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Conservative Force

Forces whose work doesn't depend on the path. It ionly depends on initial & final position. are called Conservative forces.

Ex:-

1. Gravitational force.
2. Spring force.
3. Electrostatic force.

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Non-Conservative force

Forces whose work done depends on path are called Non-Conservative.

Ex:- Friction.

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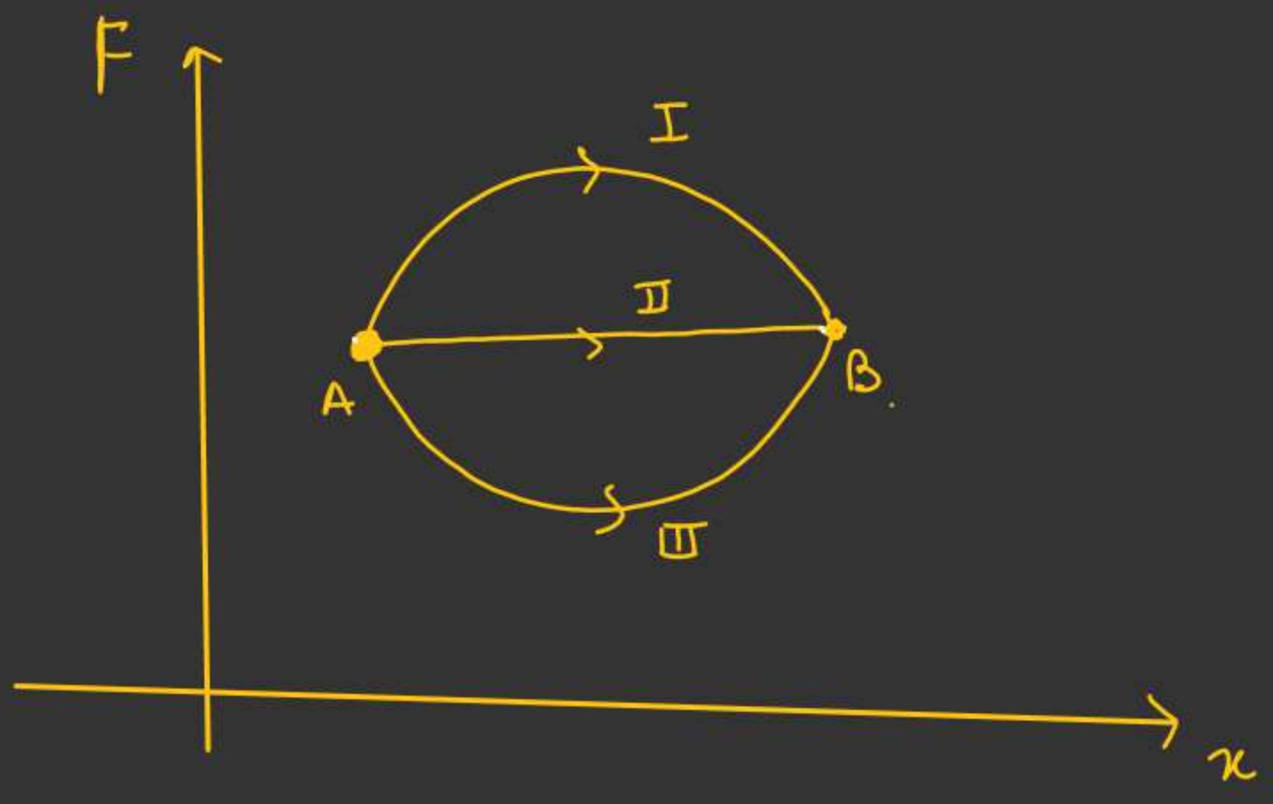
F acts on a particle and particle is displaced via three different path I, II & III

If W_I, W_{II} & W_{III} be the work done by F. Arrange W_I, W_{II} & W_{III} in increasing order.

