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$v = 7\,ms^{-1}$
$r = 5\,m$
$g = 9.8\,ms^{-2}$

$\tan\theta = \frac{v^2}{rg} = \frac{7\times7\times10}{5\times9.8} = 1$

$\tan\theta = 1$
$\theta = 45^\circ$

5) In a circus the radius of globe of death is 10m. From what minimum height must a cyclist start in order to go round the globe successfully?

Soln - $m.g.h = \frac{1}{2}mv^2$ $\qquad v = \sqrt{5gr}$
$gh = \frac{1}{2}v^2$ $\qquad = \sqrt{5\times10\times10}$
$\qquad v^2 = 5gr$

$gh = \frac{1}{2}5gr$

$h = \frac{5}{2}r$

$\Rightarrow h = 2.5\times10$
$\Rightarrow h = 25m$

Good
Ayadav 27/7/23

Teacher's Signature.........

Chapter- 1st
Work, Energy AND Power
Unit-4

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* Work: Work is said to be done by a force acting on a body. If it covers some displace. This displacement can be done in the direct. of force. ⊥ to the direction of force, opp. to the direction of force. Work done by a constant force is product of force and displace.
$W = F.S$
Work done is a scalar quantity
$W = FS\cos\theta$, where θ is angle b/w force and displacement
Dimensional formula of work done is $M^1L^2T^{-2}$

* Units of Work:
i) Absolute units:
a) S.I unit: S.I unit of workdone is Joule.
$W = F.S$, $1J = 1Nm$.
When a force of 1N displace a body through 1m then workdone will be one joule.

b) C.G.S unit (~~second~~): C.G.S unit of workdone is erg.
$W = FS$
$1\,erg = 1\,dyne.cm.$
Work done is said to be 1 erg when force of 1 dyne displace a body through 1cm.

Relation b/w Joule and erg
$1J = 10^7 erg.$

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* Gravitational units ÷

(a) S.g unit ÷ The gravitational unit of work done in S.g unit system is kgm.

$W = F.S$

$1 kgm = 1 kgf \times m$.

when a force 1kgf moves a body through a distance of 1m then the workdone is said to be one kilogram metre.

→ Relation b/w kgm and joule

$1kgm = 1kgf \times m$

$= 9.8 N \times 1m$

$1kgm = 9.8 Nm$

$1kgm = 9.8 J$ [∵ $Nm = J$]

(b) C.G.S unit ÷ The gravitational unit of work in C.G.S unit is gram metre.

$W = F.S$

$1gm = 1gf \times 1cm$

1gm - Work done is said to be one gram metre if a force of 1gf moves a body through a dist. of 1cm.

→ Relation b/w 1gm and erg

$1gm = 1gf \times 1cm$

$= 980\ dyn \times 1cm$

$1gm = 980\ dyncm$.

$1gm = 980\ erg$ [∵ $dyncm = erg$]

* Nature of workdone ÷

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i) Positive work done ÷

$W = \vec{F} \cdot \vec{S}$

$= FS\cos\theta$

If $\theta < 90^\circ$ then,

$W = +ve$

If $\theta = 0^\circ$, i.e.-- F and S be the same direction.

* Example of positive work done

i) when a body falls freely under the action of gravity then Workdone is +ve.

ii) when a ball is ~~throue~~ thrown up and applied force, displac. are in same direction then work done will be +ve.

* Negative work done

$W = FS\cos\theta$

when $\theta > 90^\circ$ or $\theta = 180^\circ$

then, $\boxed{W = -ve}$

Work done will be negative if applied force and displ. are in opp. direction.

* Example ÷

i) When a body is thrown then work done by gravitational force will be negative.

ii) When a body move on a rough surface then work done by force of friction is also -ve.

Zero work done ÷

$W = F.S$

$= FS\cos\theta$

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If $\theta = 90^\circ$
Then, $W = 0$
Work done will be zero if displace. is zero or force is $\perp$ to the direction of displacement.

* Example:

i) If we applying a force of a wall, wall does not move then displace. is zero, so, workdone is also zero.

ii) When a coolie carrying some load on his head and move on a horizontal plateform then force is $\perp$ to displacement; so, workdone will be zero.

iii) Workdone by centripetal force on a body moving in circular path will be zero.

* Constant force:

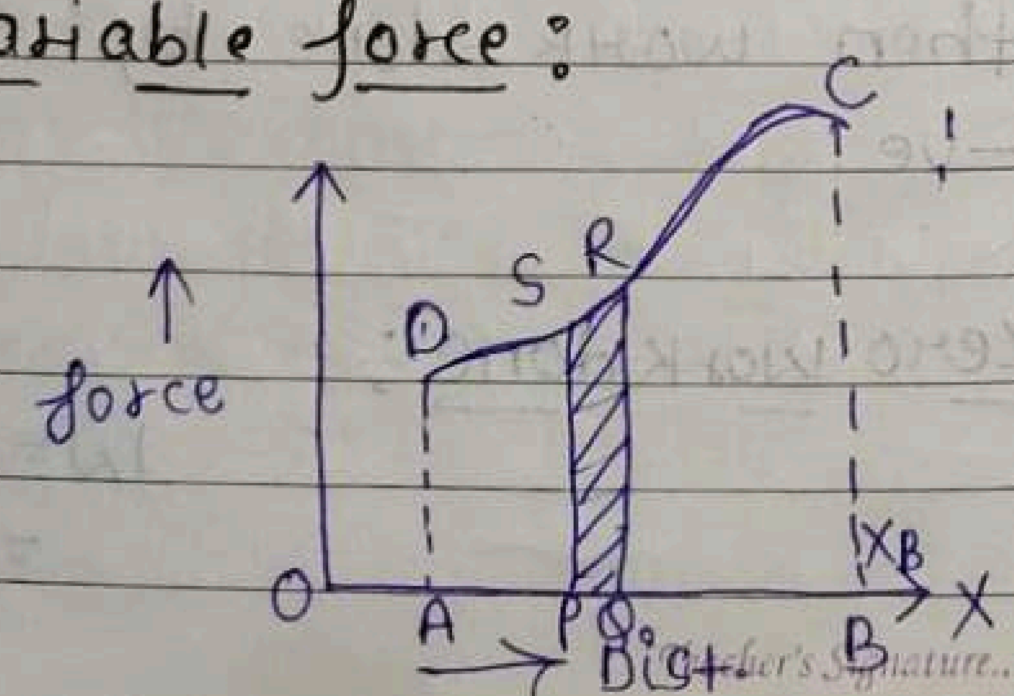
A Constant force is that force whose value remains same (constant).

* Variable force:

A Variable force is that type of force whose value does not remain same but changes with time.

* Work done by Variable force:

(a) Graphical method :-

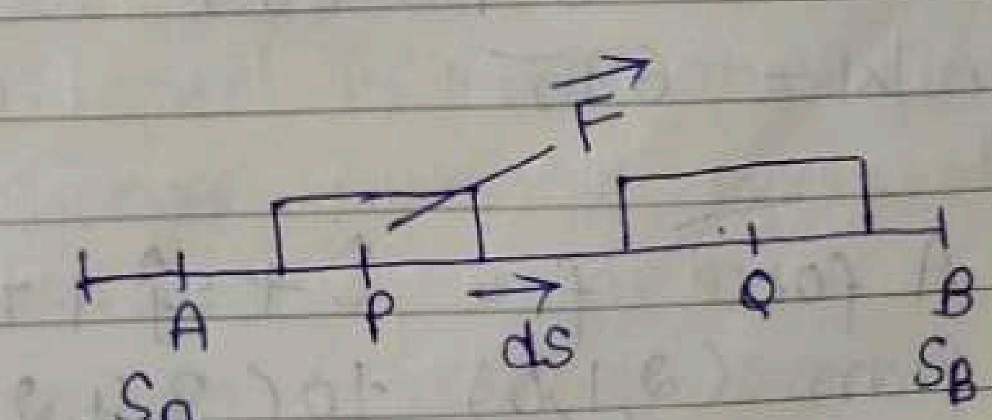


Work done is moving the body from A to B under the action of the variable force. To do this, we assume that the entire displac. from A to B is made up of a large number of infinitesimal displac.
$PQ = dx$
Small amount of work done is moving the body from P to Q is
$dW = F \times dx = (PS)(PQ) = $ area of strip PQRS
Total work done
$W = \Sigma dW = \Sigma F \times dx$
If displ. is approch to zero, then no. of terms increases without limit
$W = \lim\limits_{dx \to 0} \Sigma F(dx)$

