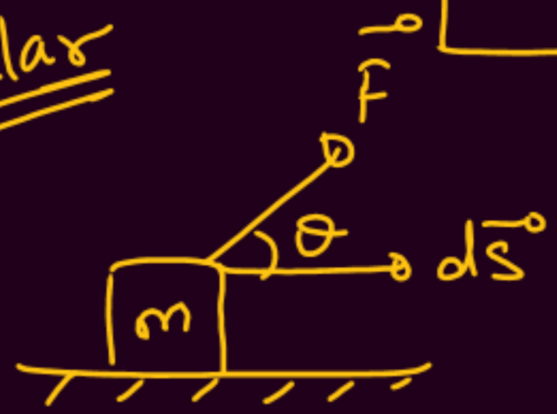
Work - Energy & Power

Work $\boxed{W = \int \vec{F} \cdot d\vec{s} = \int F\, ds \cos\theta}$

Scalar



$\theta = 90^\circ$ $W = 0$

$0 \le \theta < 90^\circ$ $W = +$

$90^\circ < \theta \le 180^\circ$ $W = -$

Unit J (SI)

erg (CGS)

① $1\ \text{Cal} = 4.2\ \text{J}$

② $1\ \text{J} = 10^7\ \text{erg}$

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

Special Case $\vec{F} = \text{const}$

$\boxed{W = \vec{F} \cdot \vec{S} = FS\cos\alpha}$

① If $\vec{S} = 0$ then

W may be non-zero

② W_f $+ / - / 0$

UCM by car

③ $W_{\text{internal forces}}$ may be non-zero

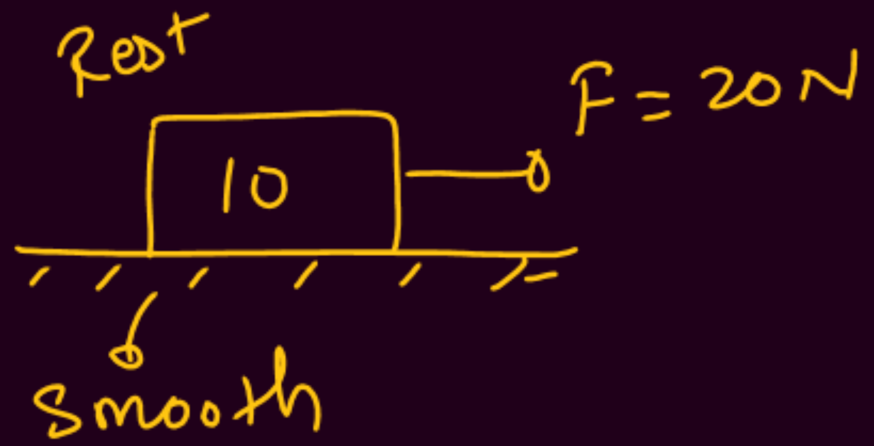
$+$ F S_1 S_2 F $-$

④ W depends on FoR

⑤ Pt. of app at Rest $W = 0$

- walking / Running $W_f = 0$
- Rope climbing $W_T = 0$
- Stair $W_N = 0$

Q



w by F in 2s

$$W = F S \cos 0^\circ$$
$$= (20)(4)(1)$$
$$= \underline{80\ J}$$

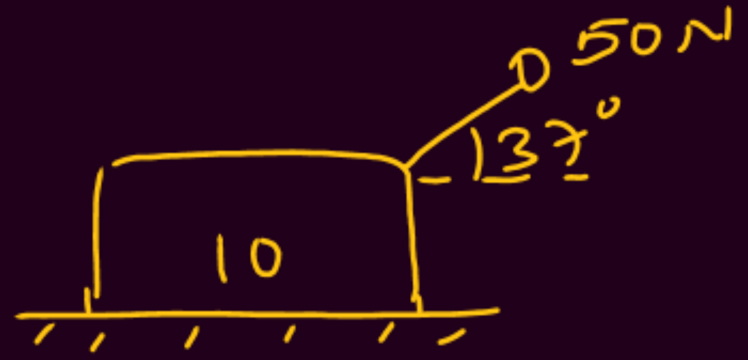
$a = 2\,m/s^2$

$S = \frac{1}{2}(2)(2)^2$

$W_N = 0$

$W_{mg} = 0$

Q



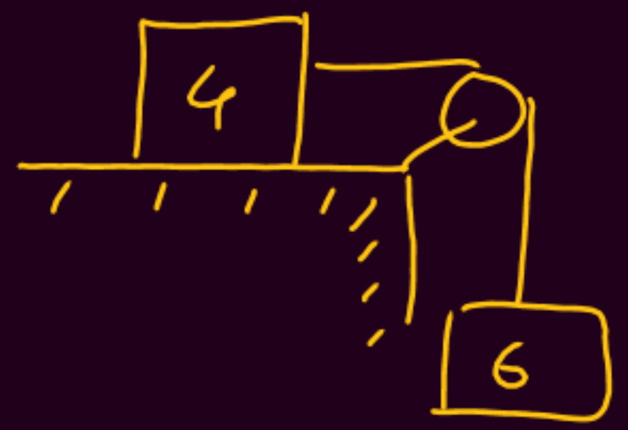
w by F in 2s

$$a = \frac{40}{10} = 4\,m/s^2$$

$$S = \frac{1}{2}(4)(2)^2 = 8m$$

$$W = F S \cos 37^\circ$$
$$= 50(8)\,4/5$$
$$= 40(8)$$
$$= \underline{320\ J}$$

Q



① w by T on 4kg in 2s

$$a = \frac{6g}{10} = 6\,m/s^2$$

$$S = \frac{1}{2}(6)(2)^2 = 12m$$

$$T = 4(6) = 24\,N$$

$$W = T S = 24(12) = \underline{288\ J}$$

② w by T on 6kg in 2s

$$W = -(24)(12) = \underline{-288\ J}$$

Q. $\vec{F} = (3\hat{i} - 2\hat{j} + \hat{k})\ N$

$\vec{S} = (\hat{i} - \hat{j} + 2\hat{k})\ m$

$W = ?$

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

$$W = (3)(1) + (-2)(-1) + (1)(2)$$

$$\underline{W = 7J}$$

Q. Displaced from $(1, -1, 2)$ to $(0, 2, -1)$

$i \qquad f$

$\vec{F} = (2\hat{i} - 3\hat{j} + 4\hat{k})\ N$

$W = ?$

$$\vec{S} = \vec{r}_f - \vec{r}_i = (0-1)\hat{i} + (2-(-1))\hat{j} + (-1-2)\hat{k}$$

$$\vec{S} = -\hat{i} + 3\hat{j} - 3\hat{k}$$

$$W = (2)(-1) + (-3)(3) + 4(-3)$$

$$\underline{W = -23J}$$

Q Rest

$\mu = 0.2$

In 3s

$W_F = 50 \times \frac{27}{2} = 675\ J$

$W_f = -(20)\left(\frac{27}{2}\right) = -270\ J$

$W_N = 0$

$W_{mg} = 0$

$N = 100\ N$

$f_L = 0.2(100) = 20\ N$

$a = \frac{50-20}{10} = 3\ m/s^2$

$S = \frac{1}{2}(3)(3)^2 = 13.5\ m$

Q. $F = 4x$

W in $x = 1m$ to $x = 3m$

$$W = \int F\,dx$$

$$W = \int 4x\,dx$$

$$W = \left[4\frac{x^2}{2}\right]_1^3 = \left[2x^2\right]_1^3$$

$$W = 2(3)^2 - 2(1)^2$$

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

Q. $F = (3x^2 - 2x)$

W in displacing from $x = 2m$ to $x = 4m$

$$W = \int (3x^2 - 2x)\,dx$$

$$W = \left(3\frac{x^3}{3} - 2\frac{x^2}{2}\right) = \left[x^3 - x^2\right]_2^4$$

