Ch-6

Work Power and Energy

$\boxed{W = \vec{f} \cdot \vec{s}}$

1

Q1: If $\vec{f} = 2\hat{i} + 3\hat{j} + 4\hat{k}$ & $\vec{S} = 1\hat{i} + 2\hat{j} + 3\hat{k}$

find the workdone.

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

$W = (2\hat{i} + 3\hat{j} + 4\hat{k})(1\hat{i} + 2\hat{j} + 3\hat{k})$

$W = 2\times1 + 3\times2 + 4\times3$

$W = 2 + 6 + 12 = 20\ J$ Ans

Dimensional work → $W = f\,s$

$W = [MLT^{-2}] \times [L]$

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

Absolute units

① $W = f \cdot s$

Joule: $1J = 1N \times$ ~~1m~~ ⇒ $\boxed{1J = N.m}$

② $W = f \cdot s$

erg: ~~dyne~~ =

$\boxed{erg = dyne \times cm}$

$\boxed{1J = 10^7\ erg}$

$\boxed{1N = 10^5\ dyne}$

Gravitational unit

(1) $W = f \cdot s$

$$\boxed{1\,kgm = 1\,kgf \times 1\,m}$$

$$\boxed{1\,kgm = 9.8\,N \times 1\,m = 9.8\,J}$$

[$\because 1\,J = N \times m$]

$1\,Kgm = 1\,Kg \times 1\,m$
$= 9.8\,N \times 1\,m$
$= 9.8\,J$

(2) $W = f \times s$

$1\,g\,cm = 1\,gf \times 1\,cm$

$$\boxed{1\,g\,cm = 980\,dyne \times 1\,cm}$$

$1\,g\,cm = 1\,dyne \times 1\,cm$
$= 980\,dyne \times 1\,cm$

Note: (1) $1\,kgf = 9.8\,N$
(2) $1\,gf = 980\,dyne$

Relation B/w (kgm) & (gcm)

$1\,kgm = 10^3\,g \times 10^2\,cm$

Nature of work done

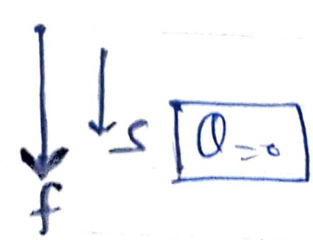
(1) Positive work:

→ $W = \vec{f} \cdot \vec{s}$

$$\boxed{W = fs\cos\theta}$$

$\theta = 0$, $\cos 0 = 1$,
work done is positive

Ex: When a Body fall under gravity
$\theta = 0$, $\cos 0 = 1$



② Negative work

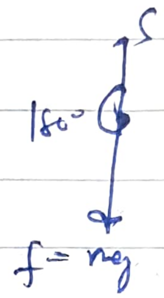
$W = \vec{f}\cdot\vec{s} = f\cdot s\cos\theta$,

$\theta = 180°$,

$\cos 180° = -1$.

$\boxed{W = -fs}$

Ex: when a Body is thrown up motion is opposed by gravity



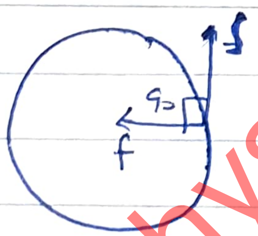
③ Zero work done

$\boxed{W = fs\cos\theta}$

$\cos\theta = 0$

$\theta = 90$

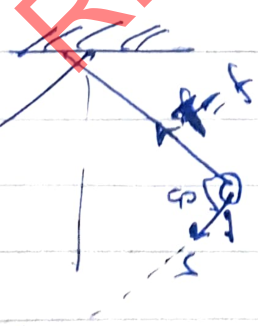
C-1



When a Body move in circle path work done by centripetal force is zero

$\theta = 90$, $\boxed{W = fs\cos 90 = fs\times 0 = 0}$

C-2



work done By Tension

$W = fs\cos 90$

$W = fs\times 0$

$\boxed{W = 0}$

Q. A force, $f = (10 + 0.50x)$, acts on a particle in x direction, where (f) in force, x in distance.
Find the work done during displacement $x = 0$ to $x = 2$?

