E&M1

work done
Power
Energy
energy Cons.
momentum
momentum Cons.
Impulse
collision → Head on Head → oblique
COM & its application

Work done by force:

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

Force acting on body

for point object, it is going act over it

Displacement of body

for point object

For extended object:

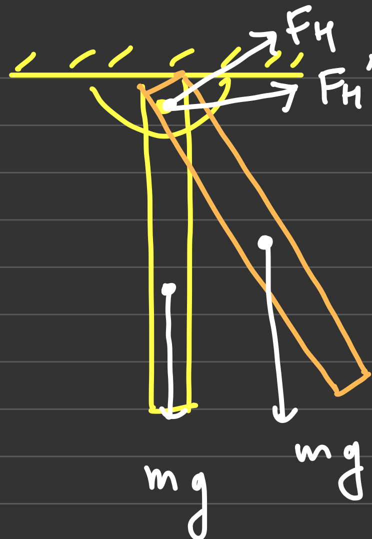
$W = \vec{F}\cdot\vec{S}$ → Displacement of point of Application of force

Force acting on body

$|F||S|\cos\theta$

"Valid for Constant force"

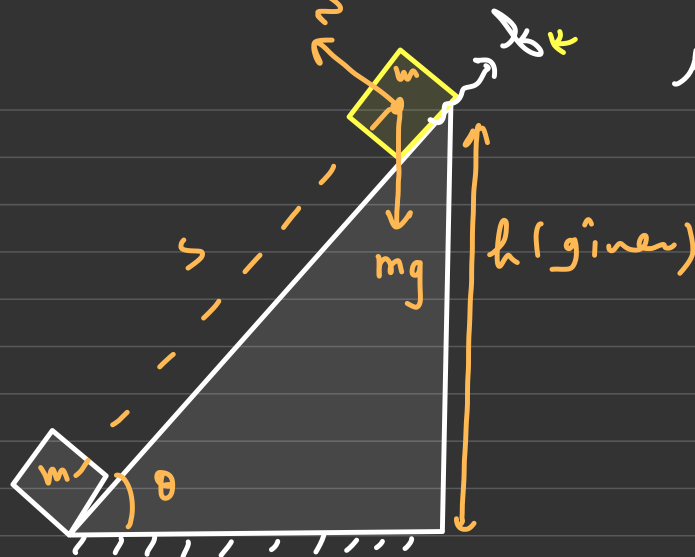
Eg #



$W_{mg} \neq 0$

$W_{Hinge} = 0$

e)



μ_k

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

$h = s\sin\theta$

$W_{mg} = F s \cos\theta = mg\, s \cos(90-\theta) = mgs\sin\theta$

$= mgh$

$W_N = FS\cos 90 = 0$

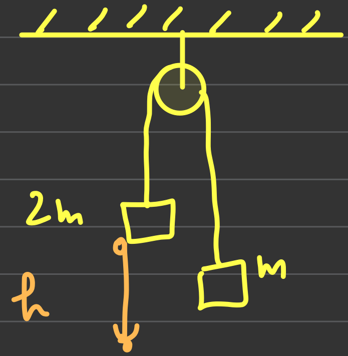
$W_{f_k} = f_k\, s \cos(180) = f_k\, s(-1) = -(\mu_k\, mg\cos\theta)\frac{h}{\sin\theta}$

$= -\mu_k\, mgh \cot\theta$

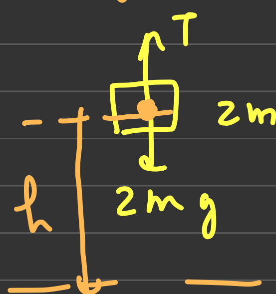
$$W_{Total} = mgh - \mu_k mgh \cot\theta$$

\# released from rest

Q)



find work on both block?



$W_{mg} = -mgh$

$W_T = +Th$

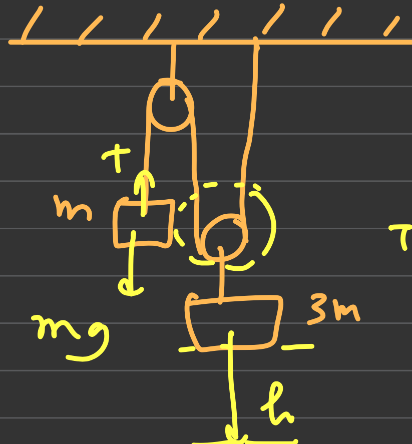
$W_{2mg} = 2mgh\cos 0 = 2mgh$

$W_T = Th\cos(180) = -Th$

$W_T = 2mgh - mgh = mgh$

9)