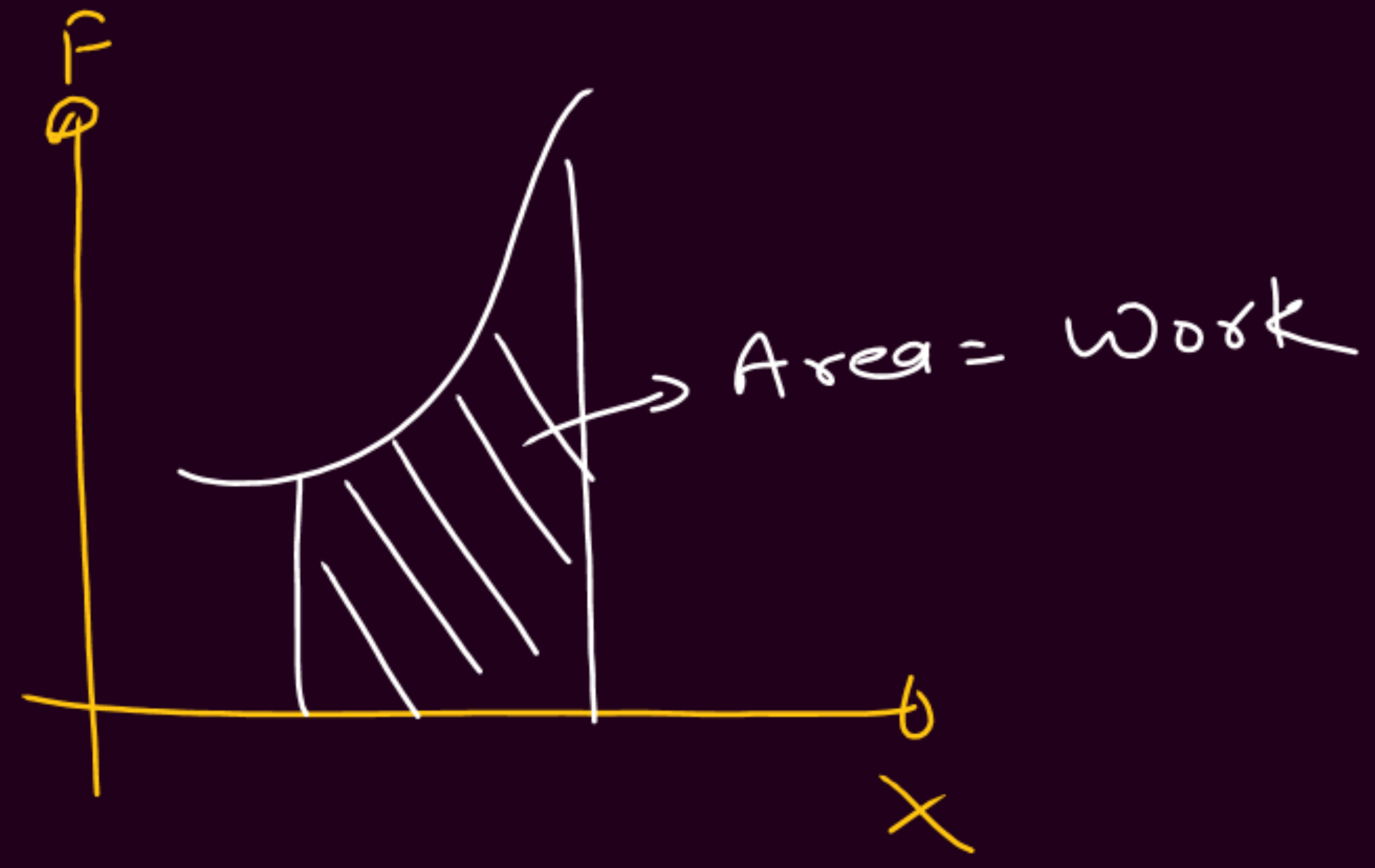
$$W = (4^3 - 4^2) - (2^3 - 2^2)$$

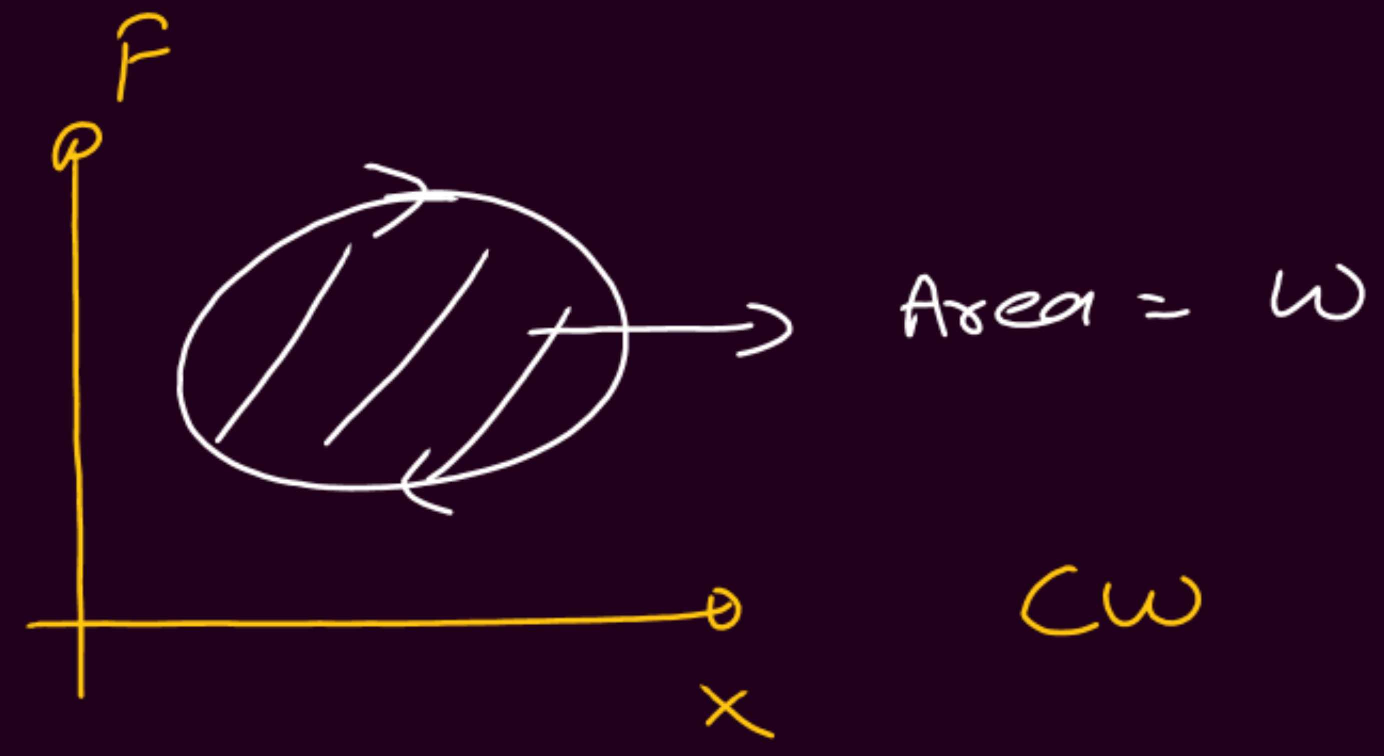
$$= 48 - 4$$

$$\underline{= 44J}$$

Graphs

$$W = \int F\,dx$$

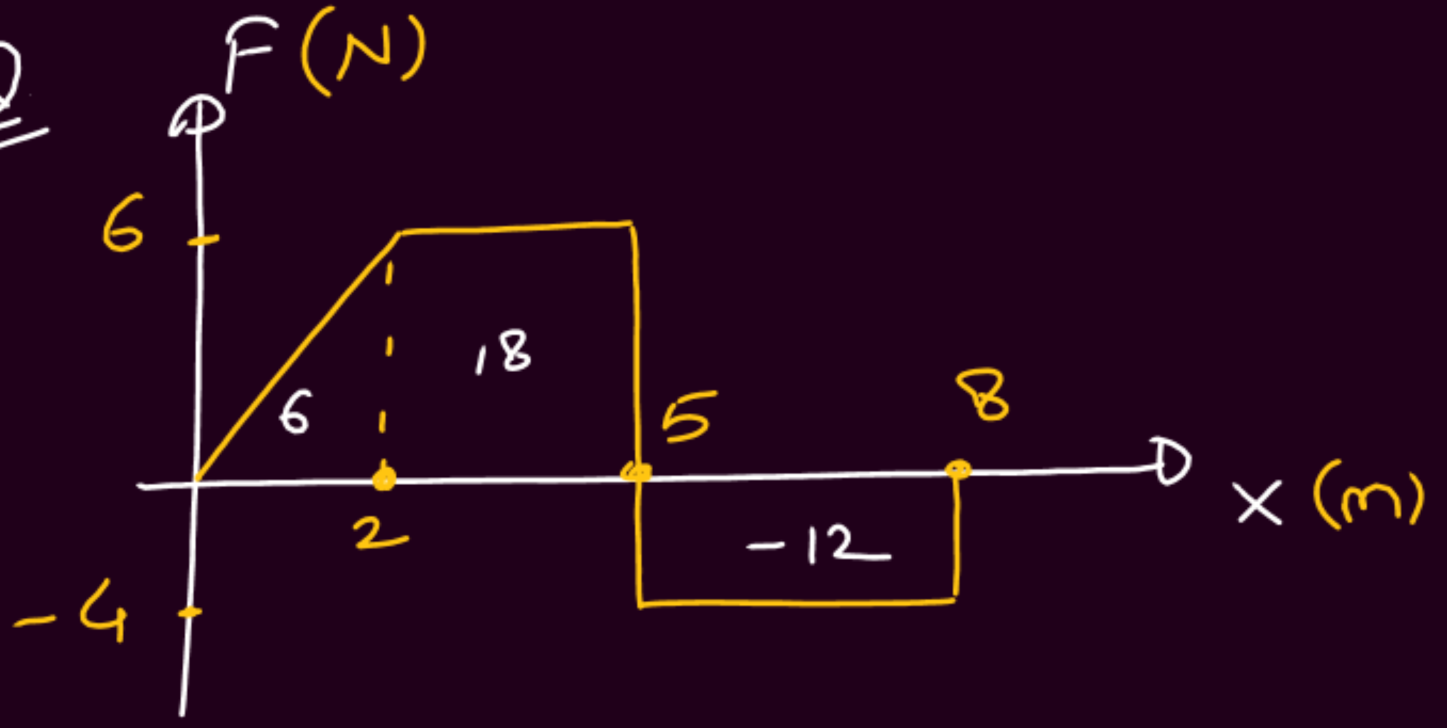




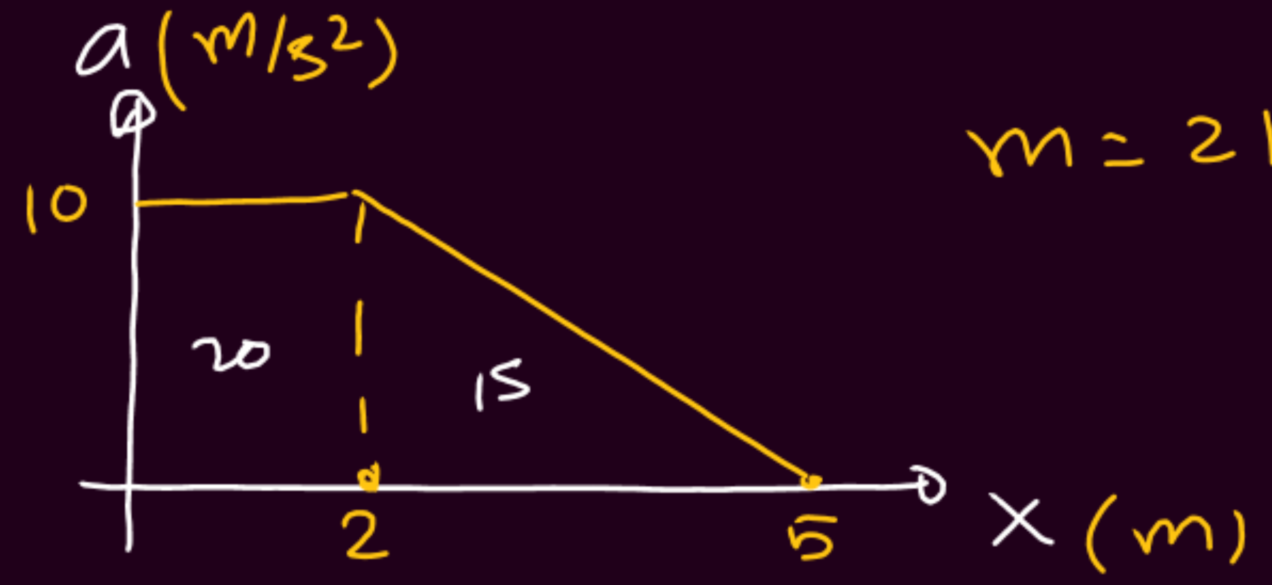
CW $\quad W = \oplus$

ACW $\quad W = \ominus$

Q



$$W = 6 + 18 - 12 = 12\ \text{J}$$



$m = 2\ \text{kg}$

$$W = 2\left[20 + 15\right] = 70\ \text{J}$$

Conservative & Non-conservative Forces

→ W.D is independent of path

→ e.g. gr / electrostatic / Spring / Const F

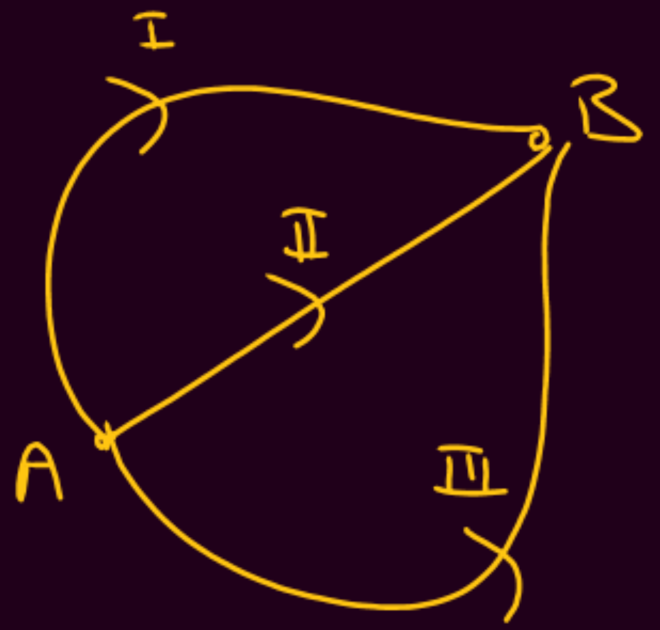
→ NCF → Friction / Air / Viscous

Conservative

→ W.D. in closed path = 0

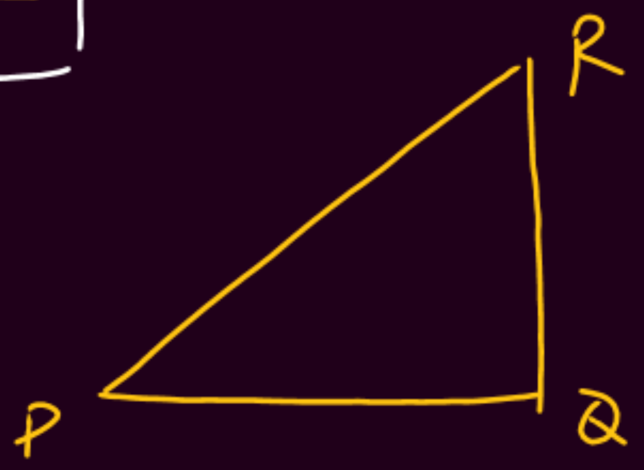
→ depends only on i & f

$W_{B\to A} = -W_{A\to B}$



$W_{I} = W_{II} = W_{III}$

If force is conservative



$W_{P\to Q} = 3J$

$W_{Q\to R} = 4J$

$W_{P\to R} = ?$

$$W_{P\to R} = W_{P\to Q} + W_{Q\to R}$$

$$= 3 + 4 = \underline{\underline{7J}}$$

Q

$$W_{P \to R} = 10\,J$$

$$W_{S \to P} = -5\,J$$

$$W_{S \to Q} = 6\,J$$

① $W_{P \to Q} = (P \to S) + (S \to Q)$

$= (+5) + 6 = \underline{\underline{11\,J}}$

② $W_{S \to R} = (S \to P) + (P \to R)$

$= (-5) + 10 = \underline{\underline{5\,J}}$

③ $W_{Q \to R} = (Q \to S) + (S \to P) + (P - R)$

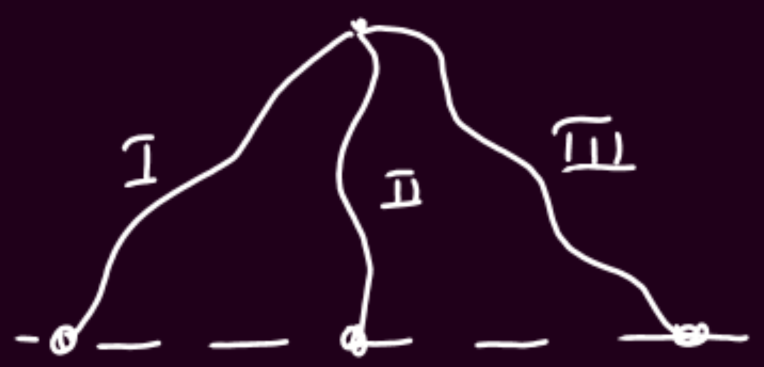
$= (-6) + (-5) + (10)$

$= \underline{\underline{-1\,J}}$

Work done by Gravity

$W = \pm mgh$

$\Delta U = \pm mgh$



$W_I = W_{II} = W_{III}$

①

$W_{mg} = mgh$

$\Delta U = -mgh$

②

$W_{mg} = -mgh$

$\Delta U = +mgh$

Work done by Spring

$F = -kx$

$W_{by} = -\frac{1}{2}k(x_f^2 - x_i^2)$

$\Delta U = \frac{1}{2}k(x_f^2 - x_i^2)$

