if it is taken to the poles? If so why?

Ans:- Time period $= T = 2\pi\sqrt{\frac{\ell}{g}}$, g value at poles greater than at equator, if it is taken to the poles g value increases time period decreases. So pendular clock gain time.

8. What fraction of the total energy is K.E. when the displacement is one half of a almplitude of a particle executing SHM?

Ans:- Total enegy K.E $= \frac{1}{2}mw^2x^2$

$$y = \frac{A}{2} \Rightarrow K.E = \frac{1}{2}mw^2(x^2 - y^2) = \frac{1}{2}mw^2\left(A^2 - \frac{A^2}{4}\right)$$

$$K.E = \frac{3}{4} \times \frac{1}{2}mw^2A^2$$

$$K.E = \frac{3}{4} \times E \quad \Rightarrow \frac{K.E.}{E} = \frac{3}{4}$$

9. What happens to the energy of a simple haumonic oscillator if its amplitude is doubled.

Ans:- Total energy $E = \frac{1}{2}mw^2A^2$

given amplitude A is doubled.

$$E' = \frac{1}{2}mw^2(2A)^2 = \frac{1}{2}mw^2\ 4A^2$$

$$= 4 \times \frac{1}{2}mw^2A^2$$

$\therefore$ Energy becomes four times $E' = 4 \times E$

10. Can a simple pendulum be used in an arificial satellite?

Ans:- No, It does not oscillate. This is be cause there exists a state weight lessness in a satellite.

SHORT QUESTION & ANSWERS (4MARKS)

1. Define simple harmonic motion. Give two examples?

Ans:- **Simple Harmonic motion :** "A body is said to be in simple harmonic motion, if it moves to and froalong a straight line, about its mean position such that at any point its acceteation is proportional to its displacement but opposite in direction and is directed always to wards the mean position".

$$a \ \alpha - y$$

Examples : 1) Motion of a simple pendulum.

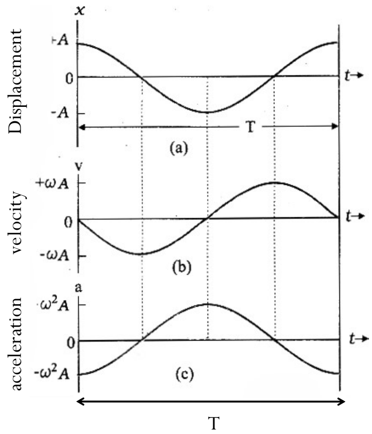
2) Motion of mass attached to a spring

3) Motion of atoms in solids.

4) Cork floating on water.

2. Present graphically the variation of displacement, velocity and acceleration with time for a particle in SHM?

Ans:- Displacement, velocity phase difference $\frac{\pi}{2}$ and acceleration, displacement phase difference is π .



3. What is phase? Discess the phase relations between displacement, velocity and acceleration in simple hormonic motion?

Ans:- Phase : The phase of a particle executing S.H.M. at any instant is defined as its state (or) condition regarols to its position and direction.

i) Displacement : $x = A\cos(wt - \phi)$, $(wt - \phi)$ is called phase and is epoch.

ii) Velocity : $V = -Aw\sin(wt - \phi)$, Here also $(wt - \phi)$ is phase angle.

iii) accelerations : $a = -Aw^2\cos(wt - \phi)$ Here also $(wt - \phi)$ is phase angle.

4. Obtain an equation for the frequncy of osillation of spring of force. Constant K to which a mass m is attaned?

Ans:- Let us consider a spring suspended vertically from a rigid support and loaded with a mass if it is now pulled down and released, it executes vertically oscillations about mean opposition.

Restoring force is directly propotional to the displacement, but oppositely directed

$$F\,\alpha - y \Rightarrow F = -K_y \quad -----(1)$$

from Newton's IInd laws to

$$F = ma \quad ----(2)$$

(1) = (2)

Ma = -k

$$a = -\left(\frac{k}{M}\right)_y \quad ------\rightarrow (2)$$

We can write $a \alpha -y$

i.e Acceleration is directly proportional to

displacement lout oppositely directed.

$\Rightarrow a = w^2 y \quad -----(3)$

Comparing above eq'n (2) & (3)

$w^2 = \frac{K}{M} \Rightarrow w = \sqrt{\frac{K}{M}}$

But $T = \frac{2\pi}{w} \Rightarrow T = 2\pi \sqrt{\frac{M}{K}}$

Frequency of oslillation $n = \frac{1}{2\pi} \sqrt{\frac{K}{M}}$

5. Derive expressions for the kinetic energy and potentioal energy of a simple harmonic oscillator?

Ans:- K.E. of S.H Oscillator : The velocity of a particle in S.H.M is given by $V = W\sqrt{A^2 - y^2}$

$$K.E = \frac{1}{2} mv^2 = \frac{1}{2} m w^2 (A^2 - y^2)$$

when $y = 0 \Rightarrow K.E_{max} = \frac{1}{2} mw^2 A^2$ (Mean position)

when $y = A \Rightarrow K.E_{min} =$ (Extreme position)

P.E of simple harmonic oscillator : When the displacement of a particle executing S.H.M. in creases the restoring force also increases. The restoring force is in the opposit direction to the displacement. Therefore work is done in moving through the displacement aganist restoring force. If F is the restoring force at the disphlacement y.

The average force against which work is done $= \frac{O + F}{2} = \frac{F}{2}$

Work done on the particle for the displacement = average force x displacement

$$w = \frac{F}{2} \times y$$

$$w = \frac{may}{2} \quad -----(1) \qquad (\because F = ma)$$

But acceleration of a particle in S.H.M. is given by

$a = w^2 y \rightarrow (2)$

using (1) & (2) eq'n weget

The work done (w) = $\frac{1}{2} mw^2 y^2$

The work done $\Rightarrow P.E = \frac{1}{2}mw^2y^2$ -----(3)

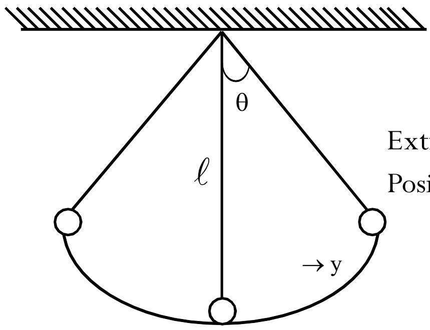
if $y = 0, \quad P.E_{min} = 0$ (Mean position)

$y = A, \quad P.E_{max} = \frac{1}{2}mw^2A^2$ (extreme position)

6. How does the energy of a simple pendulum very as its moves from one extreme position to the other during its oscillations?

Ans:- The total energy ossociated with a particle execting S.H.M at any point is the sum of potential energy and K.E. at that point.

Total energy = K.E + P.E



$$P.E = \frac{1}{2}mw^2y^2$$

$$K.E = \frac{1}{2}mw^2(A^2 - y^2)$$

$$\therefore T.E = \frac{1}{2}mw^2(A^2 - y^2) + \frac{1}{2}mw^2y^2$$

$$T.E = \frac{1}{2}mw^2A^2$$

At mean position y = 0, P.E = 0

and $K.E_{max} = \frac{1}{2}mw^2A^2, \quad T.E = 0 + \frac{1}{2}mw^2A^2 = \frac{1}{2}mwA^2$

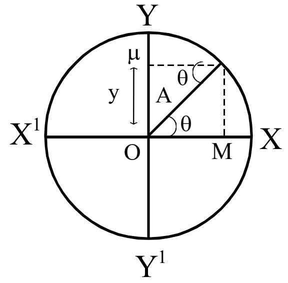
At extreme position $y = A, K.E = 0, P.E_{max} = \frac{1}{2}mw^2A^2$

From mean position to extreme position K.E. is to be converted in to P.E.

7. Derive the expression for displaement velocity and acceleration of a partice excutes S.H.M?

Ans:- Consider aparticle pmoves on the circumference of a circule of radius A with uniform angular velocits w. Let PN be the perpendicular drawn to the diametles yy' to and from about the center 0.

Let $\angle POX = \theta, OP = A, ON = Y$



From Δ ONP, $\sin wt = \frac{ON}{OP}$

ON = OP $\sin wt$

$y = A \sin wt \rightarrow (1)$

Velocity : The rate of change of displacement is k now as velocity.

$$v = \frac{dy}{dt} = \frac{d}{dt}(A\sin wt) = Aw\cos wt = Aw\sqrt{1-\sin^2 wt}$$

$$\therefore V = Aw\sqrt{1-\left(\frac{y}{A}\right)^2} \qquad \left[\because \sin wt = \frac{Y}{A}\right]$$

$$v = w\sqrt{A^2 - y^2} \quad \to (2)$$

acceleration : The rate of change of velocity is know as acceleration.

$$a = \frac{dv}{dt} = \frac{d}{dt}(A\omega\cos wt)$$

$$= -Aw^2 \sin wt \qquad (\because y = A\sin wt)$$

$$a = -w^2 y \quad ---\to(3)$$

LONG QUESTION & ANSWERS (8MARKS)

1. **Define S.H.M show that the motion of (point) projection of a particle performing uniform circular motion, on any diamenter, is simple harmonic?**

Ans:- Simple Harmonic motion : A body is said to being simple harmonic motion, if ti moves to and froalong a strignt line, about its mean position such that, at any point its acceleration is proportional to its displacement but opposite in direction and directed always towards the mean position.

$$\boxed{a\ \alpha\ -y}$$

Show that the projection of uniform circular motion on any diameter is simple harmonic : - consider a particle p moving on the circum ference of a circle of radius A with uniform angular velocity w. Let O be the center of the circle xx' and yy' are two mutually perpendacular diameters of the circle as shown in figure let PN be drawn perpendicular to the diameter yy' from P. As P moves on the circum ference of the circle. N moves on the diameter yy' to and fro about the center O. Let us consider the position of N at any time t, after leaving the point "O" during its motion. The corresponding angular displacement of the particle p is L x OP $= \theta =$wt

From $\Delta ONP \Rightarrow \sin\omega t = \frac{ON}{OP}$

ON = OP $\sin\omega t$ $\qquad (ON = y \quad OP = A)$

$$y = A\sin\omega t \quad ----(1)$$

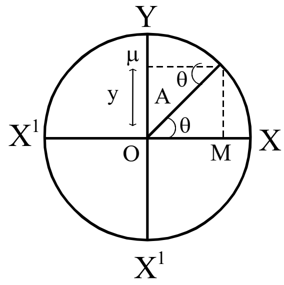
Differentiating eq'n (1) w.r.t "t" we get

Nelocity $v = \frac{dy}{dt} = \frac{d}{dt}(A\sin\omega t)$

$$v = A\omega \cos\omega t = A\omega\sqrt{1-\sin^2\omega t} \quad -----(2)$$

$$= A\omega\sqrt{1-\frac{y^2}{A^2}} \qquad \left(\because \sin\omega t = \frac{y}{A}\right)$$

$$v = \omega\sqrt{A^2-y^2} \quad ----(3)$$



Again Differentiating eq'n (2) w.r. + 't' we get acceleration

$$a = \frac{dv}{dt} = \frac{d}{dt}(A\omega \cos\omega t)$$

$$= -A\omega^2 \sin\omega t \qquad (\because y = A\sin\omega t)$$

$$a = -\omega^2 y \quad -----(4)$$

$$a \,\alpha\, -y \quad -----(5)$$

2. Show that the motion of a simple pendulum is simple harmonic and hence derive an equation for its time period. what is seconds pendulum?