System Released from rest



$T' = 2T$

$$\underset{\sim}{m}: \quad W_{mg} = \underset{\sim\sim}{-2mgh}$$

$$W_T = \underset{\sim\sim}{+2Th}$$

$$\underset{\sim}{3m}: \quad W_{3mg} = +3mgh$$

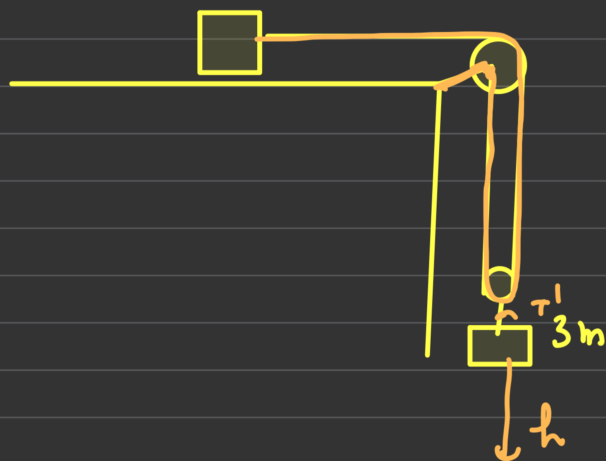
$$W_{T'} = -2Th$$

$\Rightarrow$ 

$$W_{Total} := 3mgh - 2mgh + 2\cancel{T}h - 2\cancel{T}h$$

$$= \underset{\sim\sim}{mgh}$$

e)



3m:

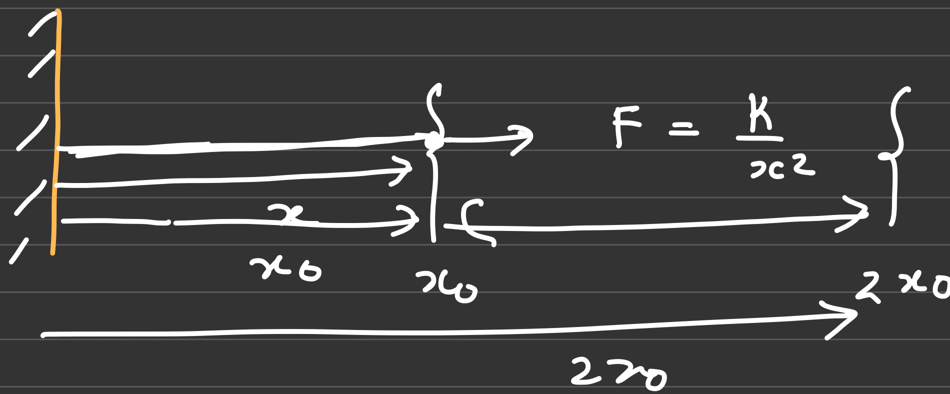
$$\begin{cases} W_{3mg} = \underbrace{3mgh} \\ W_{T'} = -2Th \end{cases}$$

m:

$$\begin{cases} W_T = 2Th \\ W_{mg} = 0 & \theta = 90 \\ W_N = 0 & \theta = 90 \end{cases}$$

$$\underbrace{W_{Total}} = \underbrace{(3mgh)}$$

work done due to variable :



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

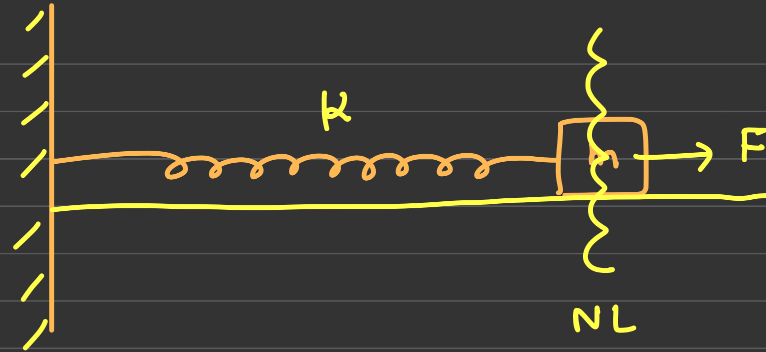
$$W = \int \frac{K}{x^2}\, dx \cos(0)$$

$$W = K \int \frac{dx}{x^2} = K\left[-\frac{1}{x}\right]_{x_0}^{2x_0}$$

$$W = -K\left[\frac{1}{2x_0} - \frac{1}{x_0}\right]$$

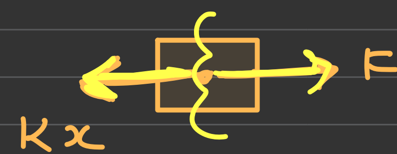
$$W = +\left[\frac{K}{2x_0}\right]$$

Q)



if block is slowly moved rightward by x_0 then find work by ext. force and spring force over block?