By integrating the eq^n.
$$W = \int_{x_A}^{x_B} F(dx)$$

Where $x_A = OA$ and $x_B = OB$
$W = \int_{x_A}^{x_B}$ area of strip PQRS
$=$ total area under the curve b/w F and x-axis from $x = x_A$ to $x = x_B$
$\boxed{W = \text{Area } ABCDA}$

(b) Mathmatical Treatment (of work done by a variable force)



Multiplying and divide by 'm' in RHS of eqn ii)

$$K.E = \frac{1}{2} mv^2 \times \frac{m}{m}$$

$$\Rightarrow \frac{1}{2m} m^2 v^2 = \frac{1}{2m} (mv)^2$$

using eqn ii)

$$K.E = \frac{1}{2m} p^2$$

$$K.E = \frac{p^2}{2m}$$

OR $p = \sqrt{2m \cdot KE}$

* **Work - Energy Th^m:**

According to this th^m workdone in moving a body on horizontal surface will be equal to change in kinetic energy of body.

Workdone = change in K.E

= final kinetic energy − Initial K.E

Proof:

Consider a body of mass 'm' initially moving with velocity 'u'. let 'v' be the final velocity

Then, workdone will be

$$W = F.S \quad \text{— i)}$$

using eqn of motion

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

$$\frac{v^2 - u^2}{2a} = S \quad \text{— ii)}$$

As,

$F = ma$

using these value in eq^n i)

$$W = m\cancel{a} \times \frac{v^2 - u^2}{2\cancel{a}}$$

$$W = \frac{1}{2} m (v^2 - u^2)$$

$$W = \frac{1}{2} mv^2 - \frac{1}{2} mv^2$$

W = final K.E − Initial K.E

$\boxed{W = \text{change in K.E}}$

This is called work energy th^m.

By calculas method:

$$dW = f \cdot dx$$

$$dW = ma \cdot dx$$

$$= \frac{m\,dv}{dt} \cdot dx$$

$$m\,dv \cdot \frac{dx}{dt}$$

$$dW = dv \cdot mv$$

Integrating on both side $u \rightarrow v$

$$\int dW = \int_u^v mv\,dv$$

$$\int dW = m \int_u^v v \cdot dv$$

$$\int dW = \left[\frac{v^2}{2}\right]_u^v$$

$$W = m\left[\frac{v^2}{2} - \frac{u^2}{2}\right]$$

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

Soln $W = f \times s$

$W = M \times g \times s$

$W = 20 \times 10 \times 10$

$W = 2000\,J$

$P = \dfrac{W}{T}$ 40

$P = \dfrac{2000}{50}$

$P = 40$ watt.

* **Energy** :- The ability of doing work is called energy.

S.I unit of energy is Joule (J)

C.G.S unit of energy is erg

1 Joule = 10^7 erg.

Dimensional formula of energy is $[M^1L^2T^{-2}]$

Commercial unit of energy is KWh

$[1\,KWh = 3.6 \times 10^6\,J]$

Their are diff types of energy

1) Mechanical energy 2) Heat energy 3) Internal energy etc.

* **Types of Mechanical energy** :-

1) **Kinetic energy** :- Kinetic energy is the energy which comes in a body due to its motion.

Example: A running person have kinetic energy.

Formula of kinetic energy = $\frac{1}{2}mv^2$

* **Derivation** :-

Consider a body of mass 'm' in startin from rest. At instant of time 't' 'v' be the velocity.

'f' be the applied force and 'a' be the acc. produced.

Now, workdone is started in the form of energy

Energy = Workdone

$W = f \cdot s$

$W = ma \cdot s$ — i)

using eqn of motion

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

$v^2 - (0)^2 = 2as$ [u = 0]

$v^2 = 2as$

$a = \dfrac{v^2}{2s}$

Put the value in eqn i)

$W = m \times \dfrac{v^2}{2s} \times s$

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

Thus,

$$\boxed{K.E = \frac{1}{2}mv^2}$$

* **Relation b/w K.E and linear momentum** :-

Let a body of mass 'm' is moving with velocity 'v' p be the linear mom.

$p = mv$ — i)

The kinetic energy is given by

$K.E = \frac{1}{2}mv^2$ — ii)

always zero. Such that if body returns to initial position then work done by conservative force will be zero.

* Non- Conservative force ÷

A force is said to be non- Conservative if work done by this force depends on the path followed by body during motion. Ex- frictional force, Induction force, Work done by non- Conservative force for a closed path will not be zero.

* Power ÷

The rate of doing work is called power. $P = \frac{W}{T}$

as, $W = f \times s$

$P = \frac{f \times s}{t} = \boxed{P = \vec{F} \cdot \vec{v}}$

$= F. \frac{s}{t} = f.v$

S.I unit of power is watt (W)

$1W = 1J/s$

When 1 Joule of work is done in 1 second then power will be 1 watt.

Or

When 1J of energy consumed in 1 sec then power will be 1 watt

Commercial unit of power is horse power (hp)

[1 horse power = 746 watt]

1) How much time will it take to perform 220J of work at a rate of 10watt

Soln $P = \frac{W}{T}$

$\Rightarrow \frac{10}{220} = \text{Time}$

$\Rightarrow \frac{22\cancel{0}}{1\cancel{0}} = \text{Time}$

$\Rightarrow 22\,sec = \text{Time}$

2) A women does 200J of work in 20sec. and A man does 400J of work in 5 sec.

i) Who is working with more power.

ii) find the ratio of power of man to women

Soln $P_1 = \frac{W_1}{T_1} = P_1 = \frac{\cancel{200}^{10}}{\cancel{20}}$

$P_1 = 10\,watt$

$P_2 = \frac{W_2}{T_2} = P_2 = \frac{\cancel{400}^{80}}{\cancel{5}}$

$P_2 = 80\,watt$

i) Man is working with more power.

ii) Ratio of man to women $= \frac{8\cancel{0}}{1\cancel{0}} \Rightarrow 8:1$

3) A man carrying a block of mass 20kg climbs upto a height of 10m in 50sec.

1) find i) Work done by man on bag

2) Power delivered by man to the bag

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S_A and S_B are the distances of point A and B. Work done is moving a body from point $A(S_A)$ to point $B(S_B)$ under the action of Varying force.
If body is at P, where force is $\vec{F}$

$\vec{PQ} = \vec{ds}$

$dW = \vec{F}\cdot\vec{ds}$

where $\vec{ds} \to 0$ total work done is moving the body from A to B can be obtained by integrating them

$$W = \int_{S_A}^{S_B} \vec{F}\cdot\vec{ds}$$

i) A force of 15N displace an obj through 10cm and work done is 1.5 Joule find the angle b/w force and displac.

Soln
$W = FS\cos\theta$

$1.5 = 15 \times 0.1 \times \cos\theta$

$\cos\theta = 1$

$\cos\theta = \cos 0^\circ$

$\theta = 0^\circ$

2) A force f is equal to $\hat{i}+5\hat{j}+7\hat{k}$ displace a body through a distance $S = 6\hat{i}+9\hat{k}$ calculate Workdone.

Soln
$W = \vec{F}\cdot\vec{S}$

$= (\hat{i}+5\hat{j}+7\hat{k})(6\hat{i}+9\hat{k})$

$6+0+63$

$W = 69J$

3) A force $f = \hat{i}+5\hat{j}+7\hat{k}$ displace a body from (2,1,0) to (3,4,2) find work done.