Ans:- **Simple pendulum :** A heavy metal point mass suspended by a light inextensible string is called an ideal simple pendulum.

Consider a simple pendulum with a metal bob of mas "m" Let "s" be the point of suspension and "i" be the length of the pendulum. Let the bob be given a small angular displacement "θ" and released. Let "A" be than mean position and "B" bethe extreme position. Let AB = X = Displacement from the mean position.

$$AB = X = \ell\theta \text{ (or) } \theta = \left(\frac{x}{\ell}\right) \quad -----(1)$$

At point "B" the force acting on the bob are

i) The weight of the bob 'mg' vertically down wards, this can be resolved into two rectiongular componeuts mg cosθ and mg sinθ as shown in figure.

ii) The tension in the string 'T' the tension T in the string balanues the components mgcosθ.

Restoring force on the bob F = - mgsinθ

Acceleration a = $\frac{-mg\sin\theta}{m} = -g\sin\theta$

When θ is very small.

$$\sin\theta \cong \theta \Rightarrow \therefore a = -g\theta \quad -------(2)$$

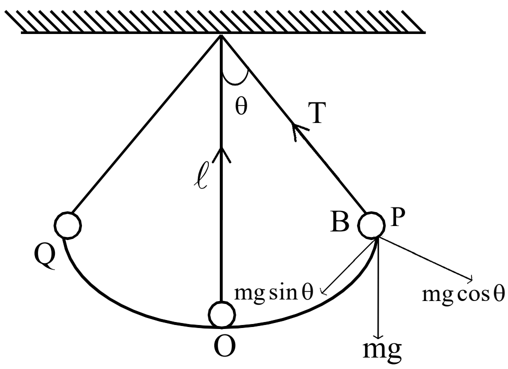
From (1) and (2) eq'n to we get

usier S.H.M. $a = -\omega^2.y \quad -----(4)$

From above eq'n (3) and (4) we, get

The work done $= w = \frac{1}{2}m\omega^2 y^2$

This work done is stored in the



$a = -g\left(\frac{x}{\ell}\right) \quad ----(3)$

-ve siqn indicates 'a^{H}' and 'θ' are in opposite directions.

Time period : $T = 2\pi\sqrt{\frac{\text{displacement}}{\text{acceleration}}} = 2\pi\sqrt{\frac{x}{a}}$

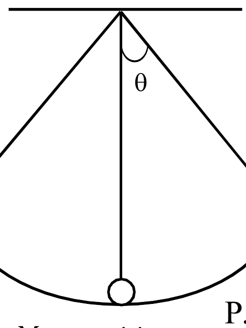
$$\boxed{T = 2\pi\sqrt{\frac{\ell}{g}}}$$

Second's Pendulum : A simple pendulum whose time period is 2see is called as a second's pendulum.

$$\boxed{T = 2\text{ sec}}$$

3. **Derive the eq'n for the K.E and P.E of simple harmonic oscillator and show that total energy of a particle in simple harmonic motion is constant at any point on its path?**

Ans:- **Expression for K.E. :** The velocity of a particle in S.H.M is given by $v = \omega\sqrt{A^2 - y^2}$



$K.E = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2(A^2 - y^2) \quad -----(1)$

we know that y = $A\sin\omega t$

$K.E = \frac{1}{2}m\omega^2A^2\left(1 - \sin^2\omega t\right) \quad ----(2)$

when y = 0, $K.E_{max} = \frac{1}{2}m\,\omega^2A^2$ (Mean position)

when y = A, $K.E_{min} = 0$ (extreme position)

Expression for P.E : When the displcement of a particle executing simple harmonic oscillation increases. The restoring force is in the oposite direcion to the displacement there fore work is done in moving though the displacement against restoring force if F is restoring force at the displacement y.

The average force aganist which work is done $= \frac{O + K}{2} = \frac{F}{2}$

work done displacement = y = average force x displacement

$\omega = \frac{F}{2} \times y$

$\omega = \frac{ma\,y}{2} \quad ----(3)$

from $P.E = \frac{1}{2} m\omega^2 y^2$ ------(5)

$$P.E = \frac{1}{2} m\omega^2 A^2 \sin^2 \omega t \quad ------(6) \qquad (y = A \sin \omega t)$$

if $y = 0$, $P.E_{min} = 0$ (Mean position)

$y = A$ $P.E_{max} = \frac{1}{2} m\omega^2 A^2$ (extreme position)

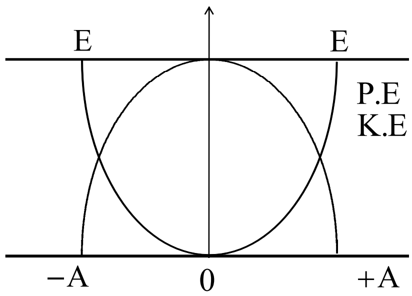
Total energy : Total energy = K.E. P.E.

$$K.E = \frac{1}{2} m \omega^2 (A^2 - y^2)$$

$$P.E = \frac{1}{2} m \omega^2 y^2$$

$$T.E = \frac{1}{2} m \omega^2 (A^2 - y^2) + \frac{1}{2} m w^2 y^2$$

$$= \frac{1}{2} m \omega^2 A^2$$



At mean position y = 0, P.E = 0

$$K.E_{max} = \frac{1}{2} m \omega^2 A^2$$

$$T.E = K.E + P.E$$

$$T.E = \frac{1}{2} m \omega^2 A^2 + 0 = \frac{1}{2} m\omega^2 A^2$$

At extreme position y = A, K.E = 0 and $P.E_{max} = \frac{1}{2} m \omega^2 A^2$

$$\therefore T.E = K.E + P.E$$

$$T.E = 0 + \frac{1}{2} m \omega^2 A^2 = \frac{1}{2} m \omega^2 A^2$$

From mean position to extreme position K.E is to be converted into P.E.

Problems :

1. A particle executes SHM such that the maximum velocity during the oscillation is numerically equal to half the maximum acceleration what is the time period?

Ans:-

$$V_{max} = \frac{1}{2} a\,max$$

$$A\omega = \frac{1}{2} A \omega^2$$

$$\omega = 2$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{2} = \pi \sec$$

2. A body descibes simple harmonic motion with an amplitude of 5 cm and a period of 0.2 sec find the acceleration and velocity of the body when the displacement si (a) 5 cm (b) cm (c) 0 cm.

Ans:- A = 5cm $= 5 \times 10^{-2}\text{m} \quad T = 0.2\,\text{sec}$

i) $y = 5\,\text{cm} = 5 \times 10^{-2}\text{m} \quad w = \frac{2\pi}{T} = \frac{2\pi}{0.2} = 10\pi$

Acceleration $a = -\omega^2 y \Rightarrow -(10\pi)^2 \times 5 \times 10^{-2}$

$$a = -5\pi^2 \text{ m/s}^2$$

Velocity $V = \omega\sqrt{A^2 - y^2} = 10\pi\sqrt{(5\times10^{-2}) - (5\times10^{-2})^2}$

ii) $y = 3\text{cm} = 3\times10^{-2}\text{m}$

Acceleration $a = -\omega^2 y = -(10\pi)^2 \times 3\times10^{-2} = -3\pi^2\text{m/sec}$

velocity $v = \omega\sqrt{A^2 - y^2} = 10\pi\sqrt{(5\times10^{-2})^2 - (3\times10^{-2})^2}$

$$= 10\pi\sqrt{25-9} \times 10^{-2}$$

$$V = 0.4\,\pi\text{m/sec}$$

iii) $y = 0$ cm $\quad a = -\omega^2 y \quad = -(10\pi)^2 \times 0 = 0$

$$\text{Velocity}(V) = \omega\sqrt{A^2 - y^2}$$

$$= 10\pi\sqrt{(5\times10^{-2})^2 - 0}$$

$$= 0.5\pi \text{ m/sec}$$

3. A simple harmonic oscillator has a time period of 2s.What will be the c change in the phase 0.25 sec offer leaving the mean position?

Ans:- T = 2 sec t=0.25 sec

$$\sin\omega t = \sin\left(\frac{2\pi}{T}\right)t$$

$$\phi = \omega t = \frac{2\pi}{T} \times t = \frac{2\pi}{2} \times 0.25$$

$$\phi = \frac{\pi}{4}$$

4. On an average a human hearts is found to beats 75 times in a minute. Calculate its frequency and period?

Ans:- The beat frequency of heart = 75/1 (min)

$$= \frac{75}{60} \text{ sec}$$

= 1.25 /sec

= 1.25 Hz

The time period $T = \frac{1}{1.25} / \text{sec}$

T = 0.8sec

5. What it the length of a simple pendulum which ticks seconds?

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

squaring on both sides.

$$L = \frac{gT^2}{4\pi^2}$$

The time period of a simple pendular which ticks seconds is 2 sec

$$g = 9.8 m/s^2 \quad T = 2 sec$$

$$L = \frac{9.8 \times 4}{4 \times (3.14)^2} = 1m$$

UNIT

IX

GRAVITATION

VERY SHORT QUESTION & ANSWERS (2 MARKS)

2. State the vector form of Newton's law of gravitation?

Ans:- Vector form of Newton's law of gravition $F = \frac{Gm_1m_2}{r^3}\hat{r}$

Where $\hat{r}$ is unit vector

3. In the gravitational force of earth on the moon is F, what is the gravitational force of moon on earth? Do these force form an action reaction pair?

Ans:- Yes, they form action and reaction pair.

5. As we go from one plant to another, how will (a) the mass and theweight of a body change?

Ans:- (a) The mass remains constant

(b) The weight (co=my) changes from one planet to another planet.

6. Keeping the length of a simple pendulum constant will the time period be the same on all plants? support your answer with reason?

Ans:- No, Time period depends on acceleration clue to gravity (g) $T = 2\pi\sqrt{\frac{L}{g}}$

g values varics from plant to planet. So time period changes..

9. "Hydrogen is in abundance around the sun but not around earth" Explain?

Ans:- The r.m.s velocity of hydrogen molecules at ordinary temperture is around 2 Km S^{-1}, ve on the sun 620 Km S^{-1} is greter than ve on the earth 11.2 KmS^{-1}. The gravitational attraction of the sun is more than the earth. Hence hydrogen is in abundance around. The sun and less around the earth.

10. What is the time period of revolution of a geostationary satellitc? Does it rotatc from west to east or from east to west?

Ans:- Time period of revolution of geostationary satellite is 24 Hrs it rotate from west to east.

11. What are polar satellites?

Ans:- A satellitos that revolves in a polar orbit is called a polar satellites. A polar orbit passes over north and sowth poles of the earth and has a smaller radius 500-800km.