$a = 0$



$F = Kx$

$$W_{ext} = \int Kx\,dx \cos 0 = \int_0^{x_0} Kx\,dx$$

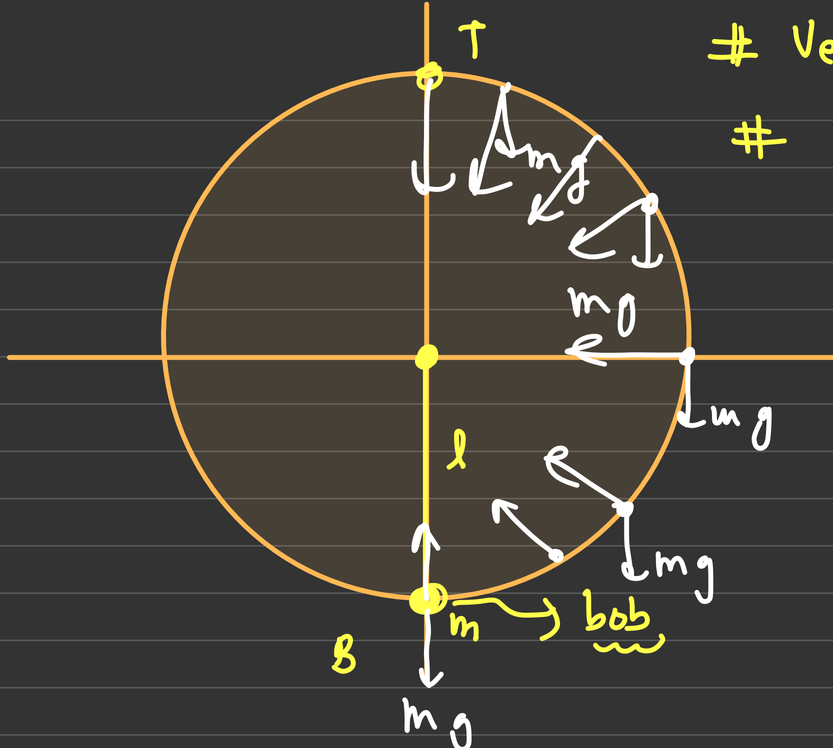
$$= \left[\frac{Kx^2}{2}\right]_0^{x_0}$$

$$= \left[\frac{Kx_0^2}{2}\right] \; \underline{\underline{4}}$$

$$W_{spring} = \int Kx\,dx \cos 180$$

$$= -\left[\frac{1}{2}Kx^2\right]_0^{x_0} = \underbrace{-\frac{1}{2}Kx_0^2}$$

Q)



Vertical Circular motion

find work done by mg and T from bottom to top?