$U = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{F^2}{2k}$

For successive equal extensions

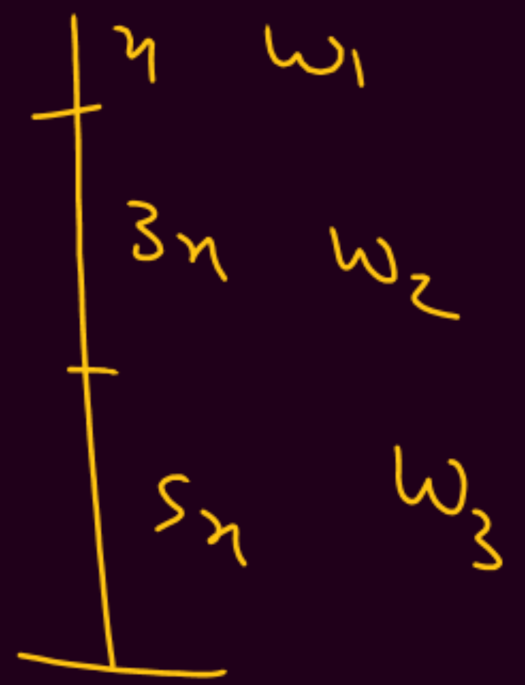
$W/\Delta U \quad 1:3:5:7$

Pg-182
(2)

$$\frac{W_1}{W_2} = \frac{mgh}{mgh} = \frac{1}{1}$$

Pg-182
(9)

1 : 3 : 5



Pg-185
(2)

S $\longrightarrow$ 10 J

Add. S $\longrightarrow$ 30 J

Q. by 10cm W_0

Additional 15cm $W = ?$

$$W_0 = \frac{1}{2}k(10)^2$$

$$W = \frac{1}{2}k\left(25^2 - 10^2\right)$$

$$W = \frac{W_0}{100}(525)$$

$$\boxed{W = \frac{21}{4}W_0}$$

Same Extension

① Tension

$$\frac{T_1}{T_2} = \frac{k_1 x}{k_2 x}$$

$$\boxed{\frac{T_1}{T_2} = \frac{k_1}{k_2}}$$

② PE

$$\frac{U_1}{U_2} = \frac{\frac{1}{2} k_1 x^2}{\frac{1}{2} k_2 x^2}$$

$$\boxed{\frac{U_1}{U_2} = \frac{k_1}{k_2}}$$

Same Force / Tension

① Extension

$$k_1 x_1 = k_2 x_2$$

$$\boxed{\frac{x_1}{x_2} = \frac{k_2}{k_1}}$$

② PE

$$\frac{U_1}{U_2} = \frac{F^2}{2k_1} \cdot \frac{2k_2}{F^2}$$

$$\boxed{\frac{U_1}{U_2} = \frac{k_2}{k_1}}$$

Same PE

① Extension

$$\frac{1}{2} k_1 x_1^2 = \frac{1}{2} k_2 x_2^2$$

$$\boxed{\frac{x_1}{x_2} = \sqrt{\frac{k_2}{k_1}}}$$

② Tension

$$\frac{F_1^2}{2k_1} = \frac{F_2^2}{2k_2}$$

$$\boxed{\frac{F_1}{F_2} = \sqrt{\frac{k_1}{k_2}}}$$

Work-Energy Theorem

$$W_{\text{by all}} = \Delta K$$

(internal + External)

Q.

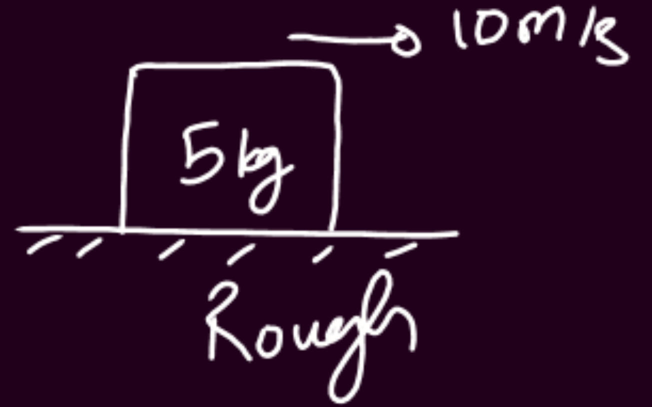
$$W_{air} = ?$$

$$W_{air} + W_{gr} = \Delta K$$

$$W_{air} + mgh = \frac{1}{2}m(gh) - 0$$

$$W_{air} = -\frac{mgh}{2}$$

Q



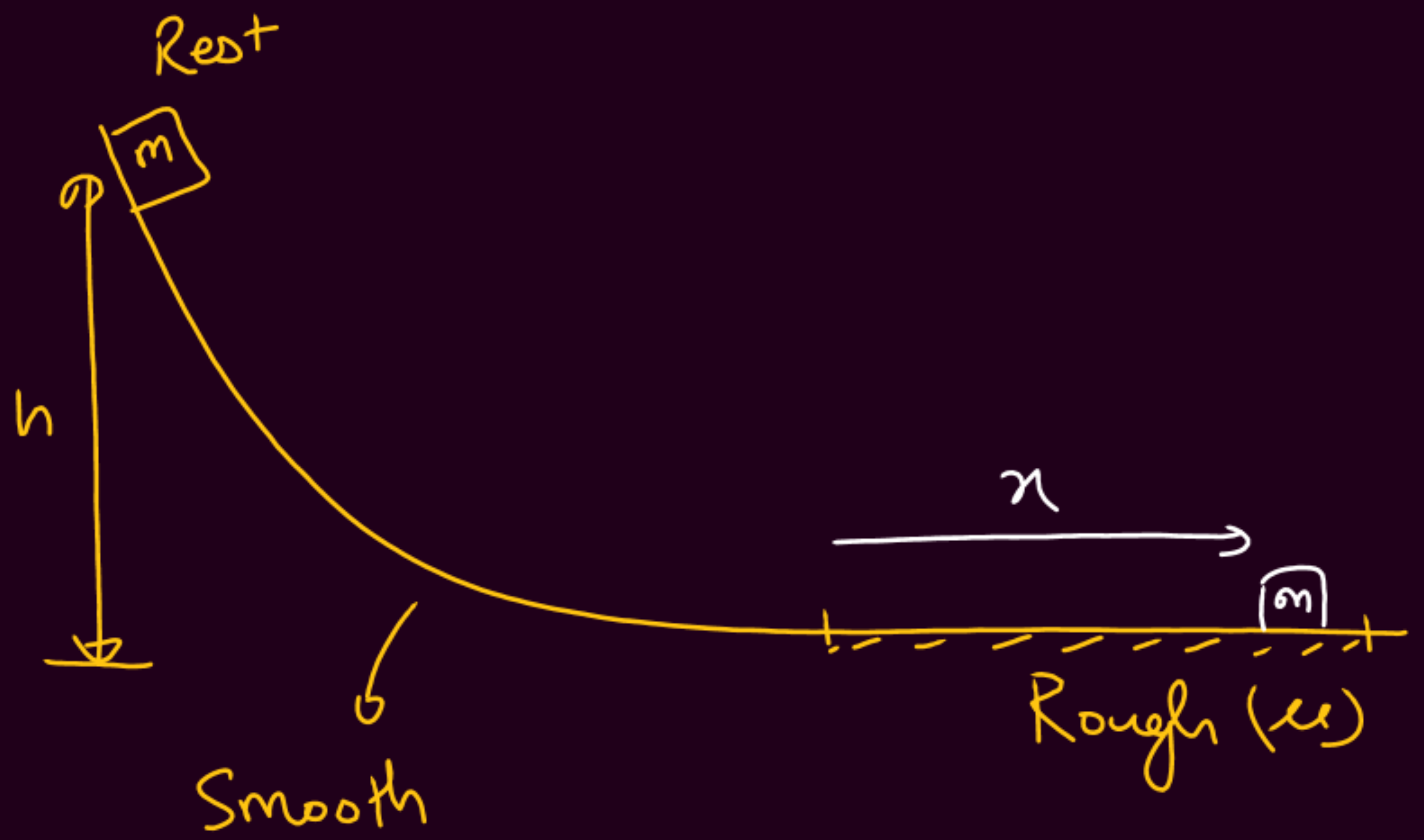
$$W_{fr} = ?$$

$$W_{mg} + W_N + W_{fr} = \Delta K$$

$$0 + 0 + W_{fr} = 0 - \frac{1}{2}(5)(10)^2$$

$$W_{fr} = -250\,\text{J}$$

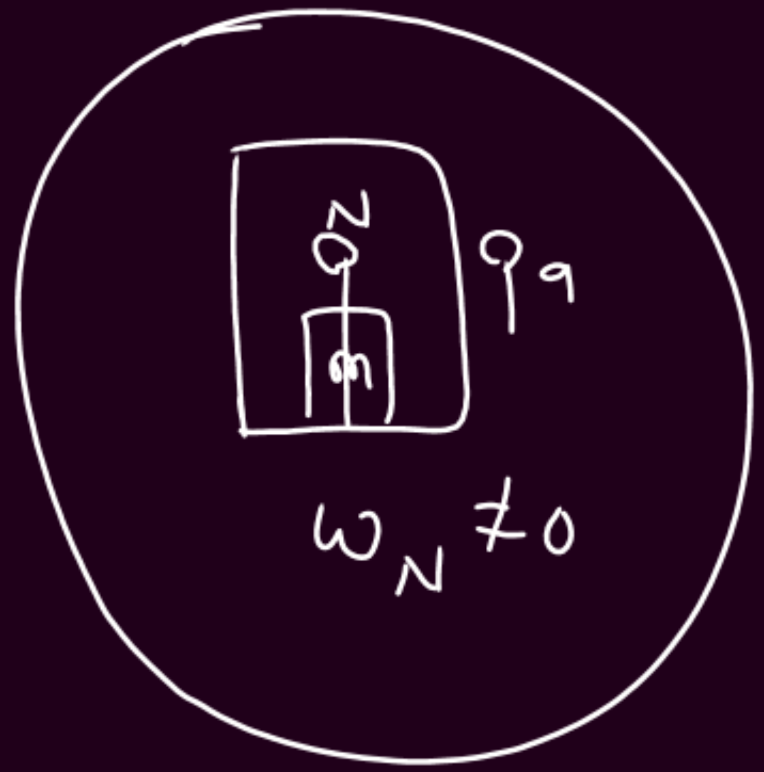
Q.