A.

$$w = f\,s$$

$$dw = f \cdot ds \qquad [\because s = x]$$

$$\boxed{dw = f \cdot dx}$$

$$\rightarrow \int dw = \int_{x=0}^{x=2} (10 + 0.50x)\,dx$$

$$\rightarrow w = \int_0^2 10\,dx + \int_0^2 0.50x\,dx$$

$$\rightarrow w = 10\,[x]_0^2 + 0.50\left[\frac{x^2}{2}\right]_0^2$$

$$w = 10[2 - 0] + \frac{0.50}{2}(2^2 - 0^2)$$

$$w = 10 \times 2 + \frac{50}{200} \times 4 = 20 + 1.$$

$$\boxed{w = 21\,J}$$

3

Power → time rate at which work is done by it

$P \rightarrow W = \frac{W}{t}$

$P = \frac{W}{t} \rightarrow \boxed{P = \frac{W}{t}}$

$P = \frac{F \cdot S}{t} = F \cdot \left[\frac{S}{t}\right]$

$\boxed{P = \vec{F} \cdot \vec{V}}$ K

Dimention → $P = [MLT^{-2}][LT^{-1}]$

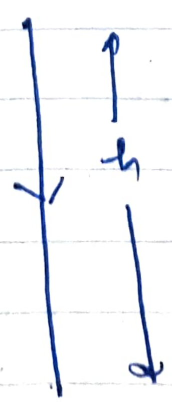
$\boxed{P = [ML^2T^{-3}]}$ K

→ $\boxed{1 \text{ h.p} = 746 \text{ watt}}$

Conservative force & Non Conservative force

* Conservative force: A force is conservative force which depend upon initial & final point & But not depend upon Nature of Path.

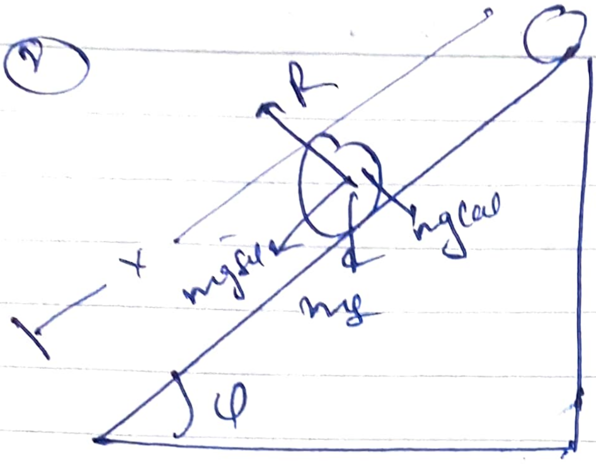
C-1



$W = F \cdot S$ → distance

→ $\boxed{W = mg \times h}$

(2)



$w = f \cdot s$

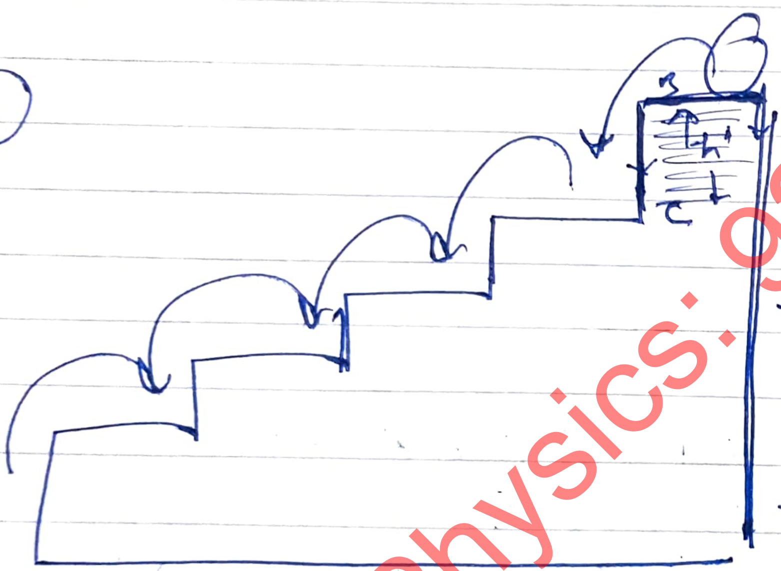
$\rightarrow w = mg\sin\theta \times x$

$\sin\theta = \frac{h}{x}$

$\boxed{h = x\sin\theta}$

$\boxed{w = m \times g \times h}$

(3)



Let there in n' step

$W_T = n \times w$

$\rightarrow w =$ workdone by Ball to covered one step

$\rightarrow \boxed{w = w_{AB} + w_{BC}}$

$w = f \cdot S_{AB}\cos\theta + f \cdot S_{BC}\cos\theta$

$\theta = 90 \qquad \theta = 0$

$w = f S_{AB} \times \cos 90 + f \times h' \times \cos 0 = 0 + fh'$

$w = 0 + mgh'$

$W_T = n \times w = n \times mgh' = mg(nh')$

$\boxed{W_T = mgh}$

Non Conservative force

- The force which depend upon Nature of Path. But not depend upon initial & final Point.