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Soln
$\vec{S} = (3-2)\hat{i} + (4-1)\hat{j} + (2-0)\hat{k}$

$\hat{i} + 3\hat{j} + 2\hat{k}$

$\vec{F} = \hat{i} + 5\hat{j} + 7\hat{k}$

$W = \vec{F}\cdot\vec{S}$

$= (\hat{i}+5\hat{j}+7\hat{k})(\hat{i}+3\hat{j}+2\hat{k})$

$= 1+15+14$

$\vec{W} = 30J$

4) A ball of mass 1kg is thrown upward find the workdone by force of gravity if it reach height of 5m

Soln
$W = fS\cos 180^\circ$

$mg \times 5(-1)$

$= 1 \times 9.8 \times 5(-1)$

$W = -49J$

V. Good

Ayesha
22/7/23

* Conservative force :-

A force is said to be conservative if work done by it in moving a body depends only on initial and final position and not on the nature of path followed. For ex:- Gravitational force, Force in an elastic spring, Electrostatic force, Magnetic force.

* Properties :-

1) Work done by or against a conservative force depend only on initial and final position
2) Work done does not depends upon the nature of path followed.
3) Work done in moving over a round trip is

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i) A 5kg ball is thrown upward with a speed of $4ms^{-1}$
i) find its kinetic energy with which it was thrown
ii) find its potential energy when it reaches highest point
iii) Calculate the max. height it reaches.

Soln i) Mass of ball = 5kg
Speed of ball = $4ms^{-1}$

$K.E = \frac{1}{2}mv^2 \Rightarrow \frac{1}{2} \times 5 \times 16 = 40$ joule.

ii) Potential energy is also 40 joule

iii) $40 = mgh$

$40 = 5 \times 9.8 \times h$

$\frac{400}{5 \times 98} = h$

$\frac{80}{98} = h$

$h = \frac{40}{49}$

Q=2) A 10 kg ball is dropped from a height of 5m
1) find initial potential energy
2) kinetic energy of ball just before it reaches ground.
3) The speed of ball just before it hit ground.

Soln
i) Mass = 10kg Height = 5m

$P.E = mgh$

$\Rightarrow 10 \times 10 \times 5$

$\Rightarrow 500$ joule

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ii) P.E = K.E (where P.E is 500 joule)

iii) $500 = \frac{1}{2}mv^2$

$500 = \frac{1}{2} \times 10 \times v^2$

$100 = v^2$

$10ms^{-1} = v$

Q=3) A ball is dropped from a height it reaches ground with speed of 19.6m/s find height from where it was thrown.

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

$9.8 \times h = \frac{1}{2} \times \frac{196}{10} \times \frac{196}{10}$

$h = \frac{98 \times 19.6 \times 10}{10 \times 10 \times 98}$

$h = 19.6m$

Q=4) The spring const. of spring 250N/m find max. compr. of spring.

5kg → 15m/s

Soln
Potential energy = kinetic energy

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

$5 \times 15 = 250 \times x^2$

$\frac{15 \times 15}{250} \quad \frac{4.5}{10} = x^2$

$\sqrt{\frac{3}{10}} = x$

$[x = 0.25]$

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Ashish

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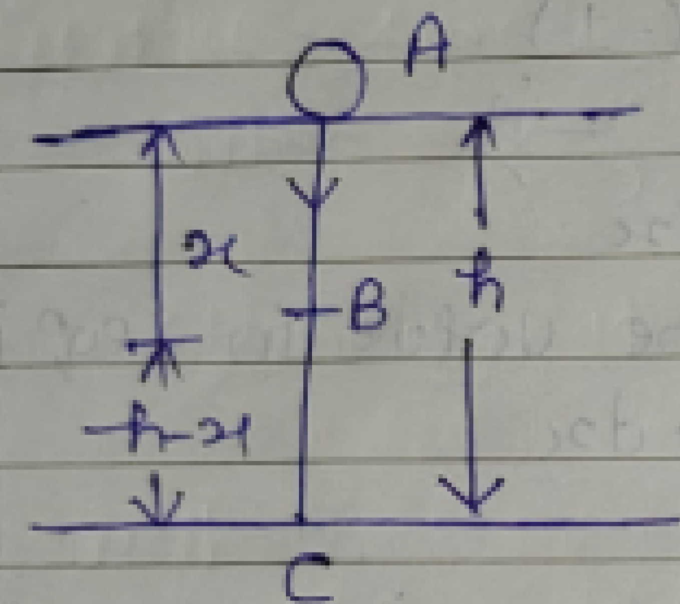
* Law of Conservation of Energy :

Acc. to this law energy can neither be created nor be destroyed but it can transfer from one form of ~~body~~ energy to another form of body. i.e total energy of a given system is always constant.

Proof :



Consider a body of mass 'm' is placed At point A up to a height h and now moving towards C

At point A

initial velocity $(u) = 0$

$K.E = \frac{1}{2}mu^2 = \frac{1}{2}m \times 0 = 0$

$P.E = mgh$

$T.E = mgh + 0$

$= mgh$

At point B

let 'v' be the velocity at point B

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

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

$a = g$

$S = x$

$u = 0$

$v^2 - (0)^2 = 2gx$

$v^2 = 2gx$

$K.E = \frac{1}{\cancel{2}}m \cdot \cancel{2}gx = mgx$

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$P.E = mg(h-x)$

$mgh - mgx$

$T.E = K.E + P.E$

$= \cancel{mgx} + mgh - \cancel{mgx}$

$= mgh$

At point C

v be the velocity

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

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

$v^2 - (0)^2 = 2gh$

$K.E = \frac{1}{\cancel{2}}m \cdot \cancel{2}gh = mgh$

$P.E = mg(0)$

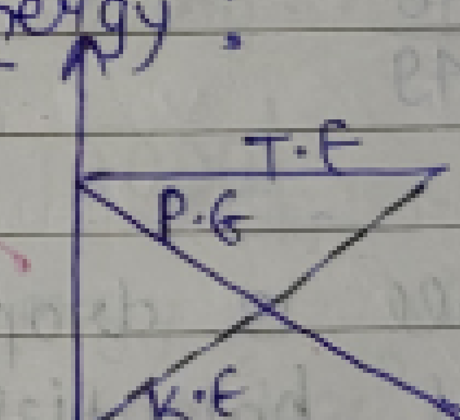
$= 0$

$T.E = K.E + P.E$

$= mgh + 0$

$= mgh$

Graph of total energy :



* Elastic potential energy:

It is the energy possessed by a body due to change in its configuration (shape).

* The force which takes back the spring to the original configuration after removal of appeid force is called restoring force.

Acc. to Hook's law:

Restoring force $\propto$ streching or compression.