if a) F is Conservative

b) F is non-Conservative



Sol^n :- a) If F is Conservative

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

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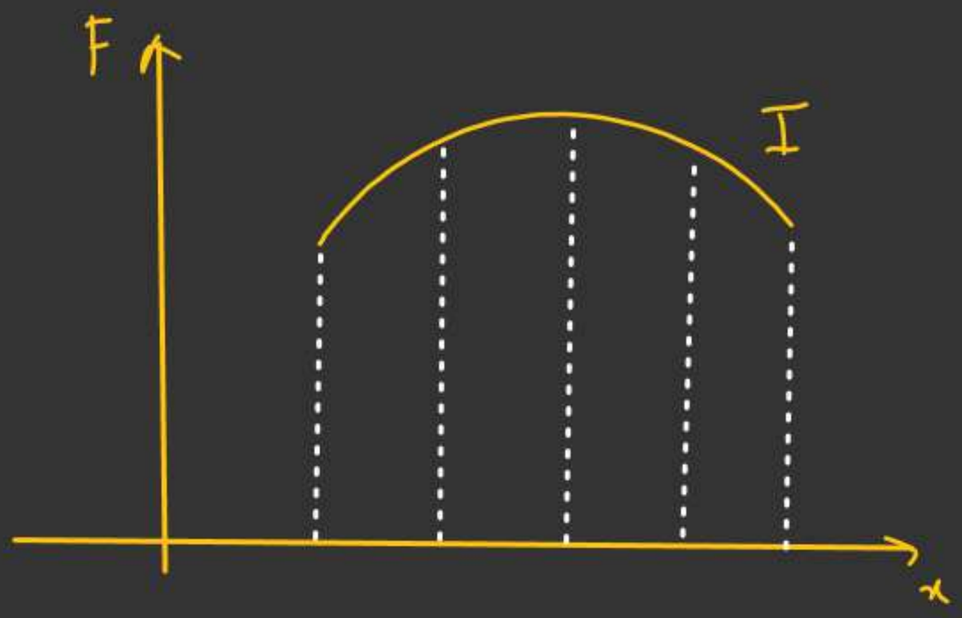
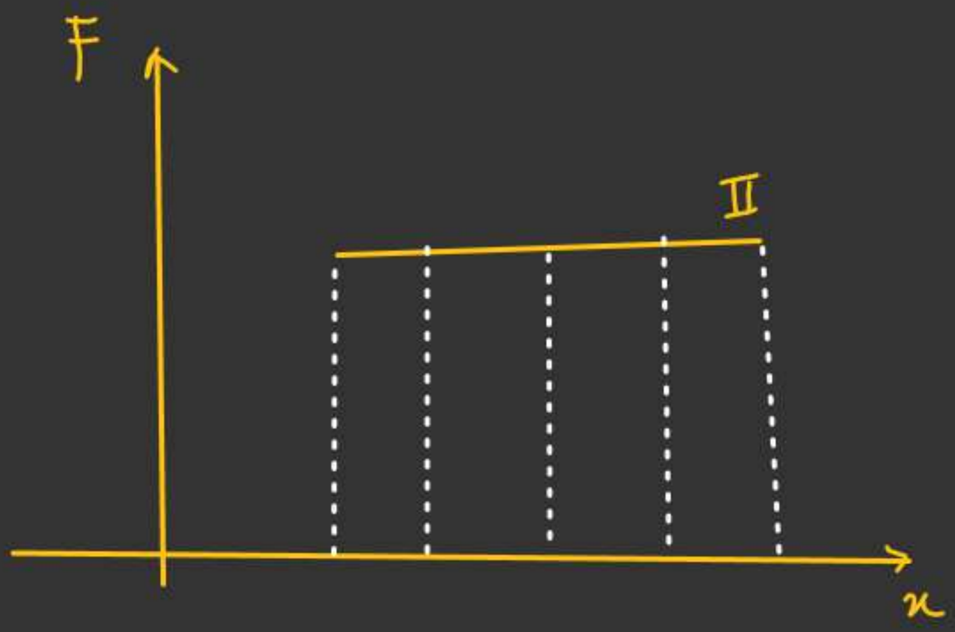
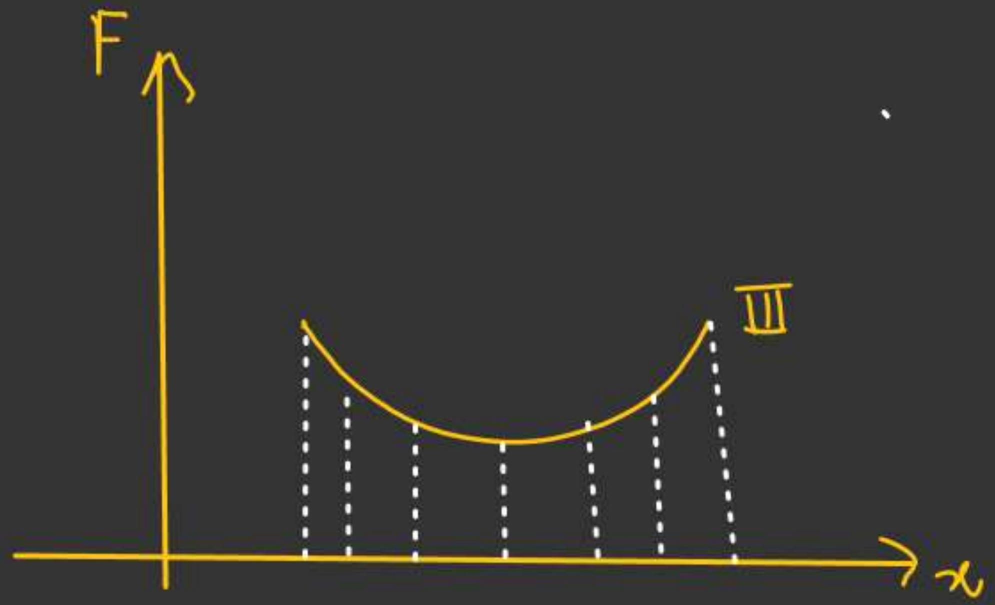
(b) If F is non-conservative







$$W_{I} > W_{II} > W_{III}$$

(Area under curve) gives work done.