ex frictional force

Kinetic energy: of a Body is energy possessed By body by virtue of its motion

Let 'dw' is small work done
Let 'ds' is small distance

$dw = f \cdot ds$ → small dist

$\Rightarrow dw = ma\,ds$ $[\because f = ma]$

$\rightarrow dw = m\frac{dv}{dt} \times ds$ $\left[a = \frac{dv}{dt}\right]$

$dw = m\left[\frac{ds}{dt}\right]dv$ $\left[v = \frac{ds}{dt}\right]$

$dw = m\,v\,dv$

Integrate Both side

$\rightarrow \int dw = \int_0^v m\,v\,dv$

$\rightarrow$

$w = m\int_0^v v\,dv = m\left[\frac{v^2}{2}\right]_0^v$

$w = m\left[\frac{v^2}{2} - \frac{0^2}{2}\right] = \frac{mv^2}{2} \rightarrow \boxed{KE = w = \frac{mv^2}{2}}$

Relation Between KE & Linear Momentum (P) (K.E)

$\rightarrow KE = \frac{1}{2}mv^2$, $\boxed{P = mv}$

$\rightarrow KE = \frac{1}{2}mv^2 = \frac{1}{2}mv^2 \times \frac{m}{m}$

$\rightarrow KE = \frac{1 m^2 v^2}{2m} = \frac{1}{2}\frac{P^2}{m}$

$\rightarrow 2m \times KE = P^2$

$\rightarrow \boxed{P = \sqrt{2 \times m \times KE}}$ A

Work energy Theorem

work done By net force in displacing a body is equal to change in KE $\boxed{W = \Delta KE = KE_f - KE_i}$

A

$dw = f \cdot ds$

$dw = ma\,ds$

$dw = m\frac{dv}{dt} \times ds$

$dw = m\left(\frac{ds}{dt}\right)dv$

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

$w = m\left[\frac{v^2}{2}\right]_u^v$

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

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

$\boxed{W = KE_f - KE_i}$

A

Potential energy of a body is energy possessed by a body by virtue of its position or configuration in some field

E = Potential energy

h

gravitational Potential energy of a body is energy possessed by body by virtue of its position above of surface

h

$W = \text{energy} = \text{force} \times \text{distance}$

$W = fd$

$\boxed{W = mg \times h = \text{energy}}$

Note.

$\boxed{f = -\frac{dV}{dh}}$

gravitational
V → Potential

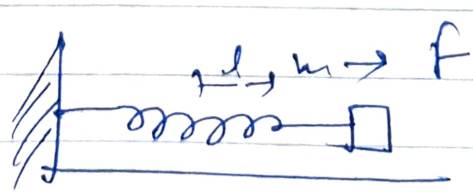
PE ⇒ gravitational Potential energy

Spring

Hook's Law

$f \propto x$

$\boxed{f = -kx}$



'x' is path covered

f is force applied

k → spring constant

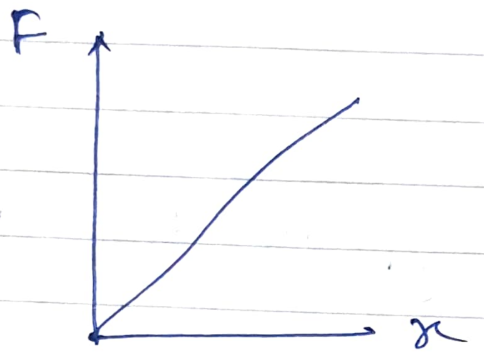
$\boxed{f = -kx}$

Hook's law, It will come back to original position

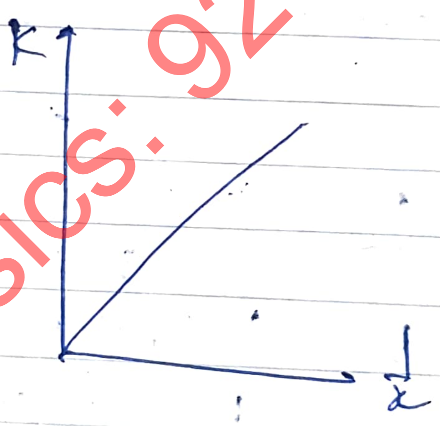
Restoring force → The force by which a Body regain its original position