SHORT QUESTION & ANSWERS (4MARKS)

4. What is the orbitel velocity? Obtain an expression for it?

Ans:- **Orbital velocity (V_0) :** The horizontal velocity required for and object to remove around aplent in a circullar orbit is called orbital velocity.

Esepression for orbital velocity : Consider a body of mass (satellite) m, revolues round the earth in a circular orbit. Let h be the height of the stwtellite from the surfuce of the earth. Then (R+h) is the radius of the orbit.

The gravitational force of attration of the earth on the body is given by

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

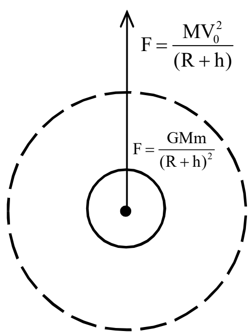
The centripetal force on the body is given by $F = \frac{mv_0^2}{(R+h)} \quad ----(2)$

In order to make the body revolse in the same orbit, its centripetal force must be equal to the gravitaional forces.

From eq (1) & (2) $F = \frac{mv_0^2}{(R+h)} \quad ----(2)$

$$V_0^2 = \frac{GM}{(R+h)}$$

$$V_0 = \sqrt{\frac{GM}{(R+h)}} \quad [\because (R+h) \cong R \text{ if } R >> h]$$



$$v_0 = \sqrt{\frac{GM}{R}}$$

$$gR^2 = GM$$

$$\Rightarrow v_0 = \sqrt{\frac{gR^2}{R}}$$

$$\boxed{v_0 = \sqrt{gR}}$$

5. What is the escape velocity? obtain an expression for it?

Ans:- **Escape velocity :** It is the minimum velocity with which a body should be projected, so that it moves into the space by over coming the earth's gravitational field.

Expression for escape velocity :-

Consider about of mass m thrown with a velocity v_e then $K.E = \frac{1}{2}mve^2 \quad ------(1)$

Gravitational P.E = work done on the body

$$P.E = F \times R = \frac{GMm}{R^2} \times R$$

$$P.E = \frac{GMm}{R^2} \text{-----}(3)$$

A body just eqcapes when its K.E = P.E

$$\frac{1}{2} mve^2 = \frac{GMm}{R}$$

$$v_e = \sqrt{\frac{2GM}{R}}$$

$$\text{but } gR^2 = GM$$

$$\Rightarrow v_e = \sqrt{\frac{2gR^2}{R}}$$

$$v_e = \sqrt{2gR}$$

$$v_e = \sqrt{2} \times \sqrt{gR}$$

$$\boxed{v_e = \sqrt{2} \times v_0}$$

6. What is a geo stationary satellite? State its uses?

Ans:- Gro-stationary satellitc : If the period of revolution of an artficial satellite is equal to the period of rotation of earth, then such a satellite is called geo stationary satellite.

Time period of geo stationary satellite is 24 hrs.

uses :

1) Study the upper lagee of atmosphere
2) Force cast chnages in atphere.
3) know the shape and size of the earth.
4) identify the minerals and natural resources present inside and on the surface of the earth.
5) Transmit the T.V. programmes to distant objects.
6) Under take space research to know about the planets, satellites, comets etc.

8. If a nutbecoues loose and gets detached from a satellite revolving around the earth, will it foll down to earth or will it revolve earth? Give reasons for your answer?

Ans:- When a nut is detached from a satellite revolving around the earth. The nut is also moving with the speed of the satellite. As the orbit of a satellite does not depend upon its mass. Hence unt is moving in same orbit under centripetal forces.

10. An object projected with a velocity greater then or equal to 112 Km/sec will not return to earth. Explain to reason?

Ans:- The easeape velocity on the surface of the erath (v_e) = 11.2 km/sec. Any object projected with the velocity greater than (or) equal to 11.2 km/sec. It will not come back. Because it has overcom the earth's gravitational pull.

So an object have back to earth.

LONG QUESTION & ANSWERS (8MARKS)

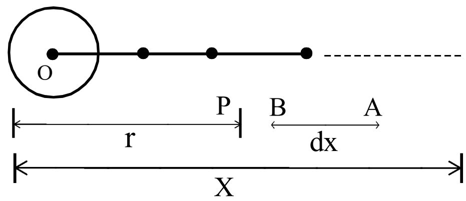
1. Define gravitation potertial energy and derive an expression for it associated with two particles of masses m_1 and m_2 ?

Ans:- Gravitational porential energy : Gravitational potential energy of a body at a point in a gravitational field of another body is defind as the amount of work done in brining the given body from infinity to that point with out acceleration.

Equation : Consider a gravitational fielddue to earth of mass, radius R. The mass of the earth can be supposed to be con centrated at its center 0. Let us calculate the gravitational potential energy of the body of mass m placed at point p in the gravitation fiedl. Where OP = and r > R,

Let OA = x and AB = dx

The gravitational force on the body at A will be



$$F = \frac{GMm}{X^2} \quad -----(1)$$

small amount of work done in bringing the body wihtout acceleration through a small distance dx is given by dw = F x d x

$$dw = \frac{GMm}{x^2} \times dx \quad -----(2)$$

Total workdone in bringing the body from inifinity to point p is given by

$$w = \int_{\infty}^{r} \frac{GMm}{x^2} dx = GMm \int_{\infty}^{r^2} x^{-2} dx$$

$$= -GMm \left(\frac{1}{x}\right)_{\infty}^{r}$$

$$= \frac{-GMm}{r} \quad \left[\because \frac{1}{\infty} = 0\right]$$

$$w = \frac{-GMm}{r} \quad -----(3)$$

This is workdone is stored in the body as its gravitatonal potential energy

$$(U) = \frac{-GMm}{r} \quad -----(4)$$

$\therefore$ Gravitational potential energy associated with two particles of masses m_1 and m_2 separtated by a distance ris given by

$$P.E = U = \frac{-G\,m_1m_2}{r}$$

Problems :

1. **Two spherical balls each of mass 1kg are placed 1 km a part. Find the gravitational force of ahraction between then?**

Ans:- $m_1 = m_2 = 1kg \qquad d = 1cm = 1\times 10^{-2}m$

$$F = \frac{Gm_1m_2}{d^2} = \frac{6.67\times10^{-11}\times1\times1}{\left[10^{-2}\right]^2} = 6.67\times\ 10^{-7}N$$

2. **The mass of a ball is four times the mass of another ball. When these ball are separted by adistance of 10 c.m.the force of gravitation between then is 6.67 x 10^{-7} N. Find the masses of the two balls.**

Ans:- $m_1 = m_2 = 4m$, $d = 10m = 10\times10^{-2}m$ $F = 6.67\ \times10^{-7}N$

$$F = \frac{G\,m_1m_2}{d^2} \Rightarrow 6.67\times10^{-7} = \frac{6.67\times10^{-11}\times m\times 4m}{[10\times10^{-2}]^2}$$

$$4m^2 = 10^2$$

$$m^2 = \frac{100}{4} = 25$$

$$m_1 = m = 5kg$$

$$m_2 = 4\times5 = 4\times5 = 20kg$$

3. **At a certain height above the earths surface, the acceleration due to gravity is 4% of its value at the surface of earth determine the height.**

Ans:- $g_n = 4\%,\ g = \frac{4}{100}g,\ R = 6400km$

$$g_h = \frac{g}{\left(1+\frac{h}{R}\right)^2} \Rightarrow \frac{4g}{100} = \frac{g}{\left(1+\frac{h}{R}\right)^2} \Rightarrow \left(1+\frac{h}{R}\right)^2 = \frac{100}{4} = 25$$

$$1+\frac{h}{R} = 5$$

$$\frac{h}{R} = 4$$

$$\Rightarrow h = 4R$$

$$\therefore h = 4R = 4\times6400 = 25{,}600\ km$$

4. A satellitc orbits the carth ata height equal to the radius of earth. Find its i) orbital speed and (ii) period of revolution?

Ans:- $h = R$

i) $v_0 = \sqrt{\frac{GM}{(R+h)}} = \sqrt{\frac{GM}{(R+R)}} = \sqrt{\frac{GM}{2R}} = \sqrt{\frac{6.67\times10^{-11}\times6\times10^{24}}{2\times6400\times10^3}}$

$= \sqrt{0.3216\times10^8}$

$= 0.5592 m/sec$

$v_0 = 5.592 km/sec$

ii) Time period $T = \frac{2\pi\,(R+h)}{v_0} = \frac{2\pi(2R)}{v_0}$

$= \frac{4\times3.14\times2\times6400\times10^3}{5.592}$

$=14374.8 = 1.44\times10^4 sec$

T=4 Hrs.

5. A satellite is revolving round in a circular orbit with a speed of 8km/sec at a height where the value of acceleration due to qraity is 8 m/sec^2. How high is the satellite from the earth surface? (R=6000km)

Ans:- $v_0 = 8km/sec = 8000m/s, \quad g_h = 8m/s^2, \quad R = 6000\times10^3 m$

$\therefore v_0 = \sqrt{\frac{GM}{R+h}} = \sqrt{g(R+h)}$

$v_0^2 = \sqrt{g(R+h)} \Rightarrow (8000)^2 = 8(6000\times10^3 + h)$

$8\times10^6 = 6\times10^6 + h$

$h = (8-6)\times10^6$

$h = 2000km$

UNIT X	# MECHANICAL PROPERTIES OF SOLIDS

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. State Hooke's law of elasticity?

Ans:- With in the elastic limit stress directly proportional to the strain.

Stress α strain

Stress = k. strain $\Rightarrow \boxed{K = \frac{\text{strees}}{\text{strain}}}$

Where K is modulus of elasticity.

2. State the units and dimensions of stress.

Ans:- i) Stress $= \frac{\text{Force}}{\text{Area}} = \frac{F}{A}$

S.I units $\rightarrow \text{N/m}^2$ (or) pascal

ii) Dimensional formula

stress $= \frac{MLT^{-2}}{L^2} = [ML^{-1}T^{-2}]$

3. State the units and dimensions of modulus of elasticity?

Ans:- Modulus of elasticity (k) $= \frac{\text{Stress}}{\text{Strain}}$

units $\rightarrow \text{N/m}^2$ (or) pascal

Dimensional for mula $\rightarrow [ML^{-1}T^{-2}]$

units $\rightarrow \text{N/m}^2$ (or) pascal

4. State the units and dimensions of young's modalus.

Ans:- Young's modulus (y) $= \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} = \frac{F/A}{e/L}$

units $\rightarrow \text{N/m}^2$ (or) pascal

Dimensional formula $\rightarrow [ML^{-1}T^{-2}]$

6. State the units and dimensions of bulk modulus.

Ans:- Bulk modulus (B) $= \frac{\text{Bulk stress}}{\text{Bulk strain}} = \frac{-pv}{\Delta v}$

units $\rightarrow \text{N/m}^2$ (or) pascal

Dimensional formula $\rightarrow [ML^{-1}T^{-2}]$

7. State the exampels of nearly perfect and plastic bodies.

Ans:- Nearly perfect elastic bodies are quartz fibre.