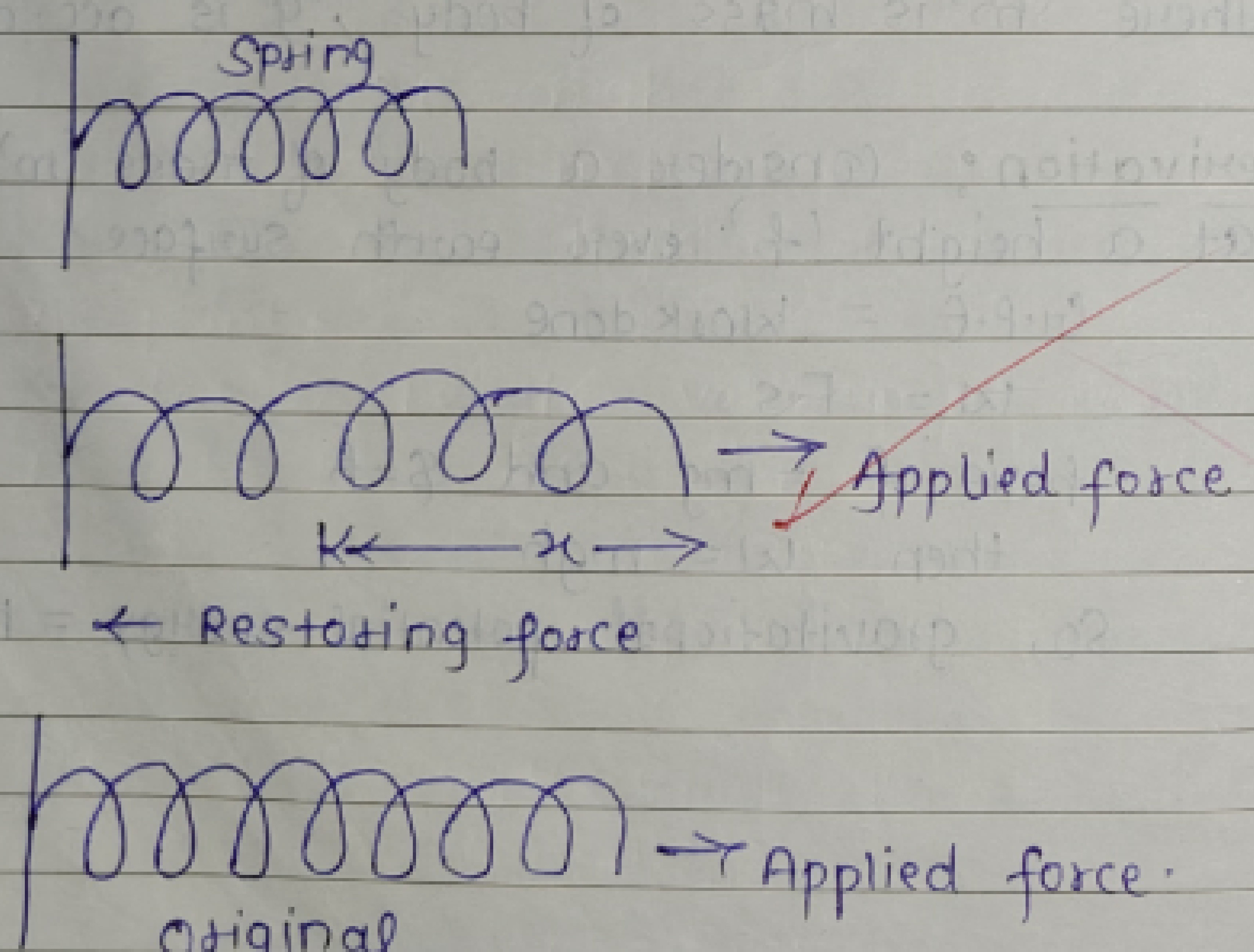
$F \propto x$

$F = -Kx$

Where 'k' is called spring constant

The direction of restoring force is opp. to the direction of streching or compression displace.

* Elastic potential energy of a spring:



Let a variable force applied on a spring then 'x' be the displ. of spring. Work will be done and stored in the form of elastic potential energy.

for small disp. 'dx', dw be small work

$dw = \vec{F} \cdot \vec{dx}$

$= F\,dx \cos 180°$

$= F\,dx(-1)$

$= -F\,dx$ —i)

as, $F = -Kx$

Put the value in eq^n i)

$dw = -(-Kx) \cdot dx$

$dw = Kx\,dx$

for total work done integrate both side

$W = \int dw = \int Kx\,dx$

$W = K \int x\,dx$

$W = K\left[\frac{x^2}{2}\right]$

$W = \frac{1}{2} Kx^2$

[So, elastic potential energy will be $= \frac{1}{2} Kx^2$]

Where K is Spring Constant.

* Mechanical energy:

It is equal to sum of kinetic and potential energy

$\boxed{M.E = K.E + P.E}$

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* Find the kinetic energy of a ball mass 20gm moving with a speed $10 cms^{-1}$

<u>Sol^n</u> $K.E = \frac{1}{2}mv^2$ $\qquad v = 0.1 ms^{-1}$

$\frac{1}{2} \times \frac{20}{1000} \times (0.1)^2$ $\qquad M = \frac{20}{1000} kg$

$= \frac{1}{100} \times \frac{0.01}{100}$

$= \frac{1}{10,000} = 0.0001$ Joule

2) A football player kicks a football of mass 200g with a speed $4ms^{-1}$. find work done

<u>Sol^n</u> $W.D = K.E = \frac{1}{2}mv^2$ $\qquad m = \frac{200}{1000}$

$= \frac{1}{2} \times \frac{200}{1000} \times 4 \times 4$ $\qquad v = 4ms^{-1}$

$= \frac{8}{5} \Rightarrow 1.6 J$

3) If linear mom. is increased by 20%. What will be % increase in K.E of body.

<u>Sol^n</u> $K.E = \frac{p^2}{2m}$ $\qquad$ Increase in mom. $= \frac{\text{final} - \text{initial}}{\text{initial}} \times 100$

$K.E = \frac{p_1^2}{2m}$ $\qquad 20 = \frac{p' - p}{p} \times 100$

$= \frac{\frac{p'^2 - p^2}{2m}}{\frac{p^2}{2m}} \times 100$ $\qquad \frac{1}{5} = \frac{p' - p}{p}$

$\frac{1}{5} = \frac{p'}{p} - \frac{p}{p}$

$\frac{1}{5} = \frac{p'}{p} - 1$

$= \frac{p'^2 - p^2}{p^2} \times 100$ $\qquad \Rightarrow \frac{p'}{p} = 6/5$

$= \frac{p'^2}{p^2} - \frac{p^2}{p^2} \times 100 \Rightarrow \frac{p'^2}{p} - 1 \times 100$

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$\left[\left(\frac{6}{5}\right)^2 - 1\right] \times 100$

$\frac{11}{25} \times 100 \Rightarrow 44\%$

* **Potential energy**: Potential energy of a body is defined as the energy possessed by the body by virtue of its position (height) or configur.
Potential energy is of 2 types
1) Gravitational p.E
2) Elastic P.E

1) Gravitational P.E → It is the energy possessed by the body due its positin above the surface of earth.

gravitational P.E = mgh

where 'm' is mass of body, 'g' is acc. due to grav

<u>Derivation</u>: Consider a body of mass 'm' is placed at a height 'h' over earth surface.

G.P.E = Work done

$W = F.S$

here $f = mg$ and $S = h$

then $W = mgh$

So, gravitational potential energy = mgh

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Case I When two bodies have equal masses

$m_1 = m_2 = m$

$v_1 = \frac{(m-m)u_1}{2m} + \frac{\cancel{2}m u_2}{\cancel{2}m}$

$\boxed{v_1 = u_2}$

$v_2 = \frac{(m-m)u_2}{2m} + \frac{\cancel{2m}u_1}{\cancel{2m}}$

$\boxed{v_2 = u_1}$

It means that when two bodies of equal masses under goes elastic collision, Their velocities are just interchange such that after collision first body moves with speed of 2nd body. and second body moves with speed of 1st body.

Case II i) When 2nd body is initially at rest

$-u_2 = 0$

$v_1 = \frac{(m_1-m_2)u_1}{m_1+m_2}$

$v_2 = \frac{2m_1u_1}{m_1+m_2}$

If both have same mass $m_1 = m_2 = m_3$

$v_1 = \frac{(m-m)u_1}{2m}$ | $v_2 = \frac{\cancel{2}mu}{\cancel{2}m}$

$\boxed{v_1 = 0}$ | $\boxed{v_2 = u_1}$

First body comes to rest and 2nd body stats moving with velocity of 1st body. This means 100%. Kinetic energy of 1st body transfer to 2nd body.

ii) When 2nd body is heavier then 1st body.

$m_2 \gg m_1$ m_1 will be neglected.

$v_1 = \frac{(0-m_2)u_1}{0+m_2} + \frac{2m_2u_2}{0+m_2}$

$= \frac{-\cancel{m_2}u_1}{\cancel{m_2}} + \frac{2\cancel{m_2}u_2}{\cancel{m_2}}$

$\boxed{v_1 = 2u_2 - u_1}$

as $u_2 = 0$

$v_1 = 2\times 0 - u_1$

$\boxed{v_1 = -u_1}$

$v_2 = 2\times 0\times u_1$

$\boxed{v_2 = 0}$

iii) If 1st body is heavier than 2nd body

$m_1 >> m_2$, m_2 will be neglected.