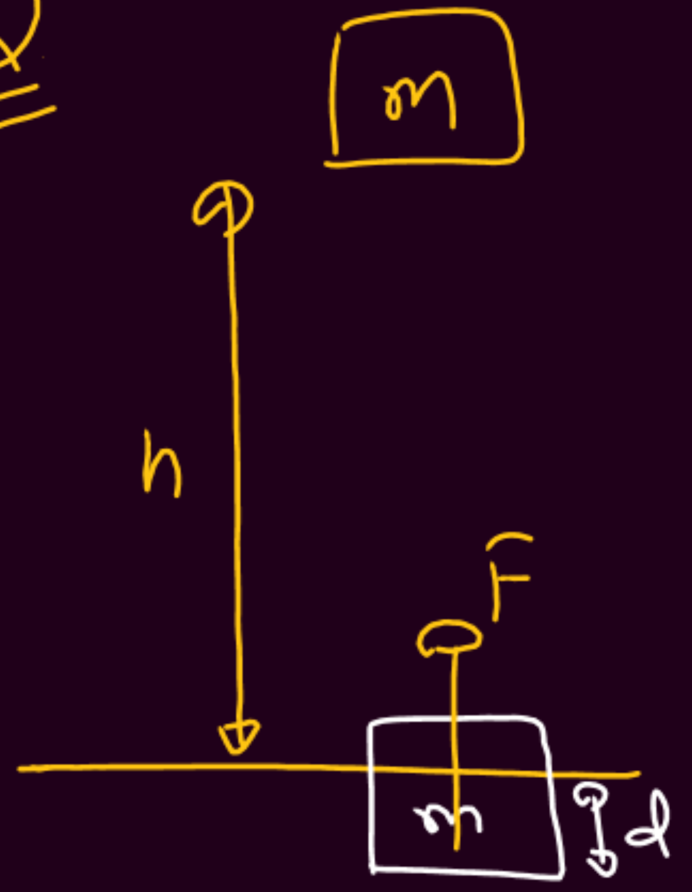
$$W_{gr} + W_N + W_{fr} = \Delta K$$

$$mgh + 0 - \mu mg\,x = 0 - 0$$

$$\boxed{x = \frac{h}{\mu}}$$



Q



Find force exerted by floor?

$$W_{gr} + W_{floor} = \Delta K$$

$$mg(h+d) - Fd = 0 - 0$$

$$F = \frac{mg(h+d)}{d}$$

$$\boxed{F = mg\left(1 + \frac{h}{d}\right)}$$

Q. $x = (t^2 - 2t + 1)\ m$

$m = 2\ kg$

W.D. in $2s$

$v = (2t - 2)$

$t = 0 \quad v = -2$

$t = 2 \quad v = +2$

$W = \Delta K = \frac{1}{2} m (2^2 - 2^2) = 0$

Work

- F given
  - Const.: $W = \vec{F} \cdot \vec{S}$
  - variable: $W = \int \vec{F} \cdot d\vec{s}$
- F not given
  - W–E Theorem: $W = \Delta K$

Q. $v = (t^2 - 2t + 1)$ m/s

$m = 2$ kg

W in 2s ?

$t = 0$ $v_1 = 1$

$t = 2$ $v_2 = 1$

$$W = \frac{1}{2}(2)(1^2 - 1^2) = 0$$

Q. $v = (x^2 + 2)$

$m = 1$ kg

W.D from $x = 1$m to $x = 2$m

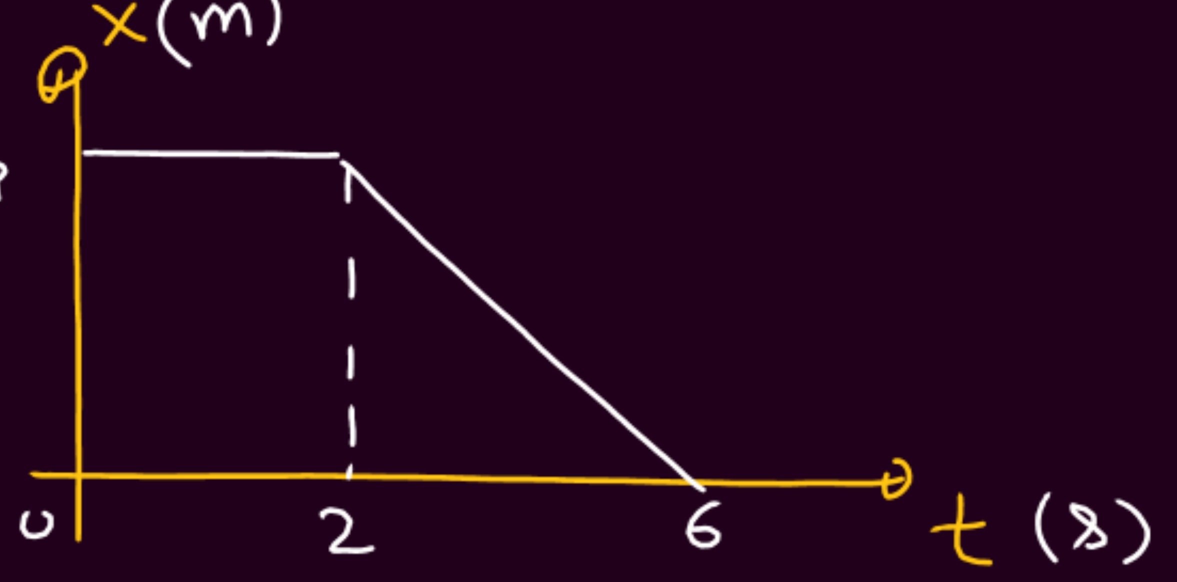
$x = 1$ $v = 3$

$x = 2$ $v = 6$

$$W = \frac{1}{2}(1)(6^2 - 3^2)$$

$$W = \frac{36 - 9}{2} = \frac{27}{2} = \underline{13.5 \text{ J}}$$

Q.



$m = 2\,kg$

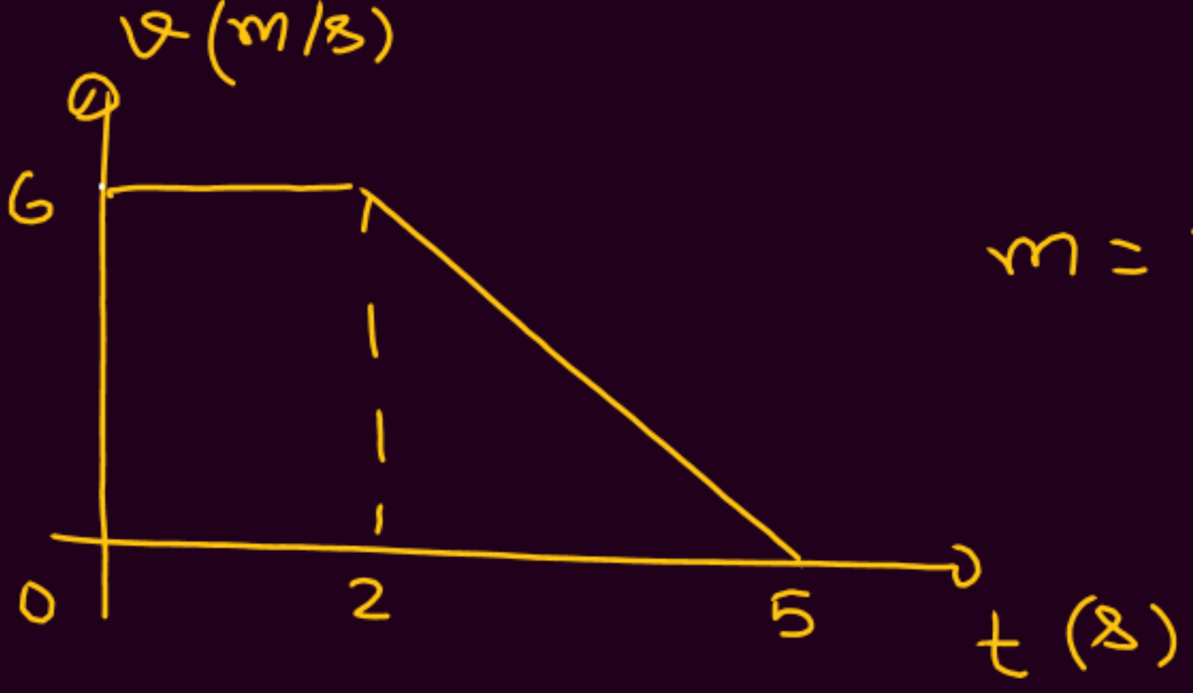
W.D. in 5s ?

$t = 0 \qquad v = 0$

$t = 5 \qquad v = -\frac{4}{4} = -1\ m/s$

$W = \frac{1}{2}(2)\left(1^2 - 0^2\right) = 1\,J$

Q.



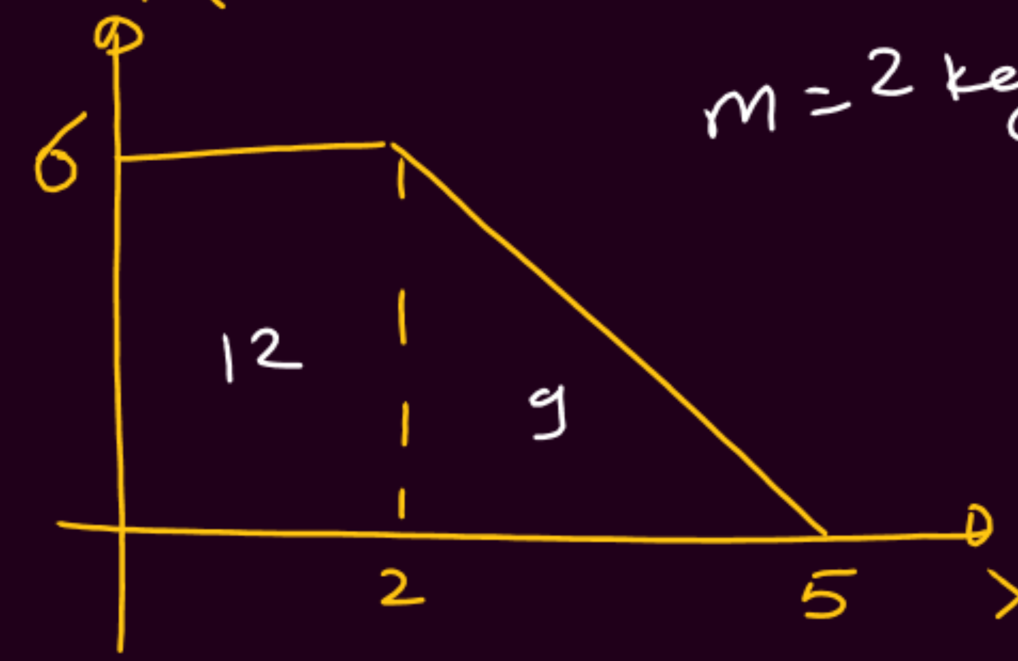
$m = 2\,kg$

W.D. in 5s ?