Nearly perfect plastic bodies are dough and clay.

SHORT QUESTION & ANSWERS (4MARKS)

1. Define Hooke's law of elasticity, proportionality, permanent set and breaking stress.

Ans:- **Hookes law :** "With in the elastic limit stress is directly proportional to the strain

stress α strain

stress = k. strain

where k is modulus of elasticity.

Proportionality limit : The maximum stress developed in a body till it obeys Hookes law is called proportionality limit.

Permanent set : Permanent deformation produced when a body is stretched behond its elastic limit.

Breaking stress : The maximum stress a body can bear before it breaks.

4. Define stress and explain the types of stress.

Ans:- Stress : The restoring force per unit area is called stress.

$$\text{Stress} = \frac{\text{Restoring force}}{\text{Area}} = \frac{F}{A}$$

Stress is classified into three types. (1) Longitudinal stress

(2) Volume (or) Bulk stress (3) Tangential (or) Shearing stress

(1) Longitudinal stress (or) Linear stress : When a normal stress changes the length of a body then it is called Longitudinal stress.

$$\text{Longitudinal stress} = \frac{F}{A}$$

(2) Volume (or) Bulk stress : When a normal stress changes the volume of a body, then it is called volume stress.

$$\text{Volume stress} = \frac{\text{Force}}{\text{Area}} = \text{Pressure}$$

(3) Tangentid (or) shearing stress : When the stress is tangentid to the surface due to the application of forces parallel to the surface, then the stress is called tangential stress.

Tangential stress = F/A

5. Define strain and exelain the types of strain.

Ans:- **Strain :** It is the ratio of chnage in dimension to its original dimension.

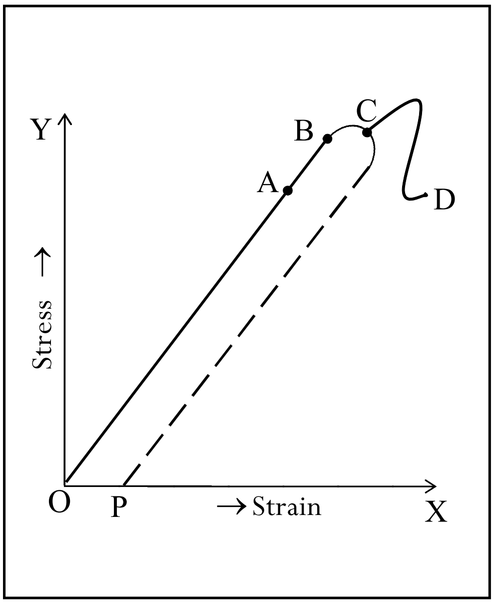
Strain $= \frac{\text{Changes in dimension}}{\text{original dimension}}$

strain is of three types.

1. **Longitudind strain :** It is the ratio of change in length to its original length.

Longitudind strain $= \frac{\text{Changes in length}}{\text{origind length}} = \frac{e}{L}$

2. **Shearing strain (or) Tangential strain :** When simultaneous compression and extension in motually perpendicular direction takes place in a body, the change of shape it under goes is called shearing strain. Shearing strain $(\theta) = \ell L$.



3. **Bulk (or) volume strain :** It is the ratio of chnage in volume to its original volume is called bulk strain. It is called Bulk (or) volume strain.

Bulk strain $= \frac{\text{Change in volume}}{\text{original volume}} = \frac{\Delta v}{v}$

7. **Explain why steel is perperred to copper, brass, aluminium in heavy-dotes machines and in structural designs.**

Ans:- The elastic behavior of materials plays an important role in everyday life. Designing of bulidings, the structural design of the columns, beams and supports require knowledge of strength of material used.

The elasticity of the meterial is due to stress developed with in the body, when external force acts on it. A material is of more elastic nature if it develops more stress (or) restoring force steel develops more stess than copeer, brass, Aluminium for same strain. So steal is more elastic.

$y = \frac{\text{stress}}{\text{strain}}$

8. **Describe the behaviour of a wire under gradilly increasing load.**

Ans:- When the load is increased in steps, a graph is drawn between stress on y-axis and corresponding strain on x-axis.

(1) Proportionality limit : In the linear losition OA, stress is proportional to strain i.e. Hookes law is obeyed by the wire up to point A.

The graph is a straight line. When ever the regains its original length.

A is called proportionality limit.

(2) Elastic limit : In the graph B is the elastic limit. Through the wire does not obey Hooke's law at B. The wire regains its original length after removing the stretching force at B. up to point B the wire is under elastic behaviour.

(3) **Permanent set (or) yield point :** In the graph C is the yield point. If the stretching force at C is removed, the wire does not regain its original length and the length of the wire changes permanently. In this position the wire flows like a viscous lieuid. After the point C, the wire is under plastic behaviour. C is called permanent set (or) yield point.

(4) **Breaking point :** When the stress increased, the wire becomes thinner and thinner and thinner when the stress in creases to a certain limit the wire breaks.The stress at which the wire breaks is called breaking stress and the point D is called breaking point.

(5) **Elastic fatigere :** The state of temperary loss of elastic nature of a body due to continuous strain is called elastic fatigue. When a body is subjected to continuous strain with in the elastic limit, it appears to have lost elastic property temporarily to some extent and becomes weak.

Problems :

1. A copper wire of 1mm diameter is stretched by applying a force of 10N. Find the stress in the wire.

Ans:- D = 1mm $= 10^{-3}$, r = D/2 = 0.5×10^{-3}m

F = 10N

$$\text{stress} = \frac{F}{A} = \frac{F}{\pi r^2}$$

$$= \frac{10}{3.14 \times (0.5 \times 10^{-3})^2} = 1.273 \times 10^7 \ \text{N/m}^2$$

2. A tungsten wire of length 20 cmis stretched by 0.1cm. Find the strain on the wire.

Ans:- $L = 20 \times 10^{-2}\text{m}, \quad \Delta L = 0.1 \times 10^{-2}\text{m}$

$$\text{strain} = \frac{\Delta L}{L} = \frac{0.1 \times 10^{-2}}{20 \times 10^{-2}} = 0.005$$

3. If an iron wire is stretched by 1%, What is the strain on the wire?

Ans:- $$\text{Strain} = \frac{\Delta L}{L} = 1\%$$

$$= \frac{1}{100} = 0.01$$

4. **Determine the pressure required to reduce the given volume of water by 2%. Bulk modulus of water is 2.2×10^9 Nm^{-2}.**

Ans:- $\frac{-\Delta v}{v} = 2\% = \frac{2}{100}$

$B = 2.2 \times 10^9 \ N/m^2$

$B = \frac{-Pv}{\Delta v}$

$P = -B \times \frac{\Delta v}{v}$

$= 2.2 \times 10^9 \times \frac{2}{100}$

$P = 4.4 \times 10^7 \ N/m^2$

UNIT XI

MECHANICAL PROPERTIES OF FLUIDS

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. Define average pressure, mention it's units and dimensional formula?

Ans:- Average presesure is defined as the normal force acting per unit area.

$$P_{ave} = \frac{F}{A} = \frac{Force}{Unit\ Area}$$

Units : $\frac{N}{m^2}$ (or) pascals

Dimensgional formula : $ML^{-1}T^{-2}$

2. Define viscosity. What are units and dimiension formula?

Ans:- The property of a liquid which opposes the relative motion between its two layers is called viscosity.

Units : $\frac{N-S}{m^2}$ (or) pascals - sec.

Dimensgional formula : $ML^{-1}T^{-1}$

3. Why are water drops and bubbles in spherical shape?

Ans:- Due to surface tension. The surface tension of a liquid tends to have minimum surface area. The spherical shape occupies minimum surface area while compasing other shapes. So rain drops are always spherical shape.

4. Which instruments are used by the principle of venturi meter?

Ans:- Carburetor of automobile, Aspirators, Bunsenburner, Automisers, Filterpamps, Sprayers are used on this venturi meter prineiples.

5. What is angle of contact?

Ans:- The angle between tangent to the liquid surface at the point of contact and solid surface inside the liquid is termed as angle of contact (θ).

6. What is magnus effect?

Ans:- The difference in the velocities of air results in the pressure difference between the lower and upper faces. and there is a net upward force on the ball. This dynamic lift due to spinning is called "magnus effect".

7. Give the expression for the excess pressure in a liquid drop?

Ans:- Excess pressure in a liquid drop $P_i - P_o = \frac{2s}{r}$

Here S = Surface tension

r = Radices of the liquid drop.

8. Give the expression for the excess pressure in an air busble inside the liquid?

Ans:- Excess pressure in an air bubble inside the

liquid $P_i - P_o = \frac{2s}{r}$

Here S = Surface tension

r = Radices of the liquid drop.

9. Give the expression for excess pressure of the soap bubble in air?

Ans:- Soap bubble have two interfaces, hence excem pressuse in side a soap bubble is

$P_i - P_0 = \frac{4S}{r}$

Where S = Surfacetension

r = radius of the soap bubble.

10. What is Reynolds number?

Ans:- Reynold number is a pure number which determines the nature of fluid flow. 'R' is the Reynold number.

Re < 1000 to stream line flow

Re > 2000 to turbulent flow

1000<Re<2000 to unsteady flow

SHORT QUESTION & ANSWERS (4MARKS)

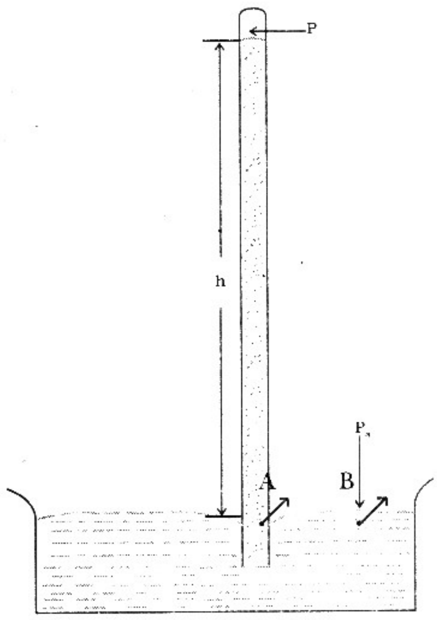
1. What is atmospheric pressure and how it is determined using Barometer?

Ans:- **Atmospheric pressure :** Atmospheric pressure at any point is equal to the weight of a column of air of the top of the earth's atmosphere.

$1 \text{ atm} = 1.013 \times 10^5 \text{pa}$

Determination of atm pressure using Barometer : A long glass tube closed at one end and failled with mercury is inverted in to a trough of merucry. This device is known as mercury barometer.

The space above the mercury column in the tube contains only mercury vapour whose pressure 'p' is so small, that it may be neglected. The pressure inside the column at 'A' must equal the pressure at 'B'



Merusry Barometers

$\therefore$ Pressure at 'B' = Atmospheric pressure = P_a

P_a = pgh = pressure at 'A'

Where 'p' is density of mercury and 'h' is the height of the mercury colmn in the tube. In the experiment it is found that the mercury colmn is the barometer has a height of about 76 cm at the sea level equivalent to one atmosphere.