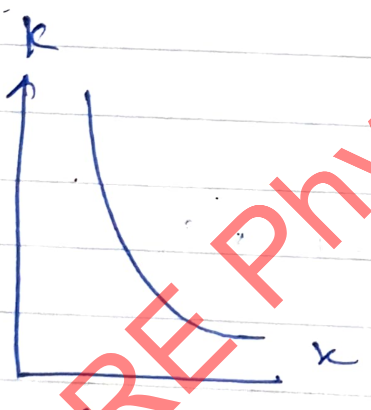
$$\boxed{F = -kx}$$

k = spring constant



$$\boxed{k = \frac{-F}{x}}$$





Work done in Spring

Let dw is small work done

and dx is small displacement

$$\rightarrow dw = -F dx$$

$\rightarrow dw = -f dx$

Integrate Both sides

$\Rightarrow \int dw = -\int f dx$ $\quad \boxed{f = -kx}$

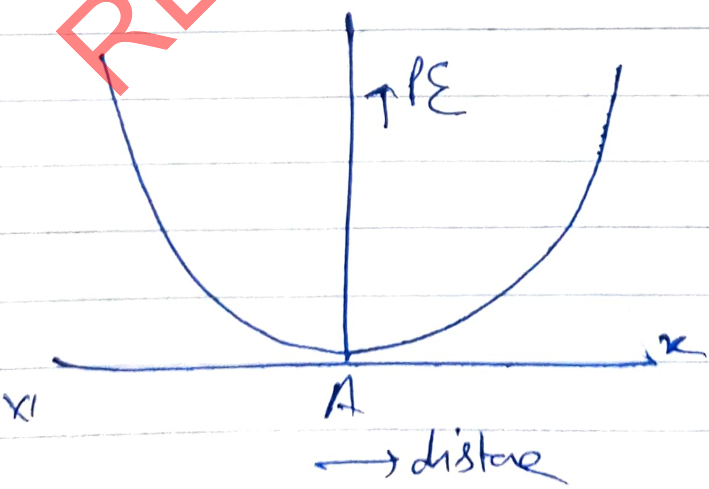
$\rightarrow w = \int -(-kx) dx$

$\rightarrow w = \int_0^x kx\,dx$

$\rightarrow w = k\int_0^x x\,dx$

$w = k\left[\frac{x^2}{2}\right]_0^x = \frac{kx^2}{2}$

$\boxed{w = \frac{kx^2}{2}}$, Potential energy of spring, $P.E = w = \frac{1}{2}kx^2$



Spring

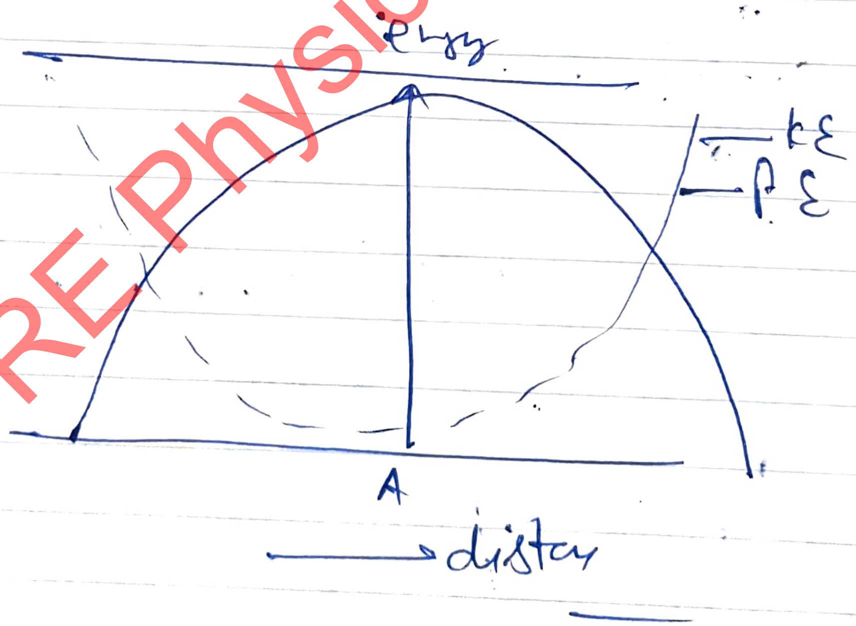
① $f = -kx$

② $W = PE = \frac{1}{2}kx^2$

KE of energy. $\boxed{KE = \frac{1}{2}mv^2}$

$TE = PE + KE$

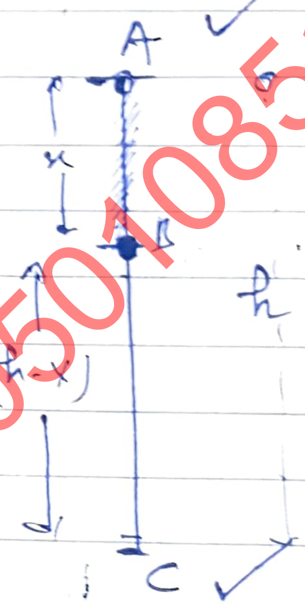
$$\boxed{TE = \frac{1}{2}kx^2 + \frac{1}{2}mv^2}$$