$W = \frac{1}{2}(2)\left(0^2 - 6^2\right)$

$W = -36\,J$

Q



$m = 2\ kg$

If initial sp. is 10 m/s then find v at 5s ?

$$W = \frac{1}{2}(2)(v^2 - 10^2)$$

$$21 = v^2 - 100$$

$$v^2 = 121$$

$$\boxed{v = 11\ m/s}$$

Conservation of ME

(1) $ME = PE + KE$

(2) $W_c + W_{others} = \Delta K$

$-\Delta U + W_{others} = \Delta K$

$W_{others} = \Delta K + \Delta U = \Delta ME$

(3) If $ME = \text{const.}$

$U_i + K_i = U_f + K_f$

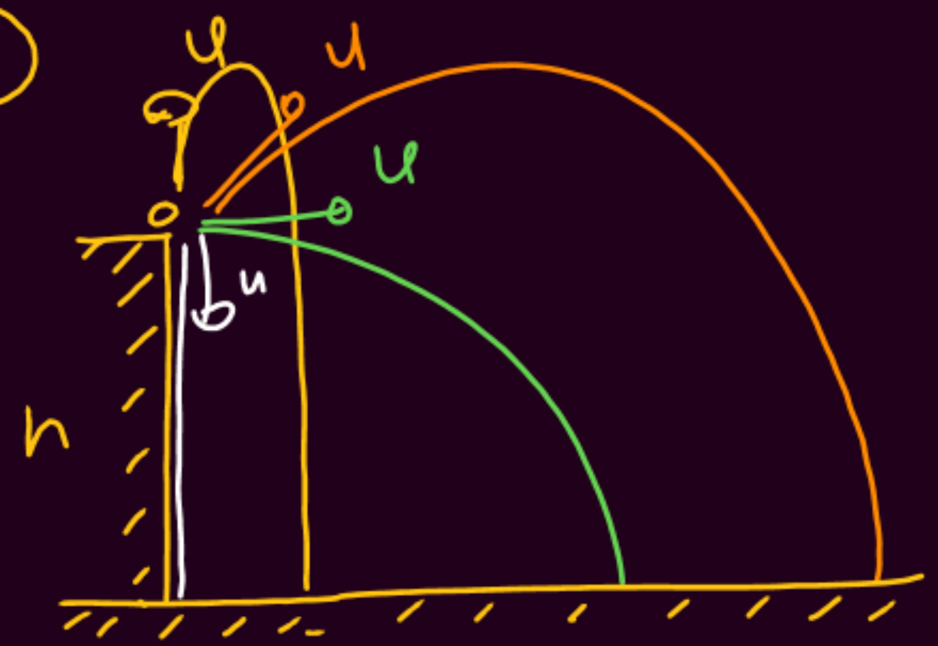
(1)

$$U_i + K_i = U_f + K_f$$

$$mgh + 0 = 0 + \frac{1}{2}mv^2$$

$$v^2 = 2gh$$

(2)

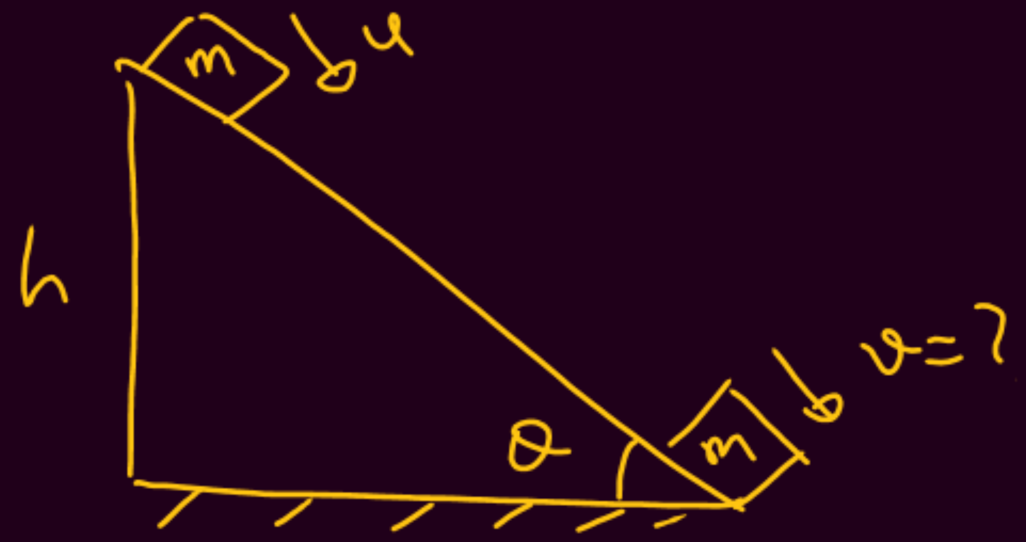


$$U_i + K_i = U_f + K_f$$

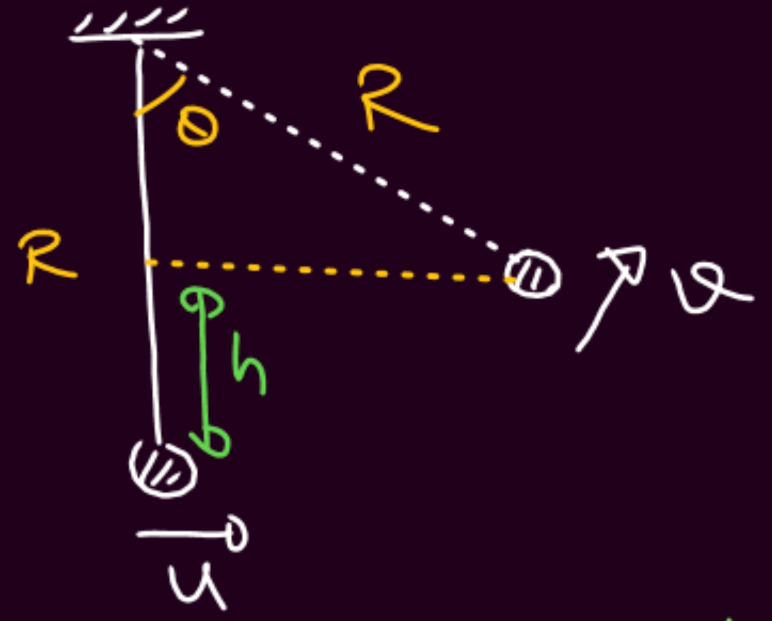
$$mgh + \frac{1}{2}mu^2 = 0 + \frac{1}{2}mv^2$$

$$\boxed{v^2 = u^2 + 2gh}$$

Irrespective of Angle of Projection



$$\boxed{W_N = 0}$$

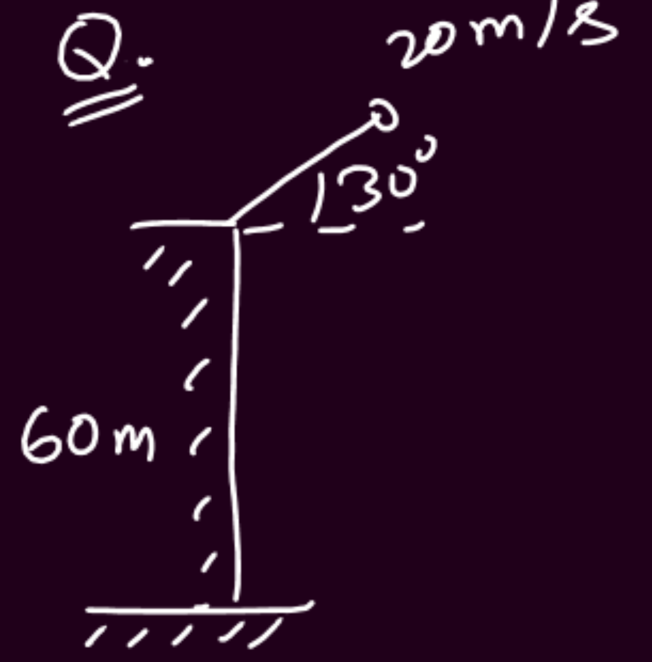


(1) $h = R(1 - \cos\theta)$

(2) $W_T = 0$

(3) $v^2 = u^2 - 2gh$

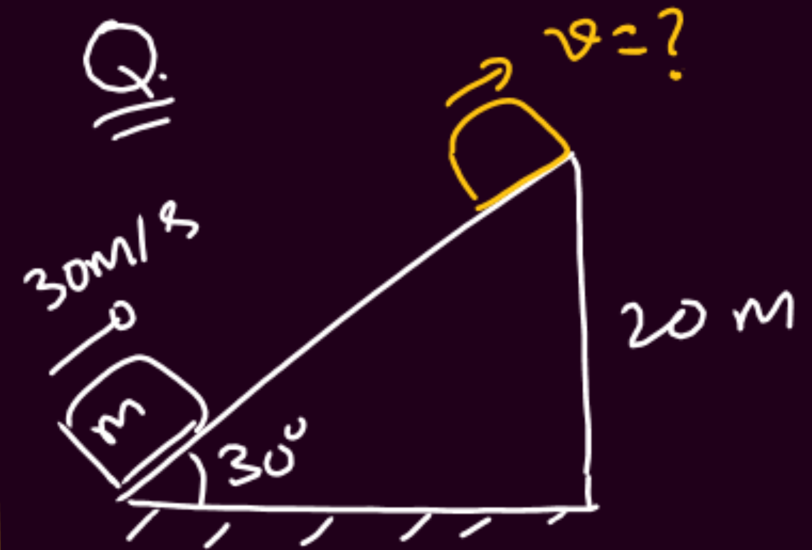
Q.



$$v^2 = 20^2 + 2(10)(60)$$

$$v = 40\ m/s$$

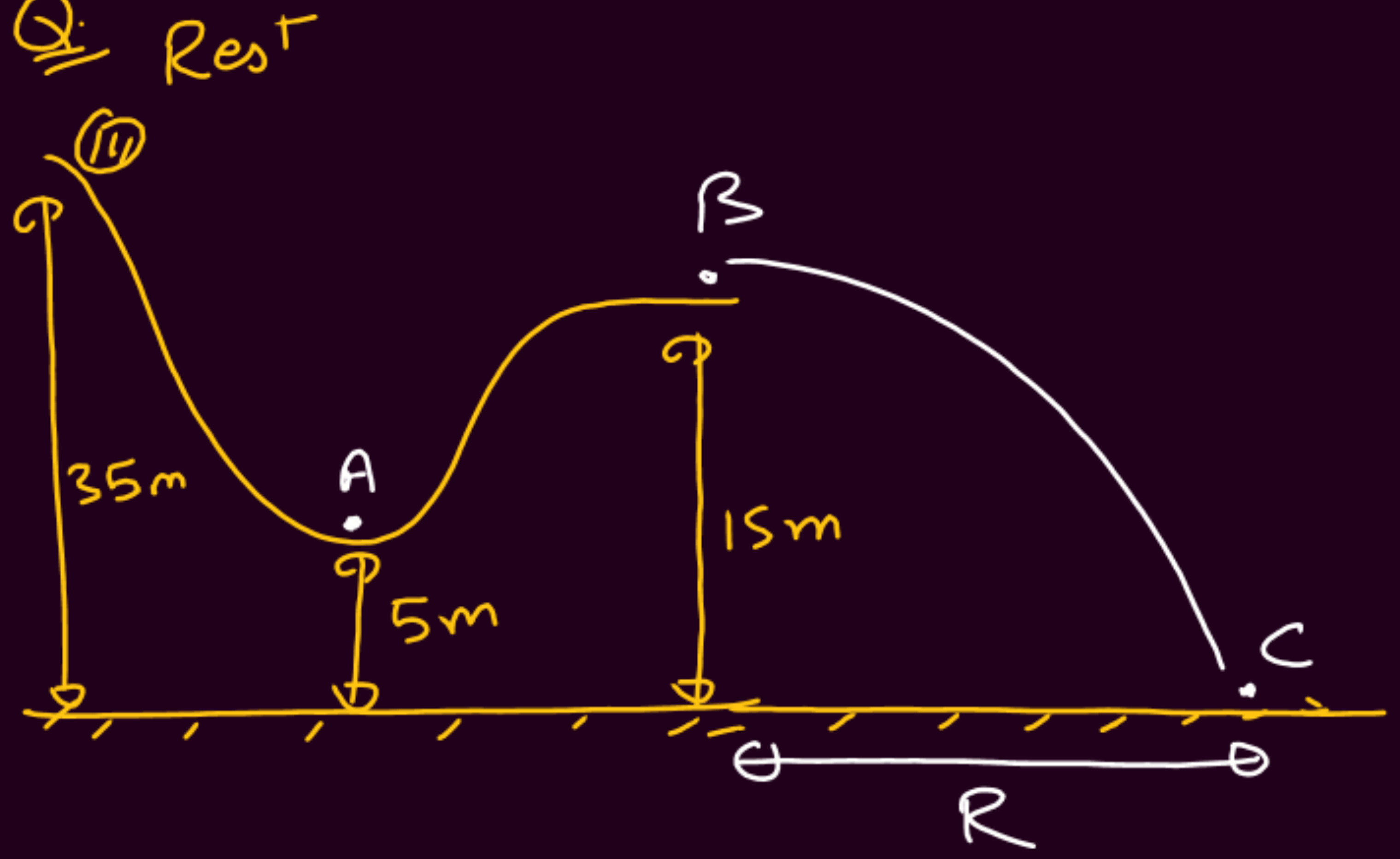
Q.



$$v^2 = (30)^2 - 2(10)(20)$$

$$v = 10\sqrt{5}\ m/s$$

Q.