$v_1 = \frac{(m_1-0)u_1}{m_1+0}$

$v_1 = \frac{\cancel{m_1}u_1}{\cancel{m_1}}$

$\boxed{v_1 = u_1}$

$v_2 = \frac{2m_1u_1}{m_1+0} = \frac{2\cancel{m_1}u_1}{\cancel{m_1}} = 2u_1$

$\boxed{v_2 = 2u_1}$

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Let v_1 and v_2 be the final velocity of each particle respectively

Momentum before collision $\rightarrow m_1v_1 + m_2v_2$

" after " $\rightarrow m_1v_1 + m_2v_2$

Put these value in eq^n i)

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 \quad \text{— ii)}$$

$$m_1(u_1 - v_1) = m_2(v_2 - u_2) \quad \text{— iii)}$$

Acc. to law of conservation of energy

K.E before collision = K.E after collision

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

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

$$m_1u_1^2 - m_1v_1^2 = m_2v_2^2 - m_2u_2^2$$

$$m_1(u_1 - v_1^2) = m_2(v_2^2 - u_2^2) \quad \text{— iv)}$$

Now divide eq^n iv) by iii)

$$\frac{\cancel{m_1}(u_1^2 - v_1^2)}{\cancel{m_1}(u_1 - v_1)} = \frac{\cancel{m_2}(v_2^2 - u_2^2)}{\cancel{m_2}(v_2 - u_2)}$$

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

$$u_1 + v_1 = u_2 + v_2$$

$\Rightarrow \boxed{u_1 - u_2 = v_2 - v_1}$ for elastic collision

Coff. of restitution (e)

$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

using eq^n

$\boxed{e = 1}$

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* as $v_2 - v_1 = u_1 - u_2$

We have to find v_1 and v_2

$$v_2 = u_1 - u_2 + v_1 \quad \text{— (vi)}$$

Put this value in eq^n ii)

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2(u_1 - u_2 + v_1)$$

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2u_1 - m_2u_2 + m_2v_1$$

$$m_1u_1 + m_2u_2 - m_2u_1 = m_1v_1 + m_2v_1$$

$$u_1(m_1 - m_2) + 2m_2u_2 = v_1(m_1 + m_2)$$

$$v_1 = \frac{u_1(m_1 - m_2) + 2m_2u_2}{m_1 + m_2}$$

$$v_1 = \frac{u_1(m_1 - m_2)}{m_1 + m_2} + \frac{2m_2u_2}{m_1 + m_2}$$

Put this value in eq^n (vi)

$$v_2 = u_1 - u_2 + \frac{u_1(m_1 - m_2) + 2m_2u_2}{m_1 + m_2}$$

$$= \frac{u_1(m_1 + m_2) - u_2(m_1 + m_2) + u_1(m_1 - m_2) + 2m_2u_2}{m_1 + m_2}$$

$$= \frac{m_1u_1 + m_2u_2 - m_1u_1 - m_2u_2 + m_1u_1 - m_2u_1 + 2m_2u_2}{m_1 + m_2}$$

$$v_2 = \frac{2m_1u_1 + m_2u_2 - m_1u_2}{m_1 + m_2}$$

$$v_2 = \frac{2m_1u_1 + u_2(m_2 - m_1)}{m_1 + m_2}$$

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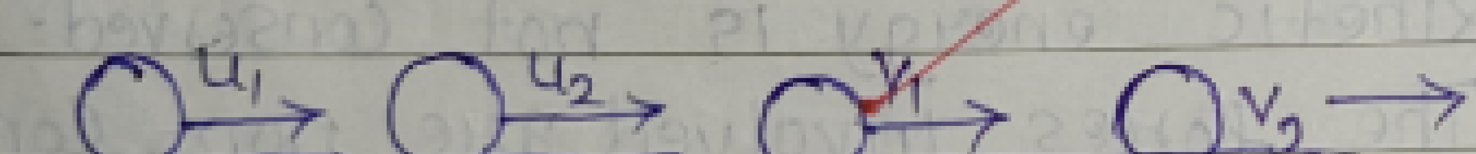
* **Perfectly Inelastic collision:**
A collision in which relative velocity after collision becomes zero is called perfectly inelastic collision.
Relative velocity means velocity of one body w.r.t other body. Relative velocity after collision become zero means after collision both bodies must be in rest w.r.t each other. This is possible in two cases
i) If after collision velocity of both objects become zero.
ii) If after collision both obj move with same velocity joined with each other.

* **Cofficient of Restitution:**
It is the ratio of velocity of sepration after collision to the relative velocity of approach before collision
It is denoted by e.

$$e = \frac{\text{Relative velocity of Sepration after collision}}{\text{Relative velocity of approach before collision}}$$



consider two bodies moving initially moving with velocity u_1 and u_2 respectively. Here $u_1 > u_2$ Thus collision takes place
v_1 and v_2 be the final velocity of bodies after collision
After collision $v_2 > v_1$ because 1st body strikes with 2nd
Now, relative velocity of sepration $= v_2 - v_1$
Relative velocity of approach $= u_1 - u_2$

$$\left[e = \frac{v_2 - v_1}{u_1 - u_2} \right]$$

For elastic collision:

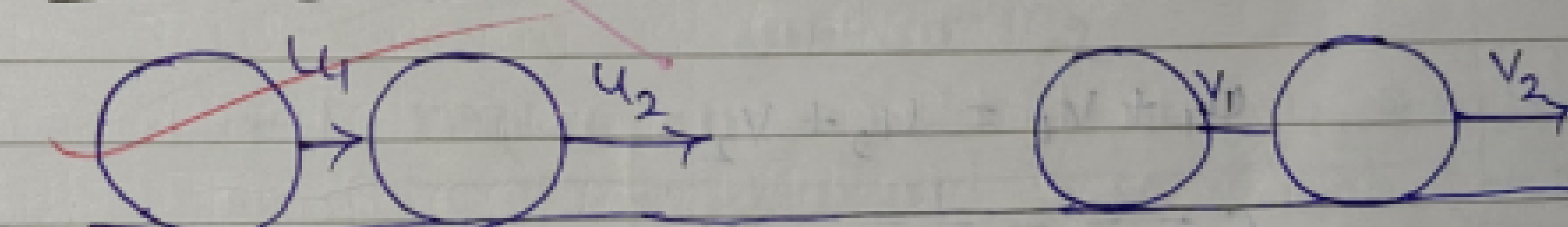
Relative velocity of sepration = Relative velocity of Approach

$$v_2 - v_1 = u_1 - u_2$$
$$\boxed{e = 1} = \text{max}$$

For perfectly inelastic collision:

Relative velocity of Sepration = 0
$$v_2 - v_1 = 0$$
$$e = 0 \quad \text{min.}$$
Thus, $\boxed{0 < e < 1}$ for other collision.

* **Elastic collision in one dimension:**



consider two bodies of mass m_1 and m_2 having initial velocity u_1 and u_2 strike with each other.
Here $u_1 > u_2$
Acc. to conservation of linear mom.
Mom. before collision = Mom. after collision

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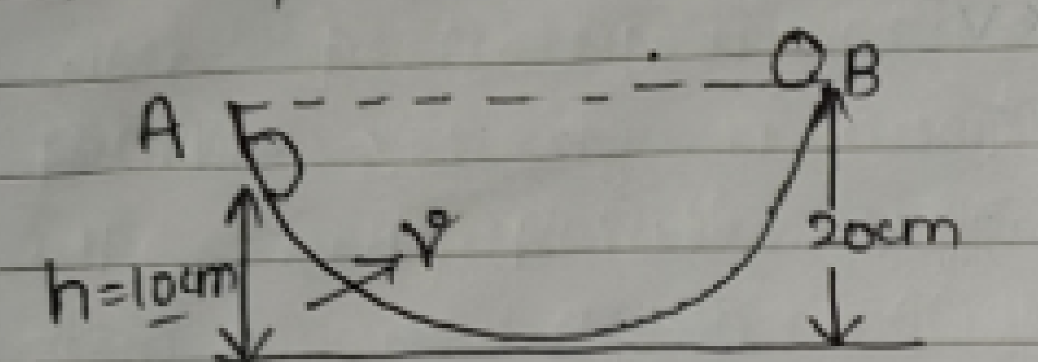
Q=5) A frictionless hemispherical bowl of radii 20cm A ball pushed from point A Reaches to B find the speed with which the ball was pushed.