Mechanical energy & its Conservation

* If force is conserved, doing work on the system, is also ~~Conserved~~ Conserved

$$\boxed{KE + PE = \text{constant}}$$



Energy 'A'

$PE = m \times gh.$

$KE = \frac{1}{2}m(0)^2 = 0$

$T.E = PE + KE$

$$\boxed{T.E = mgh + 0 = mgh}$$

energy 'C'

$\boxed{PE = m \times g \times 0 = 0}$

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

, $\boxed{u=0}$, $\boxed{a=g}$, $\boxed{s=h}$

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

$v^2 = 0^2 + 2 \times g \times h \rightarrow \boxed{v^2 = 2gh}$

$v = \sqrt{2gh}$

$KE = \frac{1}{2}mv^2 = \frac{1}{\cancel{2}}m(\cancel{2}gh) = mgh$

$$\boxed{KE = mgh}$$

$$\boxed{T.E = PE + KE = 0 + mgh = mgh}$$

Engy at 'B'

$PE = mg(h-x)$ — ①

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

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

~~$v = u^2 + 2gs$~~

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

$v^2 = 0^2 + 2 \times g \times x$

$\boxed{v^2 = 2gx}$

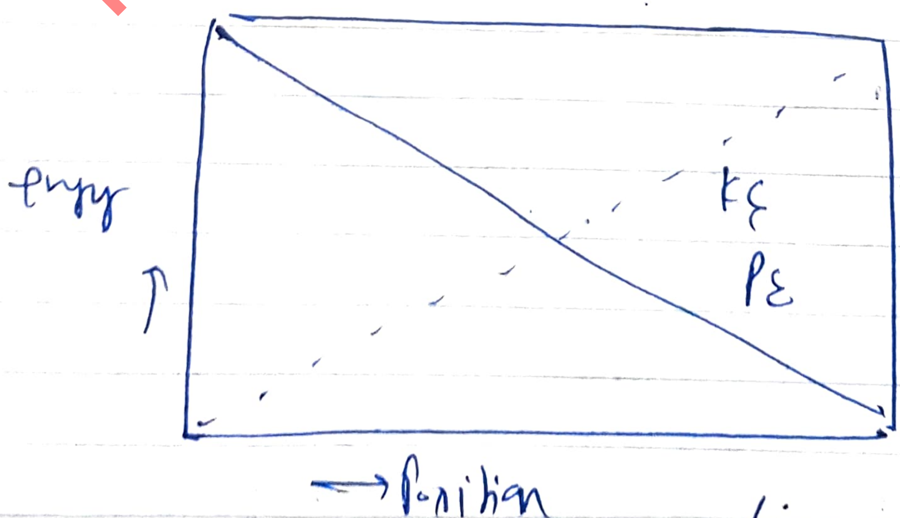
$\boxed{KE = \frac{1}{2}m(2gx) = mgx}$ — ①

$T.E = PE + KE$

$T.E = mg(h-x) + mgx$

$T.E = mgh - \cancel{mgx} + \cancel{mgx}$

$\boxed{T.E = mgh}$



Collision

as an Isolated event, in which two or more colliding Bodies exert relatively strong force on each other

$A \rightarrow \leftarrow B$

Type of Collision

(1) elastic collision → there is no change of K.E in Collision

eg: Collision B/w atom

Property

(i) Linear Momentum Conserved
(ii) Total Energy is Conserved
(iii) K.E is Conserved

(2) Inelastic collision: → In this collision, some amount of K.E Loss

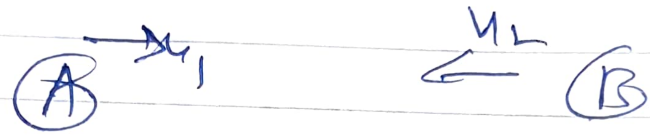
eg: Collision B/w two Bodies

Property

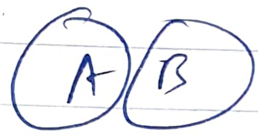
(i) Linear Momentum Conserved
(ii) Total energy not Conserved
(iii) K.E is not Conserved

Coefficient of Restitution or coefficient of resilience (e)

Ratio of Relative velocity of seprating after collision to Relative velocity of approch before collision



Initial velocity of A $\Rightarrow u_1$, Initial velocity of B $\Rightarrow u_2$] Before collision



] During collision

final velocity of A $\Rightarrow v_1$, final velocity of B $\Rightarrow v_2$] After collision

$$e = \frac{\text{Relative velocity of sepration (after collision)}}{\text{Relative velocity of approch (before collision)}}$$