① $v_A = \sqrt{2(10)(30)} = 10\sqrt{6}\ m/s$

② $v_B = \sqrt{2(10)(20)} = 20\ m/s$

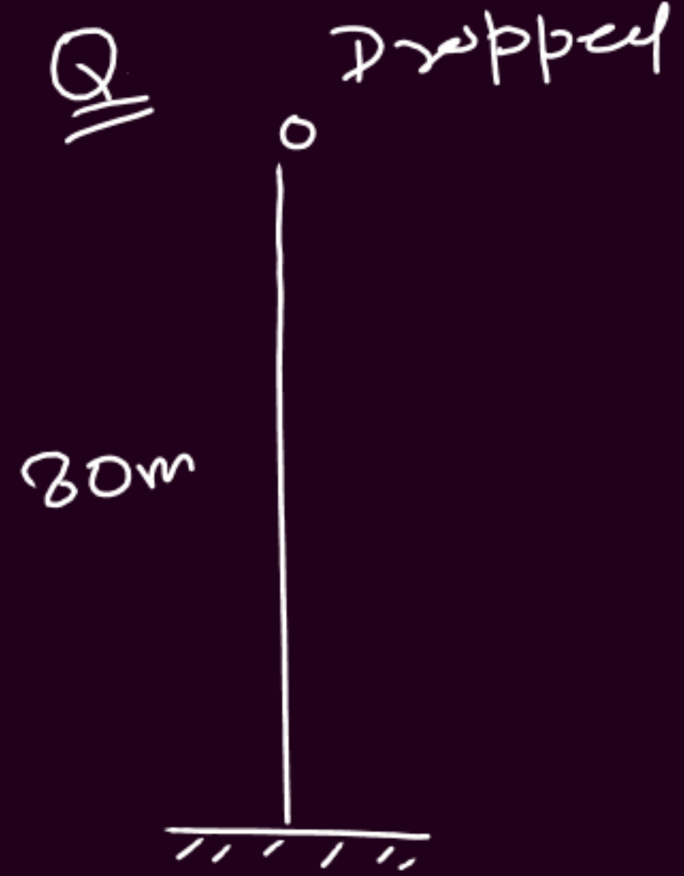
③ $v_C = \sqrt{2(10)(35)} = 10\sqrt{7}\ m/s$

④ $R = u\sqrt{\frac{2H}{g}} = (20)\sqrt{\frac{2 \times 15}{10}} = 20\sqrt{3}\ m$

$$\boxed{\frac{KE}{PE} = \frac{H-h}{h}}$$

$$\frac{KE}{PE} = \frac{mg(H-h)}{mgh}$$

Q



① at 30m

$$\frac{KE}{PE} = \frac{50}{30} = \frac{5}{3}$$

② Height $KE = 2(PE)$

$$\frac{KE}{PE} = \frac{2}{1} = \frac{80-h}{h}$$

$$h = \frac{80}{3}\,m$$

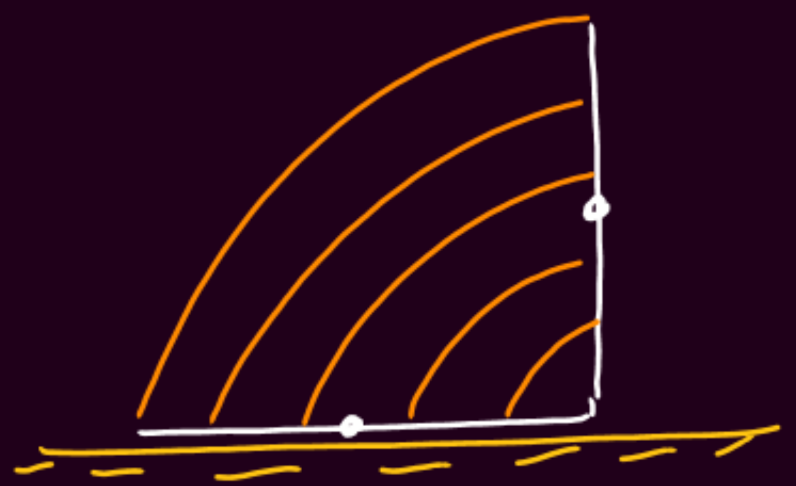
② Height

$$2(KE) = 3(PE)$$

$$\frac{KE}{PE} = \frac{3}{2} = \frac{80-h}{h}$$

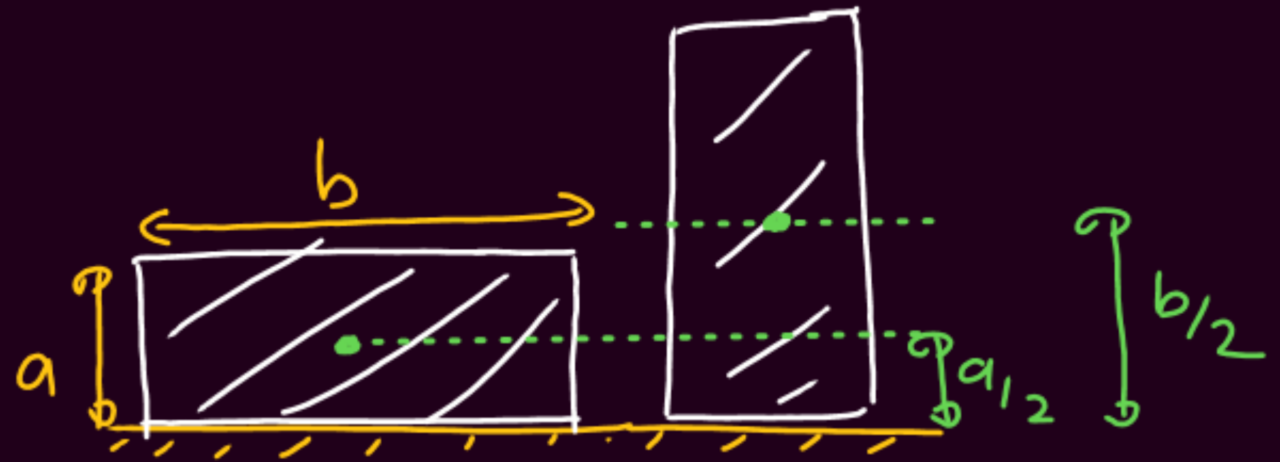
$$\boxed{h = 32\,m}$$

Rope / chain / Rod (Center of Mass)



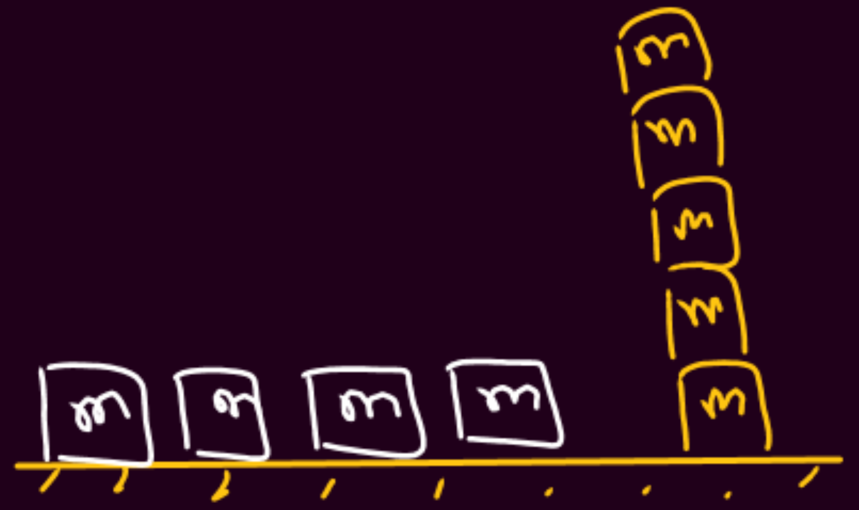
"Horizontal" ⟷ "Verticle"

$$\boxed{W = mg\frac{l}{2}}$$



$$w = mg\left(\frac{b}{2} - \frac{a}{2}\right)$$

n-identical cubes (m, l)



$$W = (nm)g\left(\frac{nl}{2} - \frac{l}{2}\right)$$

$$W = \frac{n(n-1)}{2}mgl$$

W.D.