At point A

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

$P.E = mgh$

$T.E = \frac{1}{2}mv^2 + mgh$

At B

$K.E = 0$

$P.E = mgh$

$T.E = mgh$

Energy At A = Energy At B

$\cancel{m}\left[\frac{1}{2}v^2 + gh\right] = \cancel{m}gh$

$\frac{1}{2}\cancel{m}v^2 + gh = 10 \times 20$

$\frac{1}{\cancel{2}} \times \cancel{10}^{5} \times 10 + 10 \times \frac{0.1}{\cancel{10}} = 10 \times \frac{0.2}{1}m$

$\frac{1}{2}v^2 \cancel{50} + 1 = 2$

$v^2 = 2$

$v = \sqrt{2}$

$= 1.414 ms^{-1}$

Q=6) A car of mass 1000kg moving speed 18km/h on a smooth speed and colided with spring of spring constant 6.25×10^3 N/m find max.

Soln

$K.E = P.E$

$\frac{1}{\cancel{2}}\cancel{m}v^2 = \cancel{mgh}\frac{1}{\cancel{2}}Kx^2$

$\frac{\cancel{100}}{\cancel{2}} 18 \times 18 = 6.25 \times 10^3 \times x^3$

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* **Collision:** collision is an event in which two or more coliding exert relatively strong force on each other for a short time.

Law of conservation of linear mom. and law of conservation of energy are followed in collision.

* Types of collision:

1) Elastic collision: A collision in which there is no loss of kinetic energy is called a elastic collision.

a) linear mom. is conserved.
b) Total energy is conserved.
c) The kinetic energy is conserved.
d) The force must be conservative force.

2) Inelastic collision: The collision in which their occurs some loss of kinetic energy is called inelastic collision.

a) Linear mom. is conserved.
b) Total energy is conserved.
c) Kinetic energy is not conserved.
d) The forces involved are non-conservative forces.

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* It is a device which is used to measure the speed of a fast moving obj such as bullet fired from gun.

Consider a bullet of mass 'm' moving with a velocity 'ϑ' and strike with a block of mass 'M'.

let, after striking bullet and block moves with a velocity 'v'.

Acc. to the conservation of linear mom.

Mom. before collision = Mom. after collision

$m\vartheta = (M+m)v$

$\vartheta = \frac{(M+m)v}{m}$ — i)

As, kinetic of system $= \frac{1}{2}(M+m)v^2$

P.E of system $= (M+m)gh$

Acc. to conservation of energy

K.E = P.E

$\frac{1}{2}\cancel{(M+m)}v^2 = \cancel{(M+m)}gh$

$v^2 = 2gh$

$v = \sqrt{2gh}$

Put this in eq^n i)

$\boxed{\vartheta = \frac{(M+m)}{m} \times \sqrt{2gh}}$

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i) Two balls of mass 1kg and 2kg are moving with velocities of 3m/s and 2m/s respect on horizontal surface if collision b/w them is perfectly inelastic

1) find common velocity after collision
2) find loss of K.E

Soln $V = \frac{m_1u_1 + m_2u_2}{m_1+m_2}$

$V = \frac{1\times3 + 2\times2}{1+2} = \frac{3+4}{3} \Rightarrow \frac{7}{3}$

loss of K.E $= \frac{m_1m_2(u_1-u_2)^2}{2(m_1+m_2)}$

$\Rightarrow \frac{1\times2(3-2)^2}{2(1+2)} \Rightarrow \frac{\cancel{2}\times(9+4-2\times3\times(-2))}{2(3)}$

$\Rightarrow \frac{2(1)^2}{6} \Rightarrow \frac{1}{3} = 0.33\ J$

$\Rightarrow \cancel{\frac{2(3+2)}{6}}$

$\Rightarrow \cancel{\frac{50}{6}} \Rightarrow \frac{25}{3}$

2) find the angle b/w force $\vec{f} = 3\hat{i}+4\hat{j}-5\hat{k}$ and displace $\vec{d} = 5\hat{i}+4\hat{j}+3\hat{k}$. find the projec. of f on d.

Soln $\vec{F}\cdot\vec{d} = fd\cos\theta$

Magnitude $= \sqrt{(\text{Coff of }\hat{i})^2 + (\text{Coff of }\hat{j})^2 + (\text{Coff of }\hat{k})^2}$

$\Rightarrow \sqrt{9+16+25}$

$\Rightarrow \sqrt{50} \Rightarrow 5\sqrt{2}$

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Now in elastic collision both momentum and kinetic energy are conserve.

Now mom. along x-axis – let $u_2 = 0$

Mom. before collision $= m_1u_1 + m_2u_2$

$$m_1u_1 + m_2(0)$$
$$= m_1u_1 \quad \text{—(i)}$$

Mom. after collision $= m_1v_1\cos\theta + m_2v_2\cos\phi$ —(ii)

Now mom. along y-axis

Mom. before collision $= m_1(0) + m_2(0) = 0$

Mom. after collision $= m_1v_1\sin\theta + m_2v_2\sin\phi$

$$= m_1v_1\sin\theta + (-m_2v_2\sin\phi)$$

[along -ve y-axis]

Acc. to conservation of linear momentum

Mom. before collision along x-axis = Mom. after collision along x-axis

$$m_1u_1 = m_1v_1\cos\theta + m_2v_2\cos\phi \quad \text{—iii)}$$

Mom. before collision along y-axis = Mom. after collision along y-axis

$$0 = m_1v_1\sin\theta - m_2v_2\sin\phi \quad \text{– iv)}$$

Acc. to conservation of kinetic energy

K.E before collision = K.E after collision

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

(along x-axis)

as $u_2 = 0$

$$\frac{1}{2}m_1u_1^2 = \frac{1}{2}m_1v_1^2\cos^2\theta + \frac{1}{2}m_2v_2^2\cos^2\phi \quad \text{– v)}$$

Along y-axis

$$0 = \frac{1}{2}m_1v_1^2\sin^2\theta + \frac{1}{2}m_2v_2^2\sin^2\phi \rightarrow \text{vi)}$$

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When two particles of same mass undergo perfectly elastic collision in 2-D i.e $m_1 = m_2$

let us take $u_1 = u$ and $u_2 = 0$

$$v_1^2 + v_2^2 = u_1^2$$
$$v_1\cos\theta + v_2\cos\phi = u \quad \text{— vii)}$$
$$v_1\sin\theta - v_2\sin\phi = 0 \quad \text{— viii)}$$

using vii) and viii) we get

$$v_1^2 + v_2^2 = (v_1\cos\theta + v_2\cos\phi)^2 = v_1^2\cos^2\theta + v_2^2\cos^2\phi + 2v_1v_2\cos\theta\cos\phi$$
$$v_1^2(1-\cos^2\theta) + v_2^2(1-\cos^2\phi) = 2v_1v_2\cos\theta\cos\phi$$
$$v_1^2\sin^2\theta + v_2^2\sin^2\phi = 2v_1v_2\cos\theta\cos\phi \quad \text{— ix)}$$
$$v_2\sin\phi = v_1\sin\theta \quad \text{— from viii)}$$

put in ix)
$$2v_1^2\sin^2\theta = 2v_1v_2\cos\theta\cos\phi$$
$$\cos\theta = \frac{\cancel{2}v_1^{\cancel{2}}\sin^2\theta}{\cancel{2v_1}v_2\cos\phi} = \left(\frac{v_1}{v_2}\right)\frac{\sin^2\theta}{\cos\phi} \quad \text{— x)}$$