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

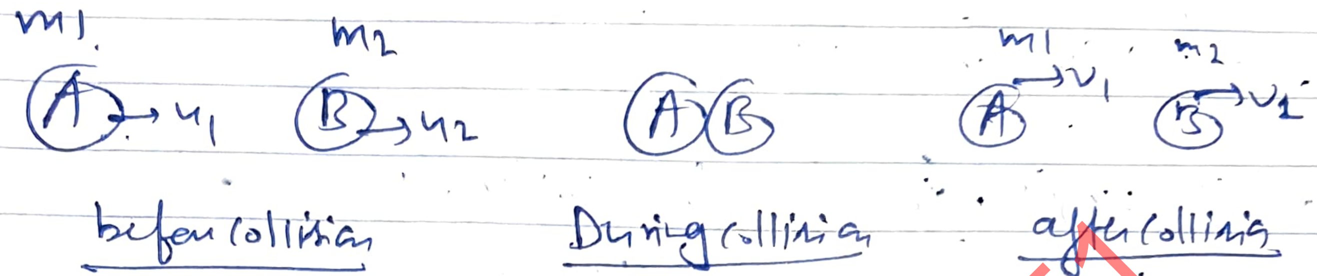
$e = 1 \rightarrow$ Perfect elastic collision

$e = 0 \rightarrow$ Perfect inelastic collision

for all collision
$0 < e < 1$

Elastic collision in one dimension

$\downarrow$



Let linear momentum before collision, $\rightarrow P_b = m_1u_1 + m_2u_2$ ——— (1)

Let linear momentum after collision $\rightarrow P_a = m_1v_1 + m_2v_2$ ——— (2)

Linear Momentum Conserved

$\rightarrow P_b = P_a$

$\rightarrow m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$\rightarrow \boxed{m_1(u_1 - v_1) = m_2(v_2 - u_2)}$ ——— (3)

Let KE before collision $\rightarrow KE_b = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$

Let KE after collision $\rightarrow KE_a = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

KE Conserved

$KE_b = KE_a$

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

$\boxed{\cancel{\frac{1}{2}}m_1[u_1^2 - v_1^2] = \cancel{\frac{1}{2}}m_2[v_2^2 - u_2^2]}$ ——— (4)

dividing equation (1) by (3)

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

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

$\rightarrow u_1+v_1 = v_2+u_2$

$\rightarrow u_1-u_2 = v_2 - v_1$

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

Velocity of (A) → (v1)

$u_1-u_2 = v_2 - v_1$

$$\boxed{v_2 = u_1-u_2+v_1}$$

$\rightarrow m_1u_1+m_2u_2 = m_1v_1+m_2v_2$

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

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

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

$\rightarrow m_1u_1+2m_2u_2-m_2u_1 = v_1(m_1+m_2)$

$$\rightarrow \frac{m_1u_1+2m_2u_2-m_2u_1}{m_1+m_2} = v_1$$

10

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

Velocity of (B) → (v_2)

$$\boxed{v_1 = v_2 - u_1 + u_2}$$

→ $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

→ $m_1u_1 + m_2u_2 = m_1(v_2 - u_1 + u_2) + m_2v_2$

→ $m_1u_1 + m_2u_2 = m_1v_2 - m_1u_1 + m_1u_2 + m_2v_2$

→ $m_1u_1 + m_2u_2 + m_1u_1 - m_1u_2 = v_2(m_1 + m_2)$

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

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

Q.1: The linear momentum of a body is increased by 10%. What is percentage change in KE?

A. $P = mv$

$P_1, \quad P_2 = P_1 + \frac{P_1 \times 10}{100} = \frac{11 P_1}{10}$ ✓

$\cancel{m} v_2 = \frac{11 \cancel{m} v_1}{10}$

$$\boxed{\frac{v_2}{v_1} = \frac{11}{10}}$$

$\rightarrow \frac{(KE)_2}{(KE)_1} = \frac{\cancel{\frac{1}{2}}\cancel{m} v_2^2}{\cancel{\frac{1}{2}}\cancel{m} v_1^2} = \left(\frac{v_2}{v_1}\right)^2 = \left(\frac{11}{10}\right)^2 = \frac{121}{100}$

$\% KE = \left(\frac{KE_2 - KE_1}{KE_1}\right) \times 100 = \left(\frac{121 - 100}{100}\right) \times 100 \Rightarrow 21\%$

graph

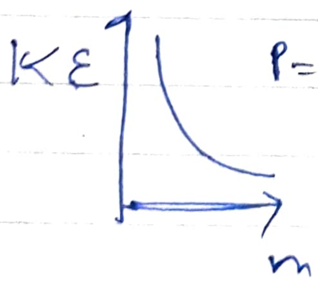
$\boxed{KE = \frac{1}{2} m v^2}$, $\boxed{P = mv}$, $KE = \frac{P^2}{2m} \rightarrow P^2 = 2 m KE$