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$$\vec{F} = (y\hat{i} + x\hat{j})$$

Work for path OB

$$d\vec{s} = dx\hat{i} + dy\hat{j}$$

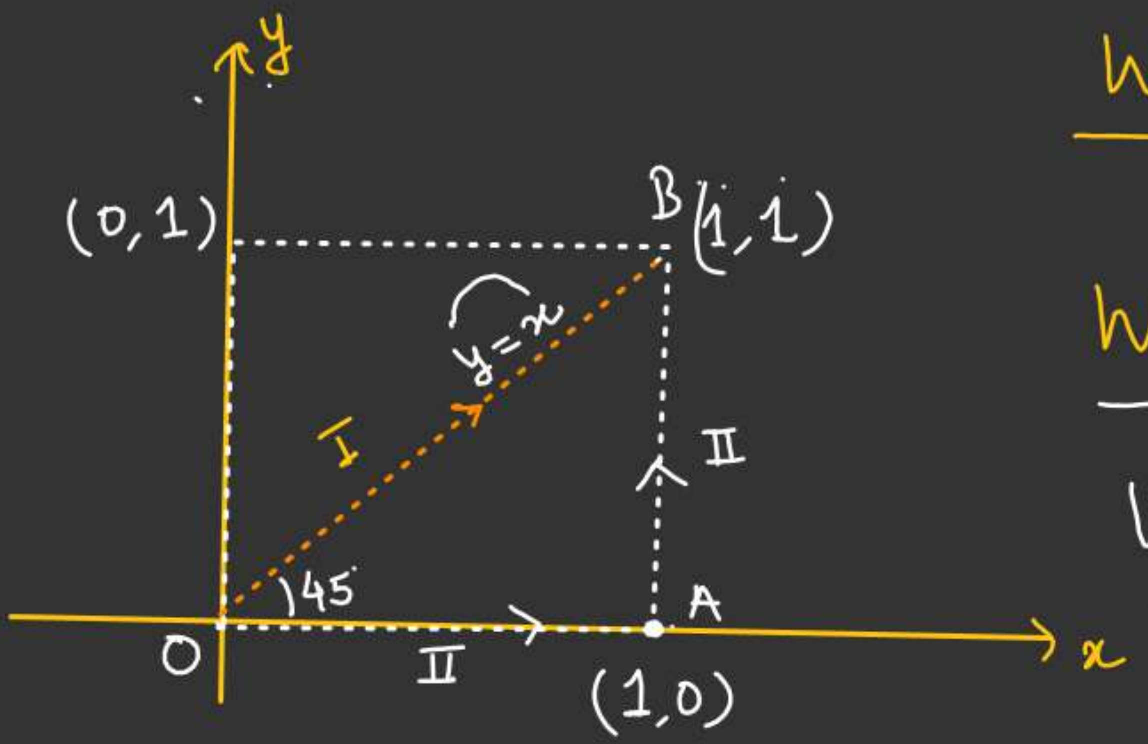
$$dW = \vec{F} \cdot d\vec{s}$$

$$dW = (y\hat{i} + x\hat{j}) \cdot (dx\hat{i} + dy\hat{j})$$

$$\int_0^{W_{OB}} dW = \int y\,dx + \int x\,dy$$

$$= \int_0^1 x\,dx + \int_0^1 y\,dy$$

$$W_{OB} = \frac{1}{2} + \frac{1}{2} = 1\,J$$



$W_{OAB} = ??$

$$W_{OAB} = \underset{0}{W_{OA}} + \underset{1\,J}{W_{AB}}$$

$W_{OA} = ?$

$y = 0$, $\vec{F} = x\hat{j}$ ✓

$$d\vec{s} = dx\hat{i}$$

$$dW = \vec{F} \cdot d\vec{s} = 0$$

$$W_{OA} = 0$$

$W_{AB} = ?$ $\quad \vec{F} = (y\hat{i} + (1)\hat{j})$

$x = 1$, $\quad d\vec{s} = dy\hat{j}$

$$dW_{AB} = \vec{F} \cdot d\vec{s}$$

$$= (y\hat{i} + \hat{j}) \cdot dy\hat{j} = dy$$

$$\int_0^{W_{AB}} dW_{AB} = \int_0^1 dy = 1\,J$$

$W_{OB} = W_{OAB}$

$\Rightarrow$ [Conservative Force

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Another Approach

$\vec{F} = y\hat{i} + x\hat{j}$

$d\vec{s} = dx\hat{i} + dy\hat{j}$

$\int dx = x$

$dW = \vec{F}\cdot d\vec{s}$

$\int_0^W dW = \int (y\,dx + x\,dy)$

$= \int dy_1$

$\int_0^W dW = \int_{(0,0)}^{(1,1)} d(xy) = [xy]_{(0,0)}^{(1,1)} = \underline{1\,J}$ ✓

$y_1 = (xy)$

Differentiating both side w.r.t x

$\frac{dy_1}{dx} = \frac{d}{dx}(xy) = x\