2. State pascal's law and verify it with the help of an experiment?

Ans:- **Pascal law :** It states that if gravity effect is neglected. The pressure at every point equilibrium of rest is same.

Proof:

- Image a circular cylinder of uniform cross sectional area 'A'. Such that points 'C' and 'D' lies on flat faces of the cylinder.
- The liquid inside the cylinder in equilibrium under the action of force exerted by the liquid out side the cylinder.
- Thus the forces on the flat faces of the cylinder at 'C' and 'D' will be perpendicular to the forces on the curved surface of the cylinder.
- Since liquid is in equilibrium. The sum of the forces acting on the cerved surface of the cylinder must be zero.
- If P_1 and P_2 are the pressures at point 'C' and 'D' respectivly F_1 and F_2 are the forces acting on the flat surface of the cylinder due to liquid, then $F_1 = P_1A$

$$F_2 = P_2A$$

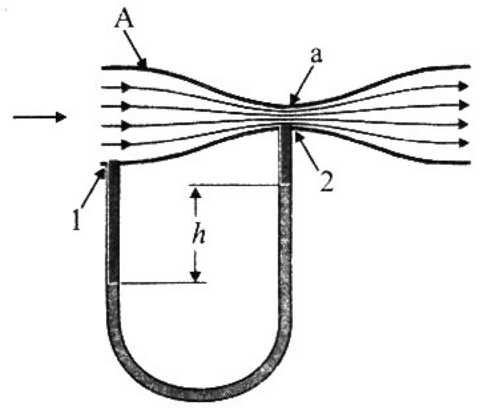
liquid is in equilibrium, therefore $F_1 = F_2$

$$P_1A = P_2A \Rightarrow \boxed{P_1 = P_2}$$

3. What is venturi - meter? Explain how it is used?

Ans:- Venturi meter : The venturi - meter is a device to measure the flow speed of incompressible fluid.

- It consists of a tube with a broad diameter and small construtionat the middle.
- A mano meter in the form of a U-tube is also attached to it, with one of arm at the broad neck point of the tube and the other construetion as shown in figure.
- The manomenter contains a liquid of denstity 'p'.



VENTURI - METER

- The pressure difference causes the fluid in the U-tube connected at the narrow neck to rise in comparision to the other arm.
- Filter pumps, sprayers used for perfumes, carburetor of automobile has used on this principle.

4. Explain surfaceTension and surface Energy?

Ans:- The force acting per unit length of an imaginary line drawn on the surface of liquid, normal to it and pasallel to the surface is called surface teusion.

$T = \frac{F}{l}$ units : N/m D.F : $ML^0 T^{-2}$

Surface energy (E) : The additional potential energy due to molecular forces per unit surface area is called surface energy.

S. energy (E) = $\frac{\text{Workdone}}{\text{Area}}$ units : J/m2 D.F : $MT^{-2} L^0$

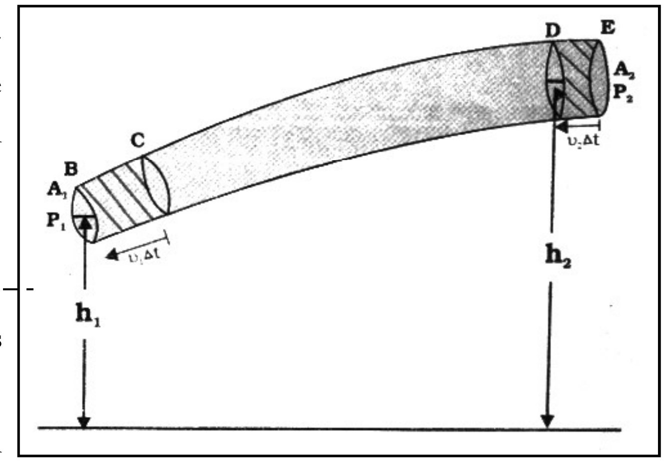
LONG QUESTION & ANSWERS (8MARKS)

1. State Bernoulli's principle from conservation of energy in a fluid flow through a tube, arrove at bernoalt's equation?

Ans:- **Bernoulli's principle :-** Bernoulli's principle state that in a stream line flow, the sum of the pressure, the K.E per unit volume and the P.E per unit volume remains a constant.

- Consider a non-viscous, incompressible fluid is showing the pipe in a steady flow.
- A_1 is eross sectonal area at one end of the pipe, and which is h_1 height from the ground level.
- A_2 is cross sectional area at second end of the pipe and which is h_2 hight from the ground level.

  where $h_1 > h_2$.
- During short time intervel this fluid would have moved v_1 is the speed at first end and v_2 is the speed at second end. But density 'δ' is same at both ends.
- P_1 P_2 are the pressures respectively.



According to the equation of continuity the mass of the liquid entering the tube equal to the mass of the liquid lowing the tube.

$\therefore P_1 A_1 V_1 dt = P_2 A_2 V_2 dt$ ----

Here mass of the liquid at furst end is $P_1 A_1 V_1 dt$

mass of the liquid at second end is $P_2 A_2 V_2 dt$

Where $f_1 = f_2$ as the fluid is incompressible

from eqn (1) $A_1 V_1 = A_2 V_2$ ------(2)

The workdone on the fluid in the tube as the fluid entess the tube through first end is $P_1V_1A_1\,dt$, and the work done by the fleid as it comes out of the tube through second end is $P_2V_2A_2\,dt$.

The total workdone on the fluid = $P_1V_1A_1\,dt - P_2V_2A_2\,dt$ ----(3)

The total workdone by the gravitational force on the fluid, as the fluid falls from the heights h_1 to h_2

$\therefore w_g = m(h_1 - h_2)g$ -----(4)

The total workdone on the fluid $= w_p + w_g$

According to work energy theorem, the workdone on the fluid is equal to the change in K.E of the fluid.

Hence

$$P_1 A_1 V_1 dt - P_2 A_2 V_2 dt + m(h_1 - h_2)g = \frac{1}{2}\left(v_2^2 - v_1^2\right)m \qquad ------(6)$$

diving B. sides by $m = \rho A_1 V_1 dt = \rho A_2 V_2 dt$

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

$$\therefore \boxed{\frac{P}{\rho} + hg + \frac{1}{2}v^2 = \text{constant}}$$

The above egn expressed as bernoulis eqns.

Applications :

1. When the forced wind flows on the top of the horese, which are ligted up due to dyamic lift on the roops.
2. Small peases of paper on the table, which are disferbed due to fan air.

Problems :

1. Diameter of the soap bubble 0.6cm. Find the work done against istplacent of bubble due to surface tensional force?

Ans:- $D = 0.6\text{cm} = 0.6 \times 10^{-2}\text{m}$

$$r = \frac{D}{2} = \frac{0.6 \times 10^{-2}}{2} = 0.3 \times 10^{-2}\text{m}$$

$$\delta = 2.5 \times 10^{-2}\ \text{N/m}$$

$$w = 8\pi r^2 s$$

$$= 8 \times 3.14 \times (0.3 \times 10^{-2})^2 \times 2.5 \times 10^{-2}$$

$$w = 5.652 \times 10^{-6}\text{J}$$

2. **Capillary tube is dippid is water capillary rised 6cm hight, what its radius of capillares tube? (S.T of water = $7.2 \times 10^{-2} N/m$)**

Ans:- $h = 6 \times 10^{-2} m, \ \delta = 7.2 \times 10^{-2} N/m$

Density of water $|P| = 10^3 \ kg/m^3$

$$\delta = \frac{hrpg}{2}$$

$$r = \frac{2s}{hpg} = \frac{2 \times 1.2 \times 10^{-2}}{6 \times 10^{-2} \times 10^3 \times 9.8}$$

$$r = \frac{14.4}{58.8} \times 10^{-3}$$

$$r = 0.24 \times 10^{-3} m \quad \Rightarrow 0.24 m.m$$

3. **Work done 'w' by the preparation of bubble w.r. to 'R' radius. How much energy required to its radius double of bubble?**

Ans:- $R_1 = R \quad R_2 = 2R$

Intuial work $(w) = 8\pi R^2 s$

Final work $(w^1) = 8\pi \left[R_2^2 - R_1^2 \right] s$

$$= 8\pi \left[4R^2 - R^2 \right] s$$

$$= 3 \times 8\pi R^2 s$$

$$\boxed{w^1 = 3w}$$

UNIT XII

THERMAL PROPERTIES OF MATTER

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. Distanguish between heat and temperature?

Ans:-

	Heat		Temperature
1)	Tremsforms the energy due to different temperatures of the two systems is called 'heat'.	1)	It is a degree of hotness (or) coldness of a body is called temperature.
2)	It is measured in jouli's (or) calories	2)	It is measured centigrade (or) fahren hait.
3)	It is determined with calorimentr	3)	It is measured with thermometer.

2. If substance contract on heating? Give an example?

Ans:- Yes, rubber, typemetal, castiron, such substances age contract on heating.

3. Why gap are left between rails on a railway track?

Ans:- The length of the railway track in creases in summer due to high temperature. Therefore a gap is left to allow this expansion.

4. What is latent heat of fusion?

Ans:- The amount of heat per unit mass required to change a substance from solid in to liquid at the same temperature and pressure is called the latent heat of fusion.

5. What is latent heat of vapourisation?

Ans:- The amount of heat per unit mass required to change a substance from the liquid to the vapour state at the same temparature and pressure is called the latent heat of vaporisation.

6. What is specific gas constant? units and D.F?

Ans:- If is defined as the constant per unit mass.

$$r = \frac{R}{M}$$

units : $J\ kg^{-1}\ k^{-1}$

D.F : $L^2\ T^{-2}\ k^{-1}$

7. Why cetensils are coated black? Why the bottom of the untensils are made of copper?

Ans:-
- Utensils are coated black, because it is a good obsorber of heat.
- Copper is a good conductor of heat, so copper is used at the bottom of cooking utensils.

8. State weins displacement law?

Ans:- The wave length (λ_m) corresponding to manimum energy emitted by a black body is inversely propertional to its absolute temperature (T).

i.e $\lambda_m \alpha \frac{1}{T}$

10. What is green house effect? Explain glocal warming?

Ans:- Green house effect : when the earth recieves sun light. It gets heated up and emits infrared, CH_4, N_2O, O_3 , chlorofluro carbon (green house gases) present in the air absorbs the heat content of infrared radiation and keeps the earth warm, This is called green house effect.

Global worming : As CO_2 content increases, more heat is retained in the atmosphere and the temperatures all over the world increases. This is called global warming.

11. Define absorptive power of a body. What is the absorpture power of a perfect black body?

Ans:- Absorptive power : At given temperature and wave length, the ratio of the amount of radient energy absorbed to the amount of radiant energy incident in a wave length range is called the absorptive power at that temperature and wavelength.

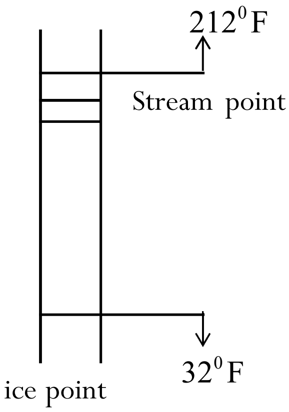
$\therefore$ Absorptive power of a perfect black body is 1.