$\boxed{P = \sqrt{2 m KE}}$ ✓

✓ ✓

$P = \sqrt{2 m KE} \Rightarrow$

$P = \text{const}$

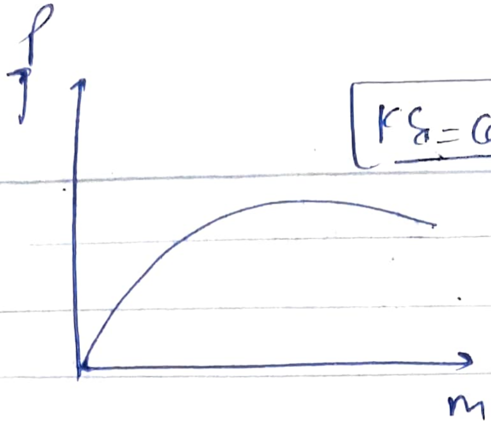


$\rightarrow P = \sqrt{2 \cdot m \cdot KE}$

$\rightarrow P^2 = 2 \times m \times KE$

$KE = \frac{P^2}{2m}$ $\boxed{KE \propto \frac{1}{m}}$

#



$\boxed{KE = const}$

$p = \sqrt{2mKE}$

$p^2 = 2mKE$

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

$p^2 = 2mKE$

$p^2 \propto 2m$

$x^2 \propto$

#

$\boxed{m = const}$

$p = \sqrt{2mKE}$

$p^2 = 2mKE$

$p^2 \propto KE$

$\boxed{\therefore 2m = constant}$

Q: Find the Average frictional force that would stop a car weighing 500 kg in a distance of 25 m If initial speed is 72 km/hr?

A

$m = 500\ kg$

$u = 72\ km/hr = \cancel{72}^{36\ 12\ 4} \times \frac{5}{\cancel{18}\ 9\ 3}\ m/sec$

$= 20\ m/sec$

$v = 0$

$s = 25\ m$

~~Frictional force = mass x acceleration~~

~~$= 500 \times \frac{25}{20}$~~ $\left(\frac{ds}{dt}\right) = v$

$W = \Delta KE$

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

$\rightarrow f \cdot s = \left[\frac{1}{2}mv^2 - \frac{1}{2}mu^2\right]$

$\rightarrow f = \frac{\left[\frac{1}{2}mv^2 - \frac{1}{2}mu^2\right]}{s} = \frac{\left[\frac{1}{\cancel{2}} \times \cancel{500} \times (0)^2 - \frac{1}{\cancel{2}} \times \cancel{500} \times (20)^2\right]}{25}$

$= \frac{250 \times 0 - 250 \times 400}{25} = \frac{0 - 100{,}000}{25}$

12

Q The length of a steel wire Increase By 0.5cm when it is loaded with a weight of 5 kg. Calculate the force constant of wire and work done in stretching the wire. Take → g = 10?

Ans

$$F = Kx$$

(i) $\boxed{x = 0.5\,cm = 0.5 \times 10^{-2}\,m}$

$f = 5\,kg = 5 \times 9.8\ N$

$$\boxed{K = \frac{F}{x} = \frac{5 \times 9.8}{0.5 \times 10^{-2}}\ N/m}$$

Spring constant / force constant

Note :-
(i) $F = Kx$
when spring is
K = spring constant or force const
(ii) $W = \frac{1}{2} Kx^2$
x → stretched distance

(ii) $\boxed{W = \frac{1}{2} Kx^2}$

$$W = \frac{1}{2} \times \frac{5 \times 9.8}{\cancel{0.5 \times 10^{-2}}} \times (\cancel{0.5 \times 10^{-2}})^2$$

$$= \frac{1}{2} \times \frac{5 \times 9.8 \times 0.5 \times 10^{-2}}{10 \times 10}$$

$$= \frac{1}{\cancel{2}} \times 5 \times 5 \times \underset{49}{\cancel{98}} \times 10^{-2+(-2)}$$

$$= 25 \times 49 \times 10^{-4}$$

$$= 1225 \times 10^{-4}\ J$$

1
4
49
25
245
98 ×
1225

RE Physics: 9205010851

Q. A rubber ball falls on a floor from a height of 19.6 m. Calculate the velocity with which it strikes the ground. To what height will the ball rebounce if it loses 25% of its energy on striking the ground?