$$\boxed{W = \frac{mgl}{2n^2}}$$

Q $1/3^{rd}$ part Hanging

$$\frac{l}{n} = \frac{l}{3}$$

$$n = 3$$

$$W = \frac{mgl}{2(3)^2} = \frac{mgl}{18}$$

Q $2/3^{rd}$ part is Hanging

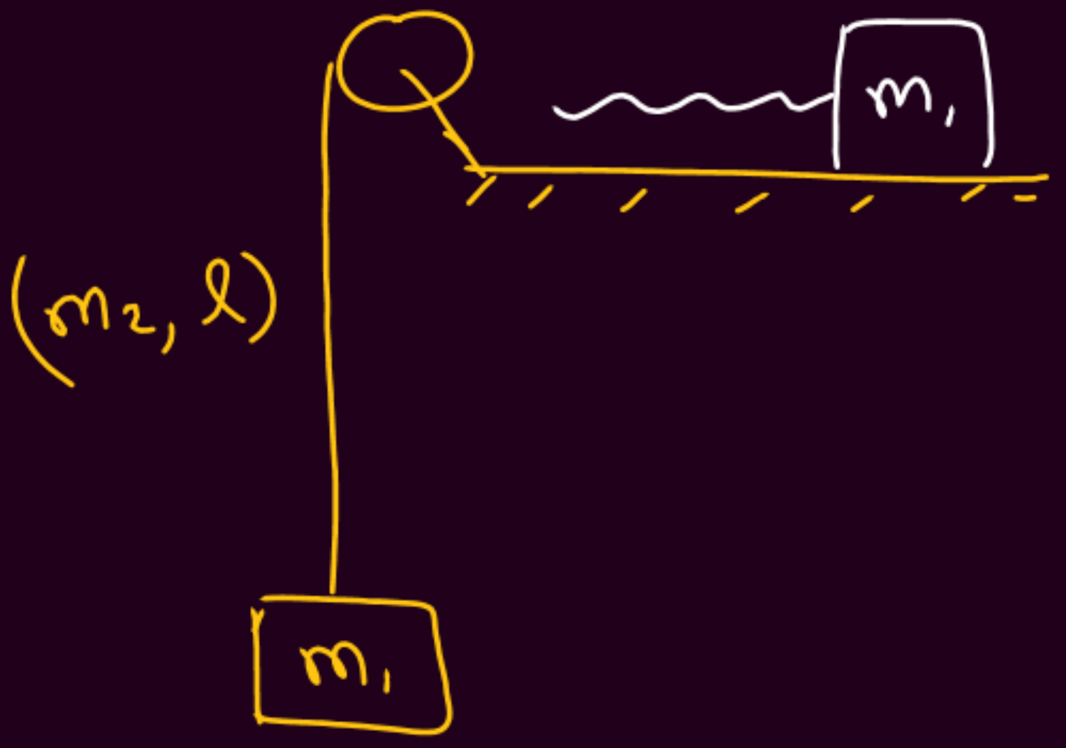
$$\frac{l}{n} = \frac{2l}{3}$$

$$n = 3/2$$

$$W = \frac{mgl}{2(3/2)^2}$$

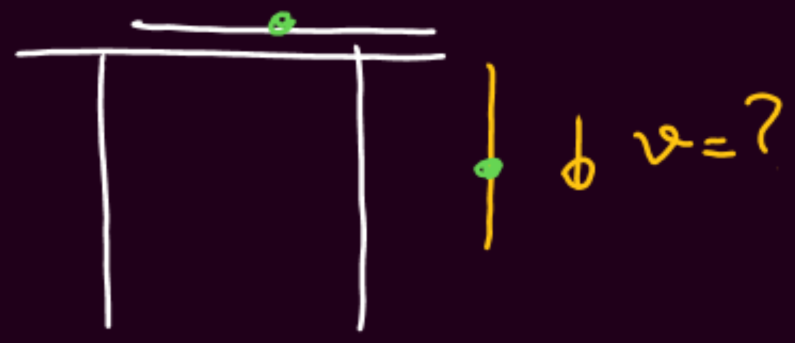
$$W = \frac{2mgl}{9}$$

Bucket & Rope



$$W = m_1 g l + m_2 g \frac{l}{2}$$

Q



$$U_i + K_i = U_f + K_f$$

$$mg\frac{l}{2} + 0 = 0 + \frac{1}{2}mv^2$$

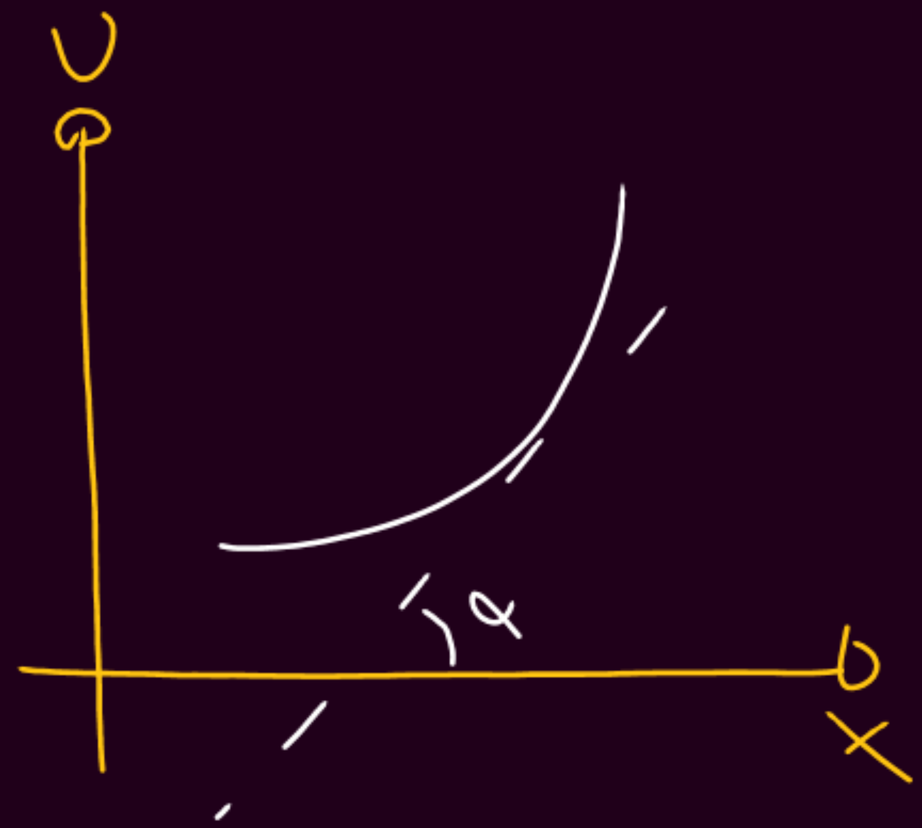
$$mg\frac{l}{2} = \frac{1}{2}mv^2$$

$$\boxed{v = \sqrt{gl}}$$

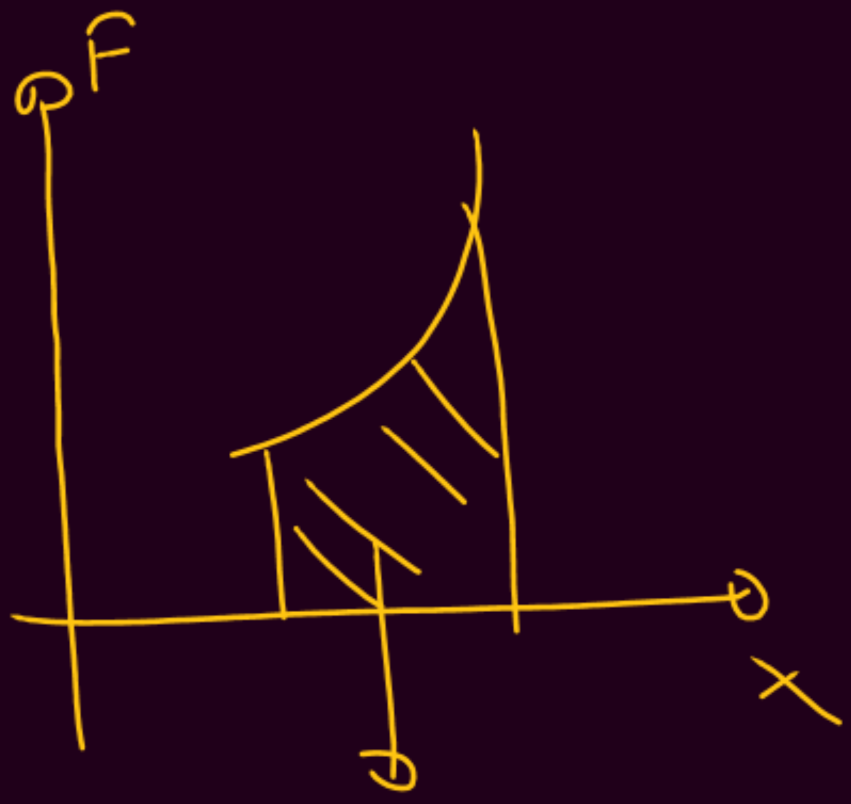
Relation betⁿ F & U

1D

$$\boxed{F = -\frac{dU}{dx}}$$



$F = -(\text{slope})$



$W = (\text{Area})$

$\Delta U = -(\text{Area})$

Q $U = (3x^2 - 2x + 1)$ J

F at $x = 2m$

$$\frac{dU}{dx} = 6x - 2$$

$$= 6(2) - 2$$

$$\frac{dU}{dx} = 10$$

$$F = -10N$$

Q. $U = (x^2 - 4x + 3)$

Find U in equilibrium?

① $F = 0$

$$\frac{dU}{dx} = 0$$

$$2x - 4 = 0$$

$$x = 2m$$

② $U = (2)^2 - 4(2) + 3$

$$U = -1J$$

Q

$$U = \frac{a}{r^6} - \frac{b}{r^{12}}$$

PE in Equilibrium ?

$$U = a\left(r^{-6}\right) - b\left(r^{-12}\right)$$

$$\frac{dU}{dr} = a\left(-6r^{-7}\right) - b\left(-12r^{-13}\right)$$

$$0 = -6ar^{-7} + 12br^{-13}$$

$$a = 2br^{-6}$$

$$\boxed{\frac{a}{2b} = \frac{1}{r^6}}$$

$$U = a\left(\frac{a}{2b}\right) - b\left(\frac{a}{2b}\right)^2$$

$$U = \frac{a^2}{2b} - \frac{a^2}{4b}$$

$$\boxed{U = \frac{a^2}{4b}}$$

$$\left\{\begin{array}{l} U = \dfrac{a}{r} - \dfrac{b}{r^2} \\[2ex] U = \dfrac{a}{r^3} - \dfrac{b}{r^6} \\[2ex] U = \dfrac{a}{r^4} - \dfrac{b}{r^8} \end{array}\right.$$

3D

$$F_x = -\frac{\partial U}{\partial x}$$

$$F_y = -\frac{\partial U}{\partial y}$$

$$F_z = -\frac{\partial U}{\partial z}$$

$$\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$$

Q $U = -3x^2yz$ $\vec{F}(1, -1, 1) = ?$

$$\frac{\partial U}{\partial x} = -6xyz = +6$$

$$\frac{\partial U}{\partial y} = -3x^2z = -3$$

$$\frac{\partial U}{\partial z} = -3x^2y = +3$$

$$\vec{F} = -6\hat{i} + 3\hat{j} - 3\hat{k}$$

$$F = 3\sqrt{6}\ N$$

Q. $U = x^2 y - 3z + 4yz^2$ $\quad \vec{F}(1, 0, -1) = ?$

$$\frac{\partial U}{\partial x} = 2xy = 0$$

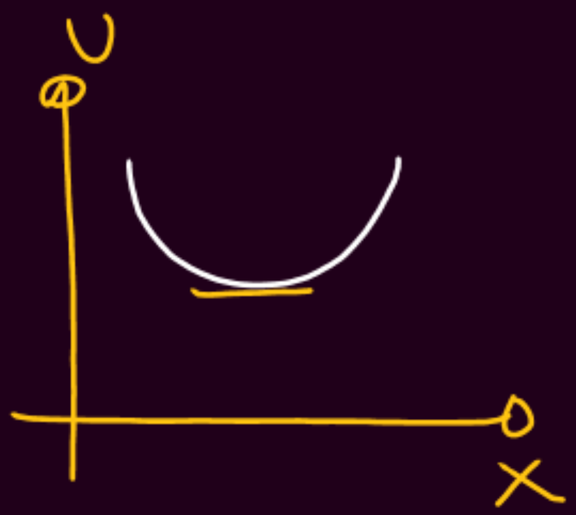
$$\frac{\partial U}{\partial y} = x^2 + 4z^2 = 1 + 4 = 5$$

$$\frac{\partial U}{\partial z} = -3 + 8yz = -3$$

$$\boxed{\vec{F} = (-5\hat{j} + 3\hat{k})\ N}$$

Types of Equilibrium

Stable



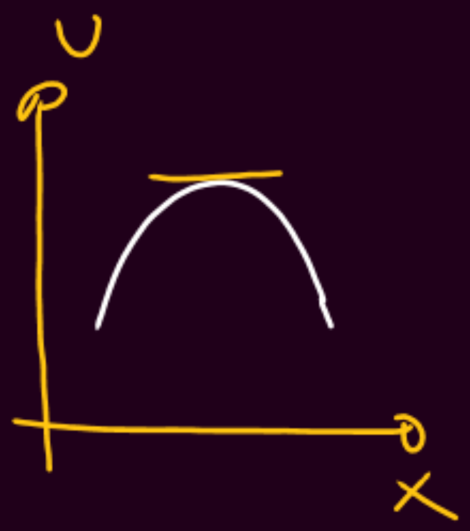
$$F = 0$$

$$\frac{dU}{dx} = 0$$

$$\frac{d^2U}{dx^2} > 0$$

(minima)

Unstable



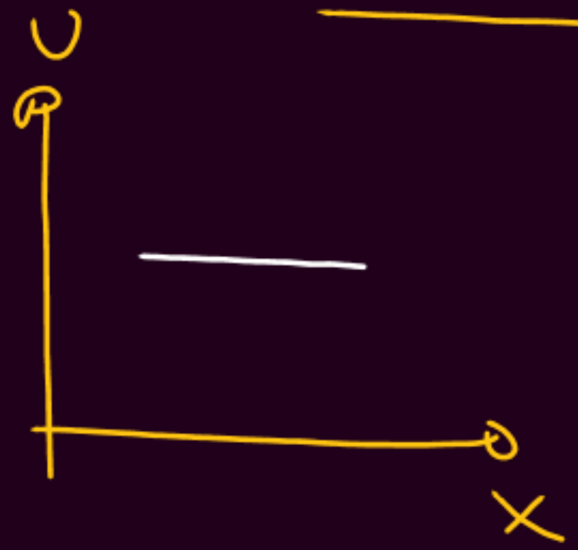
$$F = 0$$

$$\frac{dU}{dx} = 0$$

$$\frac{d^2U}{dx^2} < 0$$

(maxima)