$W_{mg} = \underbrace{-2mgl}$

$W_T =$

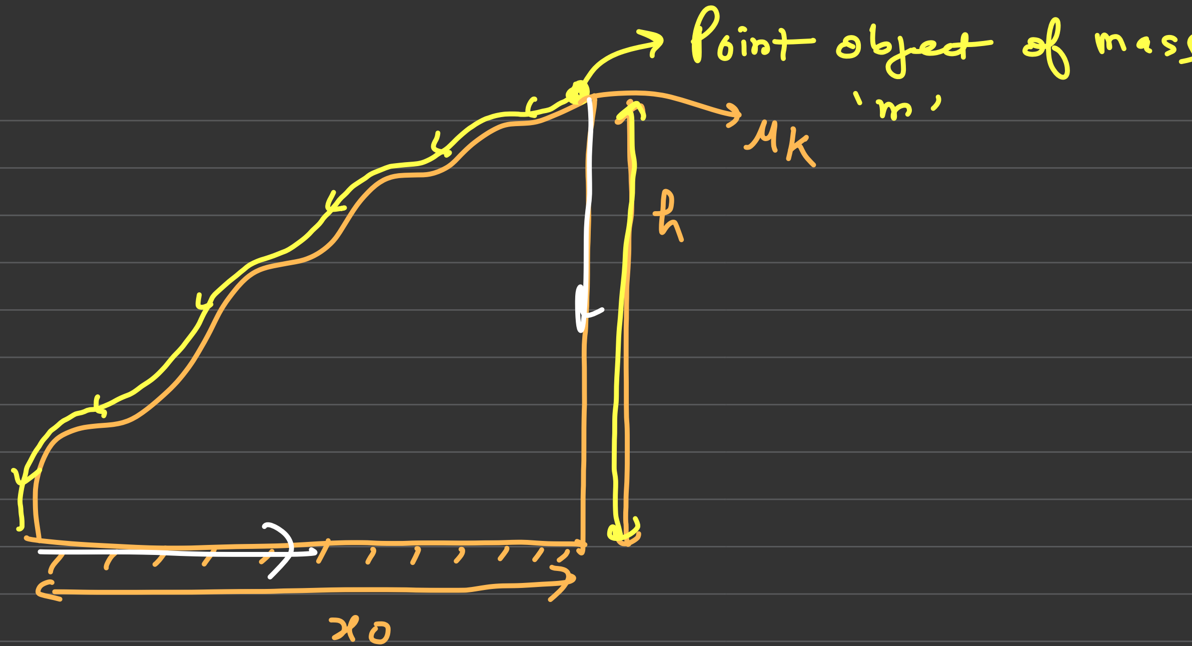
at every instant angle between T and $dx = 90°$

hence $\underbrace{W_T = 0}$

Ans

$$\begin{cases} W_{mg} = -2mgl \\ W_T = 0 \end{cases}$$

Q)



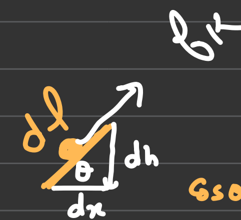
find d

$$\begin{cases} \omega_{mg} = +\underbrace{mgh} \\ \underline{\underline{\omega_{f_K} =}} \end{cases}$$

$$\left\{ \underline{\underline{W_N}} = 0 \right\} \qquad \left\{ N \text{ and } dx \right\}$$

$\theta = 90$ always

: work done due to friction :



$\cos\theta = \dfrac{dx}{dl}$

$dx = dl \cos\theta$

$$\int dW_{f_k} = \int f_k \, dl \cos 180$$

$$W_{f_k} = -\int \mu_k mg \cos\theta \, dl$$

$$= -\mu_k mg \int \underline{\cos\theta \cdot dl}$$

$$= -\mu_k mg \int_0^{x_0} dx$$

$$= -\mu_k m g x_0$$

Power:

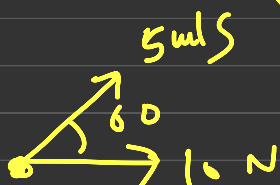
Power:

$$P_{inst} = \frac{dw}{dt} = \frac{d}{dt}(\vec{F}\cdot\vec{s})$$

$$= \vec{F}\cdot\frac{d\vec{s}}{dt}$$

$$P_{inst} = \vec{F}\cdot\vec{v}$$

"const or variable valid for both"



$$P = 10\times 5\cos 60$$

$$= 50\times\frac{1}{2} = 25 \text{ watt } (J/s)$$

Q)

$P = kt^2$

+ve Const

work done by force from t_0 to $2t_0$?

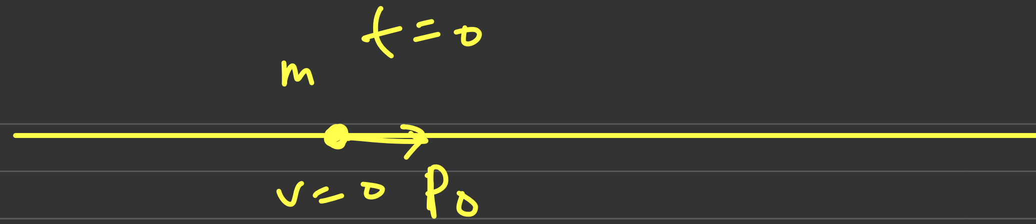
$$\frac{dw}{dt} = kt^2$$

$$\int dw = \int_{t_0}^{2t_0} kt^2\,dt$$

$$w = k\left[\frac{t^3}{3}\right]_{t_0}^{2t_0} = k\left[\frac{8t_0^3 - t_0^3}{3}\right]$$

$$= \left(\frac{7}{3}kt_0^3\right) \underline{Ans}$$

Q)



F and v is in same direction "given"