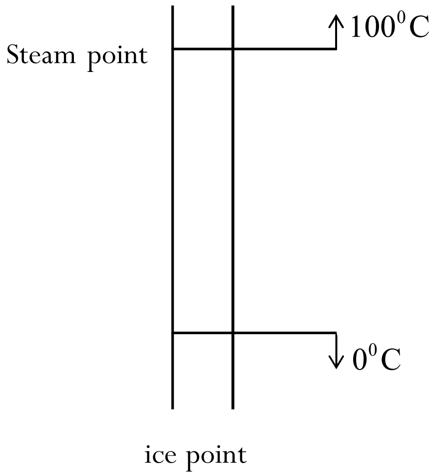
SHORT QUESTION & ANSWERS (4MARKS)

1. Explain celrius and Fahren hit scales of temperatures, obtain the selation between celain, fahran heit and kelving scales of temperatures?

Ans:- **Centingrade scale of temperature :** In this scale the lower fixed point is called the ice point and is assigned the value 0^0C. The upper fined point is called the steam point and is assigned the value 100^0C. The interval setween these two points ($100^0C - 0^0C = 100^0C$) is subdevided in to 100 equal parts each one corsesponding to 1^0C .

Fahrenheit scale of temperature : In the fahrenheit scale of temp the lower fixed point is the ice point and is assigned a value 32^0F and the upper fixed point is the steem point and is assigned a value 212^0F. The interval between these two points ($212^0F - 32^0F = 180^0F$) is subdevided into 180 equal parts each one cosresponding to 1^0F.





Relation : $\boxed{\frac{C}{100}=\frac{F-32}{180}=\frac{K-273}{100}}$

C & F relation : $\frac{C}{100}=\frac{F-32}{180}$

$$\frac{C}{5}=\frac{F-32}{9}$$

$$\boxed{C=\frac{5}{9}(F-32)} \text{ (or) } \boxed{F=\frac{9C}{5}+32}$$

2. State Newton's law of cooling.What are the conditions for applicable Newtons law of cooling?

Ans:- The state of loss of heat is directly propertional to the difference in temperature between the body and its sursoundings provided the temperature, difference is small.

i.e $-\frac{dQ}{dt} \alpha (T_2 - T_1)$

$$-\frac{dQ}{dt} = K(T - T_0)$$

Here K = Proportional constant

T = Temperature of object

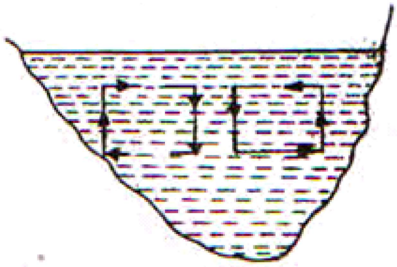
T_0 = Sursounding temperature.

Applicable conditions :

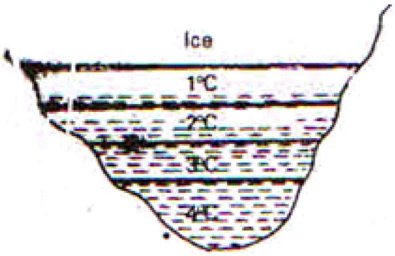
- Loss of heat is negligible by condution and only when it is due to convection.
- Temperature of the body is uniformly distributed over it.
- Temperature differences are moderate i.e up to 30K.
- Loss of heat occuss in stream lined slow of air i.e. forced convection.

3. In what way is the anomaloces behaviour of water advantageous to acquatic animals?

Ans:- In cold counfries, as atmospheric temperature decreases, the upper layers of the lakes rivers etc cool, contruct and sink to the bottom. This goes on until the whole of the water reaches the temperature of 4^0C. When the top layes cool further temperture falls below 4^0C if expands and becomes lighter. If does not sink down wards and remains at the top with further cooling the top layer gradually from ice at the top. Ice and water are bad conductors of heat.



Expansion of water moves upper to lower and lower to upper.



Formation of ice at the top with water below.

So the lower layer are protected aganist freezing by the layers of ice and cold water at 1^0C, 2^0C and 3^0C. This results in water remaining at the bottom at 4^0C. So that aquatic animals survive in those alyers of water.

LONG QUESTION & ANSWERS (8MARKS)

1. State Boyle's law and charless law derive ideal gas equation?

Ans:- **Boyless law :** The volume of a given mass of gas inversely proportional to its pressure at constant temperature.

$$\text{i.e } V \alpha \frac{1}{P} \text{ (at const. temp)}$$

$$\boxed{PV = \text{Constant}}$$

Charle's law : a) The volume of a given mass of gas is directly propertional to its absolute temp at constant pressure.

$$\text{i.e } V \alpha T \text{ (at const pressure)}$$

$$\boxed{\frac{V}{T} = \text{Constant}}$$

b) The pressure of a given mass of gas is directly proprbional to it's absolube temperature at constant volume.

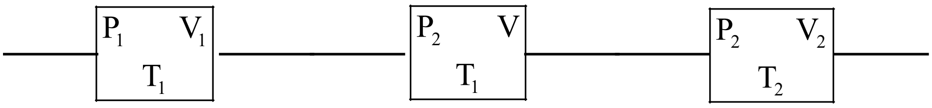
$$\text{i.e } P \alpha T \text{ (at const. volume)}$$

$$\boxed{\frac{P}{T} = \text{Constant}}$$

Ideal gas equation : Consider a given mass of gas having a volume V_1 at a pressure P, and absolate temperature T_1. When the temperature changed to T_2. Let the gas occupes a volume V_2 at a pressure 'P_2'.

Let this change takes place in two steps.

i) At constant temperature T_1 pressure of the gas changes P_1 to P_2 then volume changes V_1 to 'V'.



according boyle's law $P_1V_1 = P_2V \Rightarrow V = \dfrac{P_1V_1}{P_2}$ -----(1)

ii) Let constant pressure P_2, Absolute temperature changes T_1 to T_2 than volume of the gas changes V to V_2.

according to charle's law $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2} \Rightarrow V = \dfrac{V_2T_1}{T_2}$ ------(2)

Comparing eqn (1) & (2)

$$\frac{P_1V_1}{P_2} = \frac{V_2T_1}{T_2}$$

$$\Rightarrow \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\Rightarrow \frac{PV}{T} = \text{Constant (R)} \ (\because \text{R ideal gas constant})$$

$\boxed{PV = RT}$ for 1 mole of gas.

Problems :

1. At what temperature kelvin reading and farin heit readings are eqeal?

Ans:- The relation between kelvin scales and fahrein heit scale is $\dfrac{K - 273.15}{100} = \dfrac{P - 32}{180}$

But $K = F$

$$\frac{F - 273.15}{100} = \frac{F - 32}{180}$$

$$F - 273.15 = \frac{5}{9}F - \frac{160}{9}$$

$$F - \frac{5}{9}F = 273.15 - \frac{160}{9} = 273.15 - 17.77$$

$$\frac{4F}{9} = 255.38$$

$$\therefore\ F = \frac{9}{4}(255.38) = 574.6^0 F$$

2. Length of the aluminimum rod rises to 1% then what is the increating temperature requires? (Al = $25 \times 10^{-6} /^0 C$)

Ans:- Percentage of incresing length $= \frac{\ell_2 - \ell_1}{\ell_1} \times 100$

$$= \alpha\ (t_2 - t_1) \times 100 \quad -----(1)$$

$$\left[\because \frac{\ell_2 - \ell_1}{t_1} = \alpha\ (t_2 - t_1)\right]$$

Here 1% in eseasing in length

$\alpha = 25 \times 10^{-6} /^0 C$

From eqn (1) $\therefore\ 1 = 25 \times 10^{-6}\ (t_2 - t_1) \times 100$

$$t_2 - t_1 = \frac{1}{25 \times 10^{-4}} = \frac{10^4}{25} = 400^0 C$$

3. 37^0CTemperature, 75cm mercury level pressure at spelitic mass, volume of gas is 620CC, find the volume at N.T.P?

Ans:- Here $P_1 = 75$ cm of Hg $\quad V_1 = 620CC$

$T_1 = 37 + 273 = 310K$

at NTP $P_2 = 76$cm of Hg, $T_2 = 273K$

$V_2 = ?$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow V_2 = \frac{P_1V_1T_2}{P_2T_1}$$

$$V_2 = \frac{75 \times 620 \times 273}{76 \times 310} = 538.8\ CC$$

4. 14kg mass of Nitrogen volume is $0.4m^3$ at 30^0C temperature then find the pressure?

Ans:- Mass of the gas (m) = 14kg

$$= 14 \times 10^3\ gm$$

atomic weight of $N_2 = 28$

$V = 0.4m^3 : T = 30^0 + 273 = 303K$

$$PV = nRT = \frac{m}{M} RT$$

$$P = \frac{m}{M} \frac{RT}{V}$$

$$= \frac{14 \times 10^3 \times 8.317 \times 303}{28 \times 0.4}$$

$\therefore P = 31:5 \times 10^5 \ N/m^2$

5. A block body maximum radiation intensity is found at 2.65 um.Then find the temperature of the object emilts radiation? (Weins constant = $2.9 \times 10^{-3} m$)

Ans:- $\lambda_{max} = 2.65 \ \mu m = 2.65 \times 10^{-6} m$

wein's constant $(b) = 2.90 \times 10^{-3} mK$

$\lambda_{max} \ T = b$ (Constant)

$$T = \frac{b}{\lambda_{max}} = \frac{2.9 \times 10^{-3}}{2.65 \times 10^{-6}}$$

$\therefore \ T = 1094 \ K$

UNIT XIII

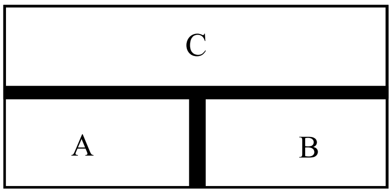
THERMODYNAMICS

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. Define thermal equilibrium. How does it lead to zero its law of thermodynamics?

Ans:- If the temperatures of the two systems are equal, then they are said to be "thermal equilibrium".

Zeroth law of thermodynamics : If two systems A,B are thermal equilibrium then two systems A, B thermal euilibrium with each other.



2. Define specific heat capality of the substance?

Ans:- Specific heat capacity : The amount of heat required to raise the 1 gm of substance through 1^0C (or) 1K is called specific heat capacity

$S = \frac{1}{m}.\frac{\Delta Q}{\Delta T}$ it depends on nature of the substance and temperature.

4. In summer, when the value of a bicycle tube is opening the escaping air appeass cold,Why?

Ans:- This happens due to adiabatic expansion of the air of the tube of the bicycle.

5. By leaving the door of an elestic refrigerator open a room cooled (or) not?

Ans:- No, A room can not be cooled by leaving the door of a refrigerator open. But it will get stightly heated.