Now,

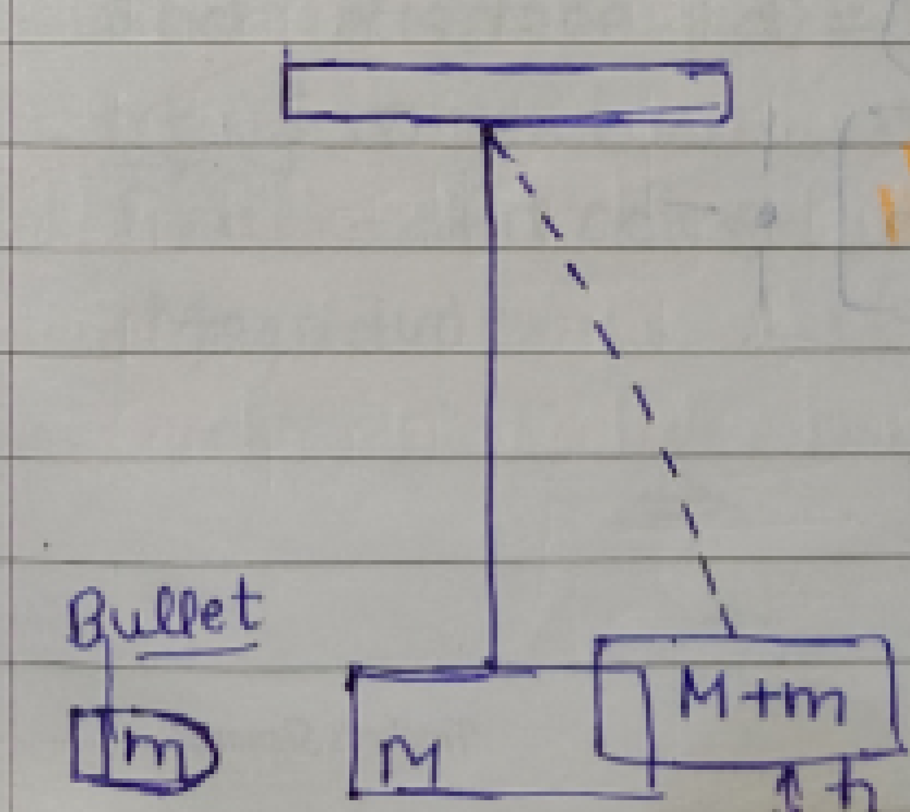
$$\cos(\theta+\phi) = \cos\theta\cos\phi - \sin\theta\sin\phi$$

Using eqⁿ x) and viii)

$$\cos(\theta+\phi) = \frac{v_1\sin^2\theta}{v_2\cos\phi}\cos\phi - \frac{v_1}{v_2}\sin^2\theta = 0$$

$$\phi + \theta = 90^\circ$$

* **Ballistic pendulum :**



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* Perfectly inelastic collision in one dimension :

SHIVA PUB.SR.SEC.SCHOOL,DAHINA

Sub – Physics   Class – 11th   M.M=70

Time : 3:00 Hrs.   Annual Exam .2024 Set - A

Q.1 The S.I unit of force is :
(a) kg- m (b) m/s² (c) Newton (d) Dyne

Q.2 The magnitude of the vector A =2i +3j+4k is :
(a) $\sqrt{30}$ (b) $\sqrt{29}$ (c) $\sqrt{50}$ (d) $\sqrt{28}$

Q.3 A particle completes one revolution of a circular track of radius 'r' then the displacement cover by the particle is :
(a) $2\pi r$ (b) Zero (c) $\frac{\pi r}{2}$ (d) πr

Q.4 Which has no dimensional formula –
(a) strain (b) Angle (c) Relative density (d) All

Q.5 The time – taken by on object in a projectile motion with Initial velocity 'u' is :
(a) $T = \frac{2u\sin\theta}{g}$ (b) $T = \frac{u^2\sin 2\theta}{2g}$ (C) $T = \frac{u^2\sin 2\theta}{g}$ (d) None

Q.6 The strong force for a very short – time period is –
(a) Momentum (b) Impulse (c) Pressure (d) Strain

Q.7 The energy stored in a stretched bow is :
(a) K.E. (b) P.E . (C) Chemical (d) Wind

Q.8 The value of acc. Due to gravity (I) on the centre of the earth is :
(a) 9.8m/s² (b) zero (c) decrease (d) increase

Q.9 Hyduralic brakes on the Principle of :
(a) Archemedies Principle (b) Pascal Law
(c) Surface tevsion (d) None

Q.10 Flying of an aeroplane works on the Principle of :
(a) Newton 3rd law (b) Bemoullie-s theorem
(c) Surface Teusion (d) None

Q.11 Derive the formula F= ma by using $F = \frac{DP}{Dt}$? (2)
Q.12 Convert 1 newton into dyne ? (2)
Q.13 Explain inertia of Rest with Suitable example ? (2)
Q.14 Derive the formula for P.E = mgh ? (2)
Q.15 Define collision and its type? (2)
Q.16 What is second pendulum and find its length ? (2)
Q.17 What is 1st law of thermodynamics ? (2)
Q.18 If the force between the two object is f. when the distance Between them is made twice and mass of each becomes Half two calculate the new force between them ? (2)

$$-\frac{1}{2}m_1u_1 + \frac{1}{2}m_2u_2 - \frac{1}{2}\frac{(m_1+m_2)(m_1u_1+m_2u_2)^2}{(m_1+m_2)^2}$$

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}\frac{(m_1u_1+m_2u_2)^2}{(m_1+m_2)}$$

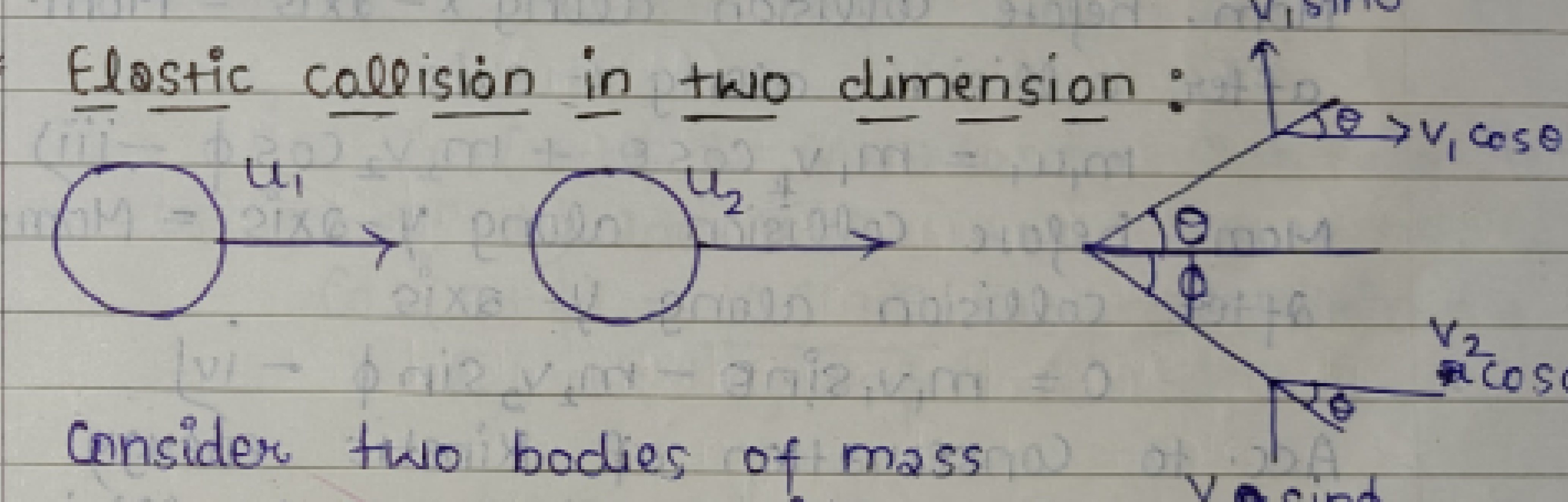
$$\frac{\cancel{m_1^2u_1^2} + m_1m_2u_1^2 + m_1m_2u^2 + \cancel{m_2^2u_2^2} - \cancel{m_1^2u_1^2} - \cancel{m_2^2u_2^2} - 2m_1m_2u_1u_2}{2(m_1+m_2)}$$

$$\Rightarrow \frac{m_1m_2(u_1^2+u_2^2) - 2m_1m_2u_1u_2}{2(m_1+m_2)}$$

$$\Rightarrow \text{loss in K.E} = \frac{m_1m_2\left[u_1^2+u_2^2-2u_1u_2\right]}{2(m_1+m_2)}$$

$$\Rightarrow \boxed{\text{loss in K.E} = \frac{m_1m_2(u_1-u_2)^2}{2(m_1+m_2)}}$$