$v(t) = ?$

$$\Rightarrow P_0 = \vec{F} \cdot \vec{v}$$

$$\Rightarrow P_0 = F v$$

$$\Rightarrow P_0 = m a v$$

$$\Rightarrow a v = \frac{P_0}{m}$$

$$\Rightarrow \frac{dv}{dt} \cdot v = \frac{P_0}{m}$$

$$\Rightarrow \int_0^v v \cdot dv = \int_{t=0}^{t} \frac{P_0}{m}\, dt$$

$$\frac{v^2}{2} = \frac{P_0 t}{m}$$

$$v = \sqrt{\frac{2P_0 t}{m}}$$

Q) Starting from rest

$t = 0 \quad v = 0$

$x = 0$

$$P = Kx^2 \quad (0,0)$$

$$v(x) = ?$$

$$\vec{F} \cdot \vec{v} = Kx^2$$

$$Fv = Kx^2$$

$$mav = Kx^2$$

$$av = \frac{Kx^2}{m}$$

$$v \cdot \frac{dv}{dx} \cdot v = \frac{Kx^2}{m}$$

$$\int_{v=0}^{v} v^2 \, dv = \int_{x=0}^{x} \frac{Kx^2}{m} \, dx$$

$$\frac{v^3}{3} = \frac{Kx^3}{3m}$$

$$v = \left(\frac{Kx^3}{m}\right)^{1/3}$$

: Energy :

"Capacity of body to do work"

if some work is done on body

+ve → $E \uparrow$

−ve → $E \downarrow$

① Kinetic Energy :

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

② Potential Energy :

$\rightarrow v \Rightarrow \frac{1}{2} m v^2$

$$\int \frac{1}{2} dm \times v^2 = \frac{1}{2} v^2 (m)$$

method II

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

work energy theorem

$$W = \Delta U + \Delta K$$

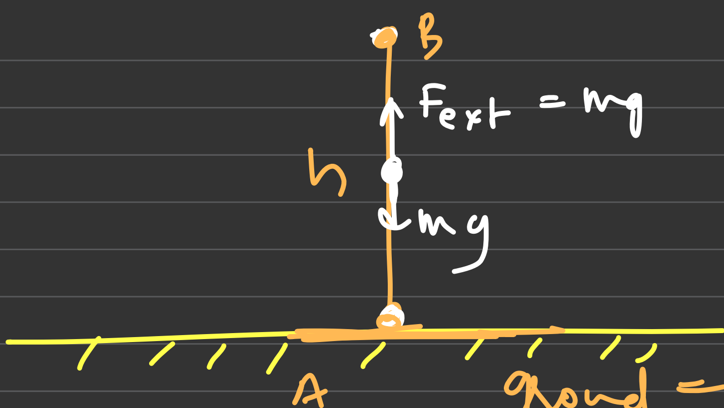
$A \longrightarrow B$

A Slowly B

$$W_{ext} = \Delta U$$

" Change in Potential is always work done by external agent (Except Cons. force) from from A to B Slowly "

#



change → final − initial

$W_{ext} = (\Delta U)_{AB}$

$+mgh = (\Delta U)_{AB}$

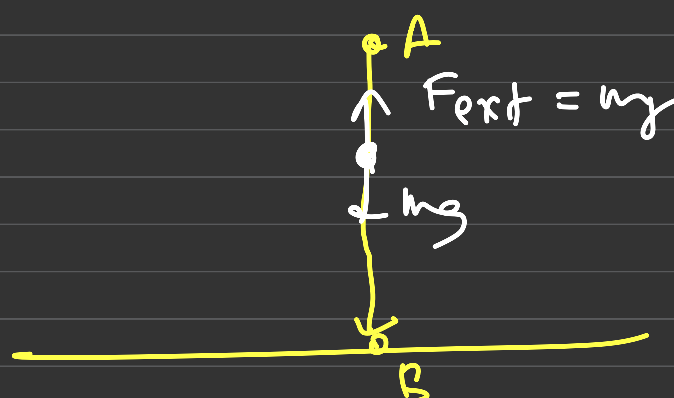
$U_B - U_A = +mgh$

ground = 0 Potential

$U_A = 0$ $\quad U_B = +mgh$

$a = 0$

#



$W_{ext} = \Delta U + \cancel{\Delta K}$ 0

$-mgh = (\Delta U)_{AB}$

$-mgh = \cancel{U_B} - U_A$ 0

$U_A = +mgh$

Law of Conservation Energy:

INEA

\# work

\# Power

DPS #1

Pre-class

Vertical Circular