6. A Thermos flask containing a liquid is shaken vigorously. What happens to its temperature?

Ans:- Work is done by the liquid on the wall of flask, since it is vigorously shaken. Hence internal energy and temperature of the liquid incereases.

7. How much will be the internal energy change in isothermal process, adiabatic process?

Ans:- - Change in internal energy during isothermal process is dv = 0 ($\because$ U is constant)

- But in adiabatie process is two ways.

ie - during adiabatic compression increases

- during adiabatic expansion decseases.

SHORT QUESTION & ANSWERS (4MARKS)

1. State and explain first law of thermodynamics.

Ans:- The amount of heat supplied to system is equal to the algebsic sum of the change in infernal energy of the system and the amount of external work done.

i.e $\boxed{\Delta Q = \Delta U + \Delta W}$ where $\Delta Q =$ amount of heat

$\Delta U =$ internal energy

$\Delta W =$ Enternal workdone

If is special care of law of conservation of energy.

2. Define two principles of specifice heat gas. Which is greater and Why?

Ans:- We have two specific heat of a gases are

(1) molar specific heat capacity at constant pressure (C_p)

(2) Molar specific that capality at constant volume (C_v)

(1) C_p : The amount of heat required to raise the temp. of 1 gm mole of a gas through 10C at constant pressure is called molar specific heat at constant pressures (C_p)

i.e $C_p = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$ where 'μ' is no of moles.

(2) C_v : The amount of heat required to raise the temp of 1gm mole of gas through 1^0C at constant volume is called molar specific heat at constant volume (C_v)

i.e $C_v = \frac{1}{\mu}\frac{\Delta Q}{\Delta T}$

$C_p > C_v$ In C_v system the gas is heated at constant volume, no work is done. there fore the heat is supplied is to be used only in rising the temp.

3. Derive a relation between the two specifie heat capacituies of gas on the basis of Ist law of thermodynamics.

Ans:- At constant pressure one mole ideal gas acquiral amount of heat (dQ) 'du' is the internal enegy raises then enternal workdone $dw = pdv$.

$\therefore dQ = du + pdv \quad ----(1)$

According to defination of specific heat at constant volume for 1 mole of gas is

$C_v = \left(\frac{dQ}{dT}\right)_r \quad ------(2)$

But at constant volume dV=0 there fore

from eqn (1) dQ=dU + P (O)

$$dQ = dU$$

from eqn (2) $C_v = \left(\frac{dU}{dT}\right)_v \quad (\because dQ = dU) \quad ------(3)$

According to defination of specific heat at constant pressure.

$$C_p = \left(\frac{dQ}{dT}\right)_p \quad ------(4)$$

Deffierentiate w.r. to temperature either sides of the eqn. (1)

$$\therefore \left(\frac{dQ}{dT}\right)_p = \left(\frac{dU}{dT}\right)_p + p\left(\frac{dV}{dT}\right)_p$$

But internal energy of the ideal gas depends on temp 'T' so bottom indicator 'p' if $\frac{dV}{dT}$ is neglected from the above eqn.

$$\therefore C_p = \left(\frac{dU}{dT}\right)_r + p\left(\frac{dV}{dT}\right)_p \quad (\because \text{from eqn(3)})$$

$$C_p = C_v + p\left(\frac{dV}{dT}\right)_p \qquad (\because PV = RT \text{ partical differ})$$

$$C_p = C_v + R \qquad P.dv = R.dT$$

$$\boxed{C_p - C_v = R} \qquad P.\left(\frac{dV}{dT}\right)_p = R$$

4. Determine the workdone by an ideal gas during isothermal change?

Ans:- Let a certain mass of gas expands from pressure P_1 to P_2 and volume V_1 to V_2 isothermally at constant temperature T.

work done 'dw' voleme of gas expands from V_1 to V_2 at constant pressure

$$dw = pdv$$

$\therefore$ total workdone $w = \int_{V_1}^{V_2} dw = \int_{V_1}^{V_2} p.dv \quad -----(1)$

In isothermal process PV=constant

PV = μ RT

$P = \frac{\mu RT}{V}$ Where $\mu = \text{no.of moles}$

'P' value substitude in eqn (1)

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

$$= \mu\ RT\ \log_e [V]_{V_1}^{V_2}$$

$$W = \mu RT\ \log_e \left(\frac{V_2}{V_1}\right)$$

Total workdone in isothermal process

$$W = 2.3026\ RT\ \log_e \left(\frac{V_2}{V_1}\right)$$

5. Determine the workdone by an ideal gas during adiabatic change?

Ans:- During an adiabatic change the state of an ideal gas changes from $(P_1\ V_1\ T_1)$ to $(P_2\ V_2\ T_2)$. The workdone during a small change in volume dv at constant pressure sis dw = pdr.

Total workdone by gas from V_1 to V_2 is

$$\text{i.e } W = \int_{V_1}^{V_2} dw = \int_{V_1}^{V_2} p.dr \qquad -----(1)$$

adiabatic relation between pressure and volume

$PV^2 = \text{constant (K)}$ --------(2)

$$P = \frac{K}{V^r} \qquad ------(3)$$

and $P_1V_1^2 = P_2V_2^2 = K$

Substitute egn (3) in (1)

$$W = \int_{V_1}^{V_2} p.dV = \int_{V_1}^{V_2} \frac{k}{V^r}.\,dr$$

$$W = k\left(\frac{V^{1-r}}{1-r}\right)_{V_1}^{V_2}$$

$$W = \left[\frac{K.V_2^{1-r}}{1-r} - \frac{K.V_1^{1-r}}{1-r}\right] = \left[\frac{P_2V_2^r\ V_2^{1-r}}{1-r} - \frac{P_1V_1^r\ V_1^{1-r}}{1-r}\right]$$

$$w = \frac{1}{1-r}\left[P_2V_2 - P_1V_1\right]$$

But gas eqn $P_1V_1 = RT_1\ \&\ P_2V_2 = RT_2$

$$w = \frac{1}{1-r}(RT_2 - RT_1)$$

$\therefore \boxed{w = \frac{R}{1-r}(T_2 - T_1)}$

6. Distingwish between isothermal and adiabatic process?

Ans:-

Isothermal change	Adiabatic change
1) Changes in P,V and constant temperature.	1) Changes in P,V of gas and constant heat.
2) Amount of heat changes	2) Temperature changes.
3) The gas semains in good thermal contact with surroundings and heat is exchanged.	3) The gas is isolated from the sussoundngs and heat is not exchanges.
4) Here PV = constant	4) Here PV^2 = constant
5) This process takes place slow	5) This process takes place quickly
6) Internal energy semains constant dV=0.	6) Entropy is constant.

7. Explain the cyclic process and Non cyclic process?

Ans:- **1) Cyclie process :** 'A' process in which the ststem after passing throgugh various stages like pressure, volume, temp changes, returns to its intial stage is called cyelic process.

- In cyclic process workdone is zero when a graph between P-V.

- In a cyclic process there will be no change in the internal energy.

i.e dv=0

- So dQ = dW for cyclic process.

Ex : Heat engine converts to heat energy.

Non cyclic process : A process which is not attains its intial stage, it is not cyclic process. Such process is called Non-cyclic process.

- Area of curves between P-V graph can be expressed as workdone.

Ex : -Diffusion of liquids (or) gases.

- Free expansion of a perfect gas.

Problems :

1. 5 moles of H_2. When it is heat to raise the temperature 20K at constant pressure $10^5 N/m^2$ then it is enpands $8.3 \times 10^{-3} m^3$ so specific heat $C_V = 20\,J/mole$ find C_p?

Ans:- $C_P - C_V = R$

with $\mu \Delta T$

$\mu C_P \Delta T - \mu C_V \Delta T = \mu R \Delta T$

$\mu \Delta T (C_P - C_V) = P\Delta T \left(\because \mu R \Delta T = P\Delta V\right)$

$5 \times 20 (C_P - C_V) = 105 \times 8.3 \times (10-3)$

$$\begin{bmatrix} \therefore \mu = 5,\ \Delta T = 20K,\ P = 1\times 10^5\ N/m \\ C_V = 20 J/mol\ K \text{ and } \Delta V = 8.3 \times 10^3 m^3 \end{bmatrix}$$

$C_P - 20 = 8.3$

$\therefore C_P = 28.3\ J/mol.K$

2. **How much heat is required to raise the temp 45^0C of 2.0×10^{-2}Kg Nitrogen at room temperature, at constant pressure?**
(N_2 w = 28, R = 8.3 J/mol.K)

Ans:- Mass of the gas $m = 2 \times 10^{-2} Kg = 20g$ m

Increasting temp $\Delta T = 45^0 C$

required heat $\Delta Q = ?$

at mass of $N_2 = 28$

at number $n = \frac{m}{M} = \frac{20}{28} = 0.714$

Nitrogen is diatomic molar specific heat of gas at constant pressure

$C_P = \frac{7}{2} R = \frac{7}{2} \times 8.3\ J/mol\ K$

$\Delta Q = {}^n C_P\ \Delta T$

$= 0.714 \times \frac{7}{2} \times 8.3 \times 45J = 933.45J$

3. **One electric heater giving heat at the rate 100W to one system.That system is working at the 75 J/sec.Then find the increasing rate of internal energy?**

Ans:- Supplied heat $\Delta Q = 100\,w = 100\ J/s$

used for work $\Delta w = 75\ J/s$

$\Delta u = ?$

$\therefore \Delta Q = \Delta U + \Delta w$

$\Delta U = \Delta Q - \Delta w$

$= 100 - 75$

$= 25 J/s$

4. Eating foods are kept in refrigerator at 9^0C if room temp is 36^0C then calculate the coeffient of performance?

Ans:- Given $T_1 = 36^0 C = 36 + 273 = 309K$

$$T_2 = 10^0 C = 10 + 273 = 283K$$

$$\text{Co.of performance } (\alpha) = \frac{T_2}{T_1 - T_2} = \frac{283}{309 - 283}$$

$$= \frac{283}{26} = 10.9$$

UNIT XIV

KINETIC THEORY

VERY SHORT QUESTION & ANSWERS (2 MARKS)

1. Define mean free path?

Ans:- The average distance covered by a molecule between two successive collisions is called the mean free path.

2. How does kinetic theory justify Avagadro's hypothesis and show the avaradro number in different gases is same?

Ans:- For two different gases, we have $\frac{P_1V_1}{N_1T_1} = \frac{P_2V_2}{N_2T_2} = K_B$

If P,V,T are same, then N is also same for two gases 'N' is called Avagadro's numbers. According to Avogrdro's hypothesis, that the number of molecules per unit volume is same for all gases at a fined temperature and pressure. In this way kinetic theory justify avogadro's hypothesis.

3. When does a real gas behave like an ideal gas?

Ans:- At low pressuses and high temperatures real gases behave like an ideal gas.

4. The absolute temperature of a gas is ineseased '3' times. What will be the increase in r.m.s velocity of the gas molecule?