A

height$_1$ = 19.6 m
velocity = ?
Loss of energy = 25%
height$_2$ = ?

$$\boxed{\begin{aligned} KE &= PE \\ \frac{1}{2}\cancel{m}v_1^2 &= \cancel{m}gh_1 \\ v_1 &= \sqrt{2gh} \end{aligned}}$$

or

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

$\rightarrow v^2 = 2 \times g \times h$

$\boxed{v = \sqrt{2g \times h}}$

i) $v = \sqrt{2 \times g \times h} = \sqrt{2 \times 10 \times 19.6}$ ℓ

ii) $E_2 = E_1 - \frac{E \times 25}{100}$

$E_2 = \frac{75 \times E_1}{100}$

$\rightarrow \cancel{m}\cancel{g}h_2 = \frac{75 \times \cancel{m}\cancel{g}h_1}{100}$

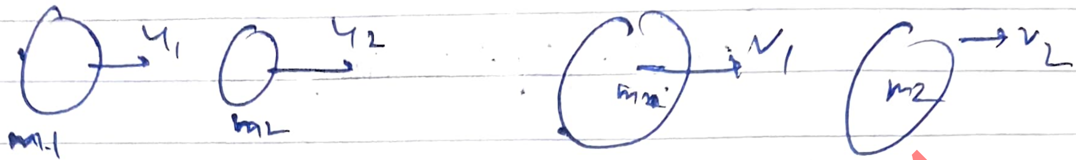
$h_2 = \frac{75}{100} \times h_1$

$\boxed{h_2 = \frac{75 \times 19.6}{100}}$

$\boxed{h_2 = 14.7\ m}$

Inelastic Collision in One Dimension

B



Before collision   after collision

$$\boxed{m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2}$$

Perfectly Inelastic Collision

$v_1 = v_2 = V$

$m_1u_1 + m_2u_2 = (m_1+m_2)V$

If $u_2 = 0$

$m_1u_1 = V(m_1+m_2)$

$$\boxed{V = \left(\frac{m_1u_1}{m_1+m_2}\right)}$$

Loss of KE

E_1 = Total KE Before collision $= \frac{1}{2}m_1u_1^2$ —— (1)

E_2 = " " After " $= \frac{1}{2}(m_1+m_2)V^2 = \frac{1}{2}(m_1+m_2)\left[\frac{m_1u_1}{m_1+m_2}\right]^2$

$E_2 = \frac{1}{2}\frac{m_1^2u_1^2}{(m_1+m_2)}$ —— (2)

Loss of KE $= E_1 - E_2 = \frac{1}{2}m_1u_1^2 - \frac{m_1^2u_1^2}{2(m_1+m_2)}$

$= \frac{1}{2}\left[m_1u_1^2 - \frac{m_1^2u_1^2}{(m_1+m_2)}\right]$

$$= \frac{1}{2}\left[\frac{m_1u_1^2(m_1+m_2) - m_1^2u_1^2}{m_1+m_2}\right]$$

$$\cancel{= \frac{1}{2}\left[m_1^2 m_1 u_1 + m_1 m_2\right.}$$

$$= \frac{1}{2}\left[\frac{\cancel{m_1^2u_1^2} + m_1m_2u_1^2 - \cancel{m_1^2u_1^2}}{m_1+m_2}\right]$$

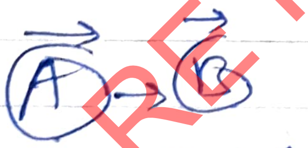
$$\text{Loss of KE} = \frac{1}{2}\left[\frac{m_1m_2u_1^2}{m+m_2}\right]$$

Q. A body of mass 2kg makes an elastic collision with another body at rest and continue to move in the original direction with speed equal to one third of its original speed. Find the mass of second body?

A.

$mass_1 = 2kg$

$m_2 = ?$



$m_1 = 2kg$ $\quad$ m_2 at rest $\quad$ $u_2 = 0$ $\quad$ $v_1 = \frac{u_1}{3}$

$\boxed{u_1 \neq 0}$

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

$$\rightarrow \frac{u_1}{3} = \frac{(2-m_2)u_1}{2+m} + \frac{2\times m_2\times 0}{(m_1+m_2)}$$

$\boxed{14}$

$\rightarrow \frac{\cancel{4}1}{3} = \left(\frac{2-m_2}{2+m}\right)\cancel{4}$

$\rightarrow \frac{1}{3} = \frac{2-m_2}{2+m}$

$\rightarrow 2+m = (2-m_2)\times 3$

$\rightarrow 2+m = 6-3m_2$

$m+2m_2 = 6-2$

$4m_2 = 4$

$m_2 = \frac{4}{4}$

$\boxed{m_2 = 1kg}$