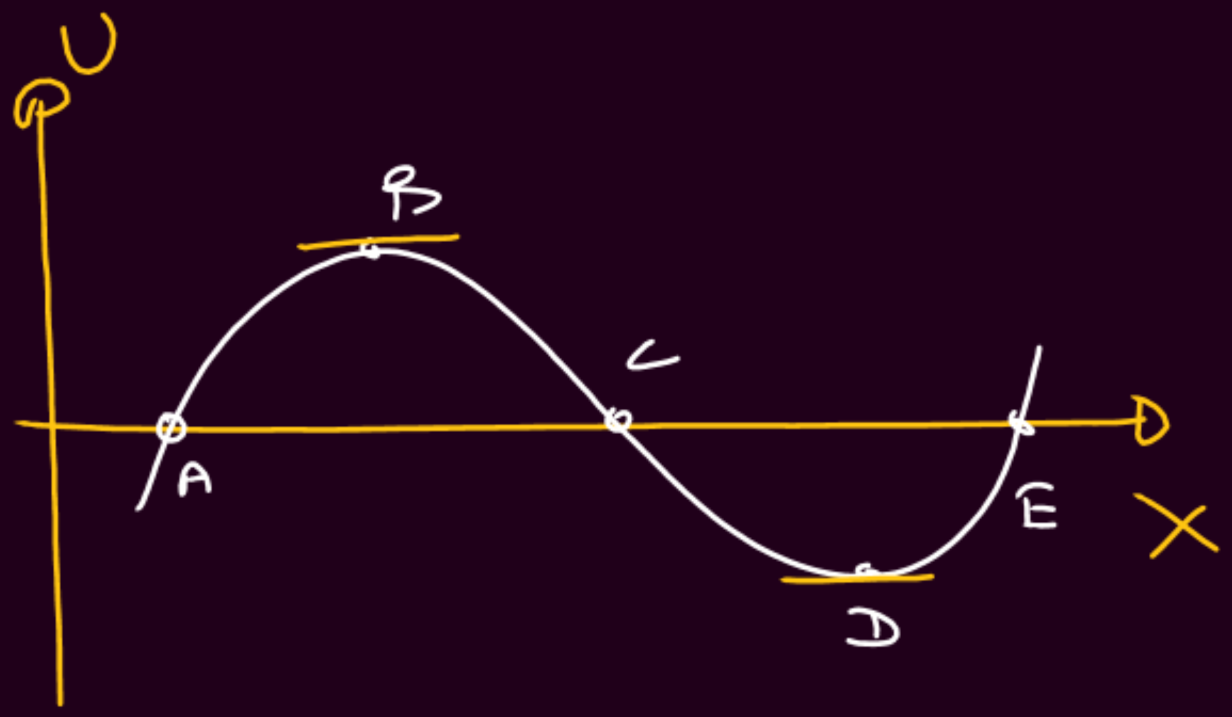
Neutral



$$F = 0$$

$$\frac{dU}{dx} = 0$$

$$\frac{d^2U}{dx^2} = 0$$



Equilibrium B, D

Stable D

Unstable B

Power

① Inst. Power $\boxed{P_{inst} = \vec{F} \cdot \vec{v} = \frac{dW}{dt}}$

② Avg Power $\boxed{P_{av} = \frac{W}{\Delta t}}$

Unit

$$\left.\begin{array}{l} W = J/s \\ 1\ hp = 746\ W \end{array}\right\} \text{Power}$$

$$\left.1\ kWhr = 3.6 \times 10^{6}\ J\right] \text{Commercial unit of Energy}$$

Net Power

$$P_{inst} = \vec{F}_{net} \cdot \vec{v} = \frac{dK}{dt}$$

$$P_{av} = \frac{W_{by\ all}}{\Delta t} = \frac{\Delta K}{\Delta t}$$

Q. $\vec{F} = (3\hat{i} - 4\hat{j} + 5\hat{k})\ N$

$\vec{v} = (2\hat{i} + \hat{j} + 3\hat{k})\ m/s$

$P_{inst} = ?$

$P = \vec{F} \cdot \vec{v}$

$P = 6 - 4 + 15$

$P = 17W$

Q. Rest const. force v_0 at t_0
mass m

① Power delivered at t

$$P = Fv = m(a)(at) = m\left(\frac{v_0}{t_0}\right)^2 t$$

$$\boxed{v_0 = 0 + at_0}$$

② Power deliver in t

$$P = \frac{\Delta K}{\Delta t} = \frac{\frac{1}{2}mv^2}{t} = \frac{1}{2}m\frac{a^2t^2}{t}$$

$$P = \frac{1}{2}m\left(\frac{v_0}{t_0}\right)^2 t$$

Pg - 219

45

$$P_{av} = \frac{W}{t}$$

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

$$= \frac{1}{2}\frac{m(at)^2}{t}$$

$$= \frac{1}{2}(ma)(at)$$

$$= \frac{Fv}{2}$$

43

$f_r = 0.5$ kgf / quintal

$1000\,N \longrightarrow f = 5\,N$

$10^7\,N \longrightarrow f = \frac{5}{10^3} \times 10^7$

$$P = (5\times10^4)\left(36\times\frac{5}{18}\right)$$

$$P = 5\times10^5\ W$$

$$= \underline{500\ kW}$$

48

$$F - \mu mg = ma$$

$$F = (\mu mg + ma)$$

$$v = at$$

$$P = m(\mu g + a)at$$

Pg - 192

2

$$\frac{(12)(746)}{1000} \text{ kW}$$

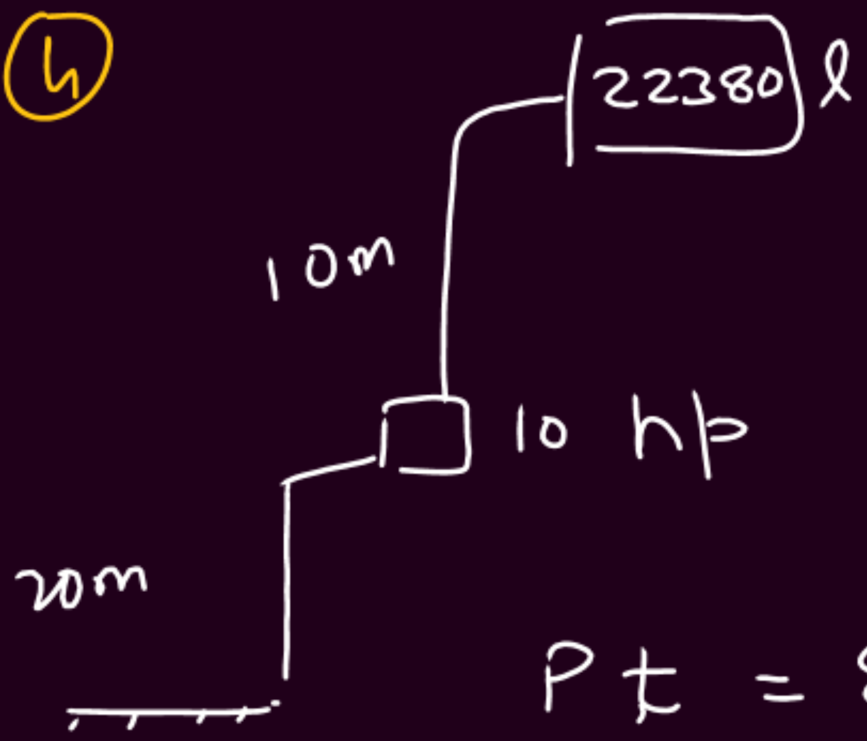
$$\frac{(12)(746)}{1000} \times (8)(10) \text{ kWhr}$$

$$\text{Rs } \frac{(0.5)\cancel{(12)}\cancel{(750)}\cancel{(8)}\cancel{(10)}}{\cancel{1000}}$$

40, 3, 3, 4

$= 360$

4



$$Pt = E = mgh$$

$$t = \frac{(\cancel{22380})(10)(30)}{(1\cancel{0})(\cancel{746})}$$

3

$$t = \frac{30 \times 30}{60} = 15 \text{ min}$$

10 Heart

$$\text{Power} = \frac{dW}{dt} = P\frac{dV}{dt}$$

$$\text{Power} = (20000)(10^{-6})$$

$$= 0.02\,W$$

Q $m = 2\,kg$

$v = (2t^2 - 4t + 1)\ m/s$

① Power delivered in 3s ?

$$P_{av} = \frac{\Delta K}{\Delta t} = \frac{\frac{1}{2}m(v^2 - u^2)}{\Delta t}$$

$$= \frac{2(7^2 - 1^2)}{2\ (3)} = 16\,W$$

$t = 0 \quad u = 1$

$t = 3 \quad v = 18 - 12 + 1 = 7$

② Power delivered at 3s ?

$$\frac{dv}{dt} = a = (4t - 4)$$

$$P = Fv = (2)(4 \times 3 - 4)(7)$$

$$\underline{P = 112\,W}$$

Case-1 $F = \text{const.}$

$x \propto t^2$

$v \propto t$

$a \propto t^0$

$P \propto t$

$P = Fv$

$P = F(at)$

$P = F\sqrt{2ax}$

$v \propto \sqrt{x}$

$a \propto x^0$

$P \propto \sqrt{x}$

Case $P = \text{Const}$

$$P = \frac{\Delta K}{\Delta t}$$

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

Rest $(t=0)$

$$\frac{1}{2} m v^2 = Pt$$

$$\boxed{v = \sqrt{\frac{2Pt}{m}}}$$

$$x \propto t^{3/2}$$

$$v \propto t^{1/2}$$

$$a \propto t^{-1/2}$$

$$P = F v$$

$$P = m \frac{dv}{dt} v$$

$$v^2 \propto t$$

$$v \propto x^{1/3}$$

$$a \propto x^{-1/3}$$

$$P = m\left(v \frac{dv}{dx}\right) v$$

$$v^3 \propto x$$

Water Jet

$$F = \rho A v^2$$

$$P = \rho A v^3$$

Motor

① Power of motor $= \rho A v^3$

② (Rate at which the KE is imparted) $= \frac{1}{2} \rho A v^3$

mass per unit length $= \rho A$

Pg-228

2

$P = (\rho A) v^3$

$= 100 (2)^3$

$= \underline{800\ W}$

35

$$P = \frac{mgh}{t}\left(\frac{90}{100}\right)$$

$P = 15 \times 10 \times (60)\ (0.9)$

$= 8100\ W$

$= 8.1\ W$

26

$\vec{F} = 2t\,\hat{i} + 3t^2\,\hat{j}$

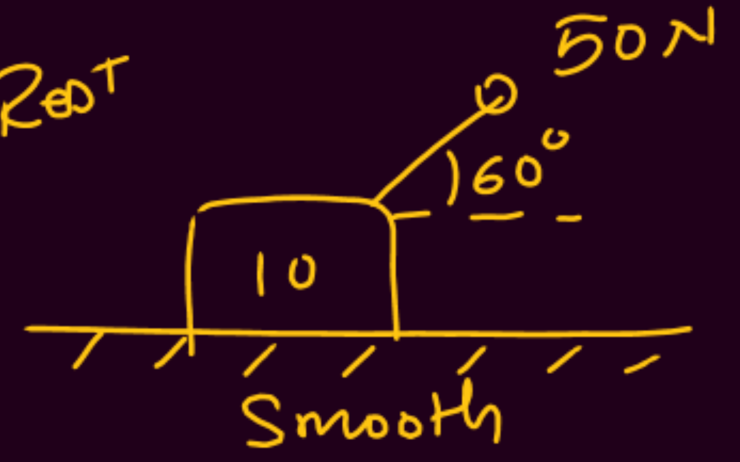
$\vec{a} = 2t\,\hat{i} + 3t^2\,\hat{j}$

$\vec{v} = t^2\,\hat{i} + t^3\,\hat{j}$

$P = \vec{F} \cdot \vec{v}$

$P = (2t^3 + 3t^5)\ W$

Q



Power delivered by force at 2s ?

① $a = \frac{25}{10} = 2.5\ m/s^2$

② $v = at = (2.5)(2) = 5\ m/s$

$P = \vec{F} \cdot \vec{v}$

$P = Fv\cos\theta$

$P = (50)(5)\cos 60^\circ$

$\boxed{P = 125\ W}$