Ans:- case (i) : The r.m.s velocity of gas moleculer $V_1 = \sqrt{\frac{3RT_1}{M}}$

case (ii) : The rms velocity of gas molecules $V_2 = \sqrt{\frac{3RT_2}{M}}$

Incsease in r.m.s velocity of gas moleuls

$= V_2 - V_1$

$= 1.732V_1 - V_1 = 0.732V_1$

5. What is the enpression between pressure and kinetic energy of a gas moleules?

Ans:- By kinetic theory pressure $p = \frac{1}{3}mv\ \vartheta^2$ and

Kinetic energy $= \frac{1}{3}mv\ \vartheta^2$, Where 'm' is the mass of the molecules, n is the no. of moles per unit volume ϑ - is the mean-square - speed.

$$\therefore P = \frac{2}{3}\left(\frac{1}{2}mv\ \vartheta^2\right)$$

$$\boxed{P = \frac{2}{3} \times K.E}$$

SHORT QUESTION & ANSWERS (4MARKS)

1. How specific heat capacity of mono atomic, diatomic and poly atomic gases can be enplained on the basis of law of equipartition of energy?

Ans:- (i) Monoatomic gases : According to law of equipartition of energy a molcule of monoatomic gas has only '3' (translational) degree of freedom i.e f =3.

The molecular specific heat of the gas at constant volume is given by $C = \frac{1}{2}R$ Where 'f' is degree of freedom.

$\therefore C_v = \frac{3}{2}R = 3 \text{ cal/mol} - k$ ($\because$ R=2cal/mole-K)

The molar specific heat at constant pressure is given by

$$C_P = \left(\frac{f}{2}+1\right)R = \left(\frac{3}{2}+1\right)R = \frac{5}{2}R = 5\text{cal/mol}$$

$$= 5 \text{ cal/mol} - K$$

(ii) Diatomic gases : A molecule of diatomic gas has '5' degree of freedom 3 translational nad 2 sotational i.e f = 5.

$$\therefore C_v = \frac{f}{2}R = \frac{5}{2}R = 5\text{cal/mole} - K$$

$$C_p = \left(\frac{f}{2}+1\right)R = \frac{7}{2}R = 7\text{cal/mole} - K$$

(iii) Polyatomic gases : Polyatomic molecules has '3' translational, 3-rotational degrees of freedom.
i.e f = 6

$$\therefore C_v = \frac{f}{2}R = 3R = 6\text{cal/mol} - K$$

$$C_p = \left(\frac{f}{2}+1\right) = 4R = 8\text{cal/mol} - K$$

2. Prove that the average K.E of a molecule of an ideal gas is directly proportional to the absolute temperature of the gas.

Ans:- Since the pressure of the gas is given by

$P = \frac{1}{3}mn\vartheta^2$, where $m \rightarrow$ mass of the gas

$n \rightarrow \frac{N}{V}$ no. of molucule per unit volume.

$\vartheta \rightarrow$ r.m.s velocity of gas

$\therefore p = \frac{1}{3} m \frac{N}{V} \vartheta^2$

$\Rightarrow PV = \frac{1}{3} mN \vartheta^2$ -----(1)

we know 1 gm molecule of the gas is PV = RT -------(2)

from egn (1) & (2) $RT = \frac{1}{3} mN \vartheta^2$

$$\frac{3RT}{N} = m \vartheta^2$$

$$\Rightarrow \frac{3}{2} \frac{R}{N} T = \frac{1}{2} m \vartheta^2$$

$$\Rightarrow \frac{3}{2} K_B T = \frac{1}{2} m \vartheta^2 \qquad \left(\because \frac{R}{N} = K_B\right)$$

Here K_B Bottman constant and 'T' - absolute temp.

$$\therefore \boxed{E = \frac{3}{2} K_B T} \qquad \left(K.E = \frac{1}{2} m\vartheta^2\right)$$

Hence K.E of a molecule an ideal gas is directly propertional to the absolute temperature of the gas.

LONG QUESTION & ANSWERS (8MARKS)

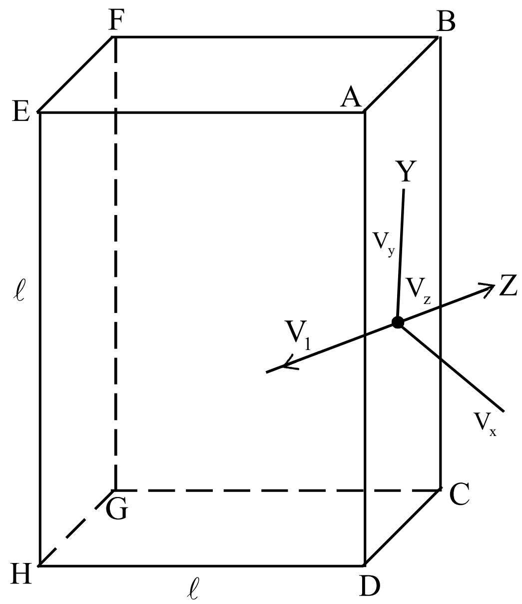
1. **Derive an expression for the pressure of an ideal gas in a container trom kinetic abeory and hence given kinetic interpretation of temperature.**

Ans:- Let us consider a cubical vessel of side 'ℓ' with perfectly elastic wall, containing gas molecules. Let the three sides of the cube be taken as co-ordinates axis. Consider a molecule moving with velocity V_1 in any direction at any instant. The components of 'V' along the three sides are $\vartheta_x, \vartheta_y, \vartheta_z$ respectively, then

$\vartheta_1^2 = \vartheta_x^2 + \vartheta_y^2 + \vartheta_z^2$ ------(1)

If 'm' is the mass of this molecule if transfers a momentum $m\vartheta_x$ when it striks the face ABCD of the cabe. Since the wall is perfectly elastic, this molecules is reflected back with a velocity - ϑ_x and momentum - $m\vartheta_x$ so the change in momentum = $m\vartheta_x - (-m\vartheta_x) = 2m\vartheta_x$.

This moleule then travells towards the opposite face. collide with if rebounds and travels again towards the face ABCD. The distance travelled between two successive collisions is '2ℓ'. Time taken between two successise collisions is $\frac{'2\ell'}{v}$.



$\therefore$ no. of collisions per second $= \frac{\vartheta_x}{2\vartheta}$

Change in momentum per one second $= (2m\vartheta_x) \times \left(\frac{\vartheta_x}{2\ell}\right)$

$$= \frac{m\vartheta_x^2}{\ell}$$

Thes force exerted by this molecule $= \frac{m\vartheta_x^2}{\ell}\left(\because R = \frac{dp}{dt}\right)$

hence force exested by 'N' such molecules in the x-direction

$$f_x = N\frac{m\vartheta_x^2}{\ell} = \frac{mN\vartheta_x^2}{\ell}$$

Pressure exested by the molecules in the x - direction is 'P_x'

i.e. $P_x = \frac{f_x}{\ell^2} = \frac{mN\,\vartheta_x^2}{\ell} \times \frac{1}{\ell^2} = \frac{mN\,\vartheta_x^2}{\ell^3}$ ------(2)

Simillarly pressure exested by the molecules in the y and z disections aree

$$P_y = \frac{mN\,\vartheta_y^2}{\ell^3} \quad \text{------(3)}$$

$$P_z = \frac{mN\,\vartheta_z^2}{\ell^3} \quad \text{------(4)}$$

Since the pressure exested by a gas in all the directions is same, the average pressure.

$$P = \frac{P_x + P_y + P_z}{3} = \frac{mN}{3\ell^3}\left[\vartheta_x^2 + \vartheta_y^2 + \vartheta_z^2\right]$$

$$= \frac{mN}{3V}\vartheta^2 \text{ (from eqn (1))}$$

$(\because \text{cube } V = \ell^3)$

Here 'ϑ^2' is the mean squase velocity of the molecule, 'V' is the volume of the vessel.

If 'm' is the mass of the gas then M = mN

$$\boxed{\therefore\ P = \frac{1}{3}\frac{m\vartheta^2}{v} = \frac{1}{3}mn\vartheta^2} \qquad \left[\because n = \frac{N}{V}\right]$$

This pressuse is aethually the pressure exerted by an ideal gas.

Kinetic interpretation of temperature :

Since the pressure of the gas in given by $P = \frac{1}{3}\, mn\, \vartheta^2$

Wehre m = mass of the gas

$\Rightarrow n = \frac{N}{V} \Rightarrow$ no. of molecules per unit voleme.

$\Rightarrow V \rightarrow$ r.m.s velocity of gas.

$$\therefore P = \frac{1}{3}\, m\, \frac{N}{V}\, \vartheta^2$$

$$\Rightarrow PV = \frac{1}{3}\, mN\, \vartheta^2$$

We know the ideal gas for one mole PV=RT

$$\text{we get } RT = \frac{1}{3}\, mN\, \vartheta^2$$

$$\frac{3RT}{N} = m\vartheta^2 \quad \rightarrow \text{multiply with } \frac{1}{2} \text{ on both sides}$$

$$\therefore \boxed{\frac{1}{2}m\vartheta^2 = \frac{3}{2}K_B T} \qquad \left(\because \frac{R}{N} = K_B\right)$$

Here K_B is Bollman constant. So mean kinetic energy of a molecule is $K_B T$. Which depends upon the temp. As temp increases means kinetic energy of the molecules also increases.

Problems :

1. Caluclate the ratio of Oxizen, Hydrozen mulucules of r.m.s velocities at same temperature?

Ans:- r.m.s velocity of gas $\vartheta = \sqrt{\frac{3RT}{M}}$

$$\Rightarrow \frac{\upsilon_0}{\upsilon_4} = \sqrt{\frac{\mu_H}{\mu_0}}$$

$$\mu_H = 2 \text{ and } \mu_0 = 32$$

$$\frac{\vartheta_0}{\vartheta_H} = \sqrt{\frac{2}{32}} = \frac{1}{4}$$

$$\therefore \boxed{\vartheta_0 : \vartheta_H = 1:4}$$

2. '4' molecules in a gas, whose velocities are 1,2,3,4 km/s respectively calculate the r.m.s velocity of gas moleucle.

Ans:- $\vartheta_1 = 1\ km/s$ $\vartheta_2 = 2\ km/s$ $\vartheta_3 = 3\ km/s$ $\vartheta_4 = 4\ km/s$

$\therefore \vartheta\ rms = ?$

$$\vartheta\ rms = \sqrt{\frac{\vartheta_1^2 + \vartheta_2^2 + \vartheta_3^2 + \vartheta_4^2 +}{n}} = \sqrt{\frac{1^2 + 2^2 + 3^2 + 4^2}{4}}$$

$$= \sqrt{\frac{1+4+9+16}{4}} = \sqrt{\frac{30}{4}} = \sqrt{7.5} = 2.735\ km/s$$

3. 1 gm of Helium is at 127^{0}C temperature then find the molecular kinetic energy? (given R = 8.31 J/mol-K)

Ans:- Given deta : $t = 127^0 C$

$$T = 273 + 127 = 400,\ R = 8.31 J/mole$$

$$K.E = \frac{3}{2} K_B T = \frac{3}{2} \times 1.38 \times 10^{-23} \times 400 = 8.28 \times 10^{-21} J$$