* Elastic collision in two dimension :

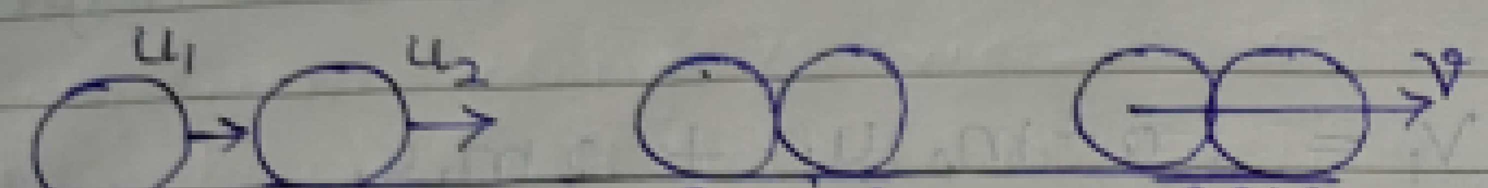


Consider two bodies of mass m_1 and m_2 moving with velocity u_1 and u_2 respect. $u_1 > u_2$ then bodies collide with each other. After collision both move in diff. direction with velocities v_1 and v_2 respect. let θ and φ be the angle made by 1st body and 2nd body with axis of motion.

Now, v_1 and v_2 spilt into two rectangular components

$v_1 \longrightarrow v_1\cos\theta$, $v_1\sin\theta$ and $v_2 \longrightarrow v_2\cos\phi$, $v_2\sin\phi$

* Perfectly inelastic collision in one dimension :



Consider two bodies of mass m_1 and m_2 moving with velocity u_1 and u_2 respec. $u_1 > u_2$ then after collision both moves with a velocity (v)

Then acc. to Conservation of momentum :

Mom. before collision = Mom. after collision

$m_1u_1 + m_2u_2 = (m_1+m_2)v$ — i)

K.E before collision = $\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$

K.E energy after collision = $\frac{1}{2}(m_1+m_2)v^2$ —ii)

Some loss of K.E take place during perfectly inelastic collision.

loss in K.E = K.E before collision − K.E after collision

$\Rightarrow \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1+m_2)v^2$

using eqn 1st

loss in K.E $= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1+m_2)\left[\frac{m_1u_1+m_2u_2}{m_1+m_2}\right]^2$

$= \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}\frac{\cancel{(m_1+m_2)}(m_1u_1+m_2u_2)^2}{(m_1+m_2)^{\cancel{2}}}$

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$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}\frac{(m_1u_1+m_2u_2)^2}{(m_1+m_2)}$

$-m_1^2u_1^2 - m_2^2u_2^2 - 2m_1m_2u_1u_2$

Q.19 What is a vector quantity ? Find the unit vector of the vector $A = \hat{i}+2\hat{j}+3\hat{k}$? (2)

Q.20 What is surface tension and its unit ? (2)

Q.21 Derive the formula for centre of mass of two particle system ? (2)

Q.22 If two vectors $\vec{A}$ and $\vec{B}$ are represented by the two sides of a triangle and the third side represent the Resultant, Then find the formula for the resultant of two vectors ? (3)

Q.23 What is coefficient of friction ? (3)

Q.24 What is simple harmonic motion and derive the force law for SHM ? (3)

Q.25 What is modulus of elasticity and explain Young-s modulus of elasticity ? (3)

Q.26 What are degree of freedom and calculate the degree of freedom for triatomic gas for linear and Non – linear case ? (3)

Q.27 What is adiabatic expansion and find the work done for adiabatic expression ? (3)

Q.28 Show that the Harmonic wave function $Y(x,t) = \text{It} \sin\left(\frac{2\pi}{v}(vt\text{-}x)+\phi\right)$ is periodic in 'x' ? (3)

Q.29 Derive the Avogadro's law i.e $n_1 = n_2$ from the kinetic theory of gas ? (3)

Q.30 What is pressure and its application ? (3)

Q.31 What is simple pendulum and derive the formula for its time - period of oscillation by using simple – harmonic oscillation ?(5)

OR

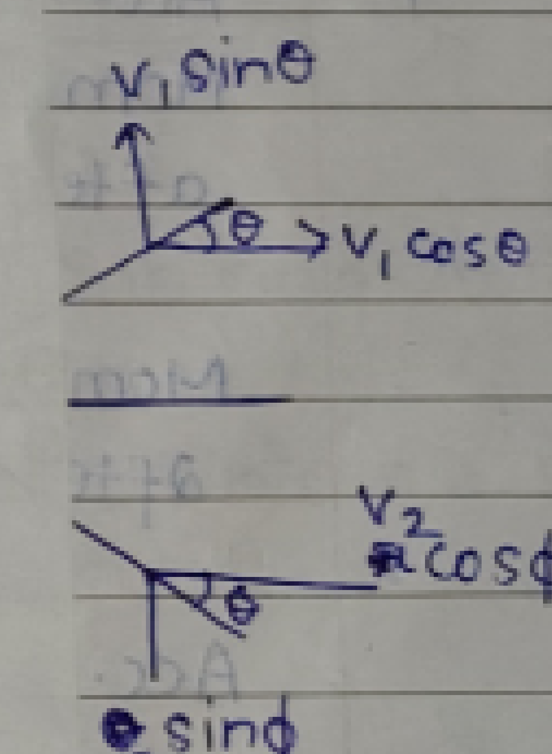
Calculate the time period of flight , Maximum height , Horizontal range for a projectile projected at an angle 'θ' with the x –axis ?

Q.33 State and prove Bernoulli's theorem and its application ? (5)

OR

(a)Derive the formula for the effect of height on the gravity of earth ? (3)

(b)Define Pascal Law and write its application? (2)



ies collide with
ve in diff.
respect
by 1st body
rectangular

components

$v_1 \longrightarrow v_1\cos\theta$, $v_1\sin\theta$ and $v_2 \longrightarrow v_2\cos\phi$, $v_2\sin\phi$

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$\vec{W} = \vec{f} \cdot \vec{S}$

$\vec{F} \cdot \vec{d} = 3\hat{i} + 4\hat{j} - 5\hat{k} \; (5\hat{j} + 4\hat{j} + 3\hat{k})$

$15\hat{i} + 16\hat{j} - 15k$

$16\hat{j} = 16$

$\vec{F} \cdot \vec{d} = fs \cos\theta$

$16 = 5\sqrt{2} \times 5\sqrt{2} \cos\theta$

$16 = 25 \times 2 \cos\theta$

$8 \; \frac{\cancel{16}}{\cancel{50}_{25}} = \cos\theta$

$\frac{8}{25} = \cos\theta$

3) A cyclist comes to a skitting stop up 10m during this process the force on the cycle due to the road is 200N.

1) How much work does the road do on cycle
2) How much work does cycle do on the road.

Soln $W = fs \cos 180°$

$W_{cg} = 200 \times 10 \; (-1)$ $\qquad \cos 180° = (-1)$

$W_{cg} = -2000J$

Work done cycle on road $= 2000$ joule

4) A bullet of mass 0.3kg falls from the celling of an elevator moving down with uniform speed of 7m/s. It hits the floor of the elevator (length of elevator = 3m) and does not rebound. What is the heat produced.

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Soln P.E of bullet $= mgh$

$= 0.3 \times 10 \times 3$

$= 9$ Joule.

5) $F = -\hat{i} + 2\hat{j} + 3\hat{k}$ Newton
$S = 4\hat{k}$ What is net work done

Soln $W = f \times s$

$W = -\hat{i} + 2\hat{j} + 3\hat{k} \; (4\hat{k})$

$= (0 \times \hat{i}) + 2\hat{j} \times 0 + 12\hat{k}$

$\Rightarrow 0 + 0 + 12\hat{k}(1)$

$W = 12$ joule

$kgm s^{-2}$

Good

Ayadan 12/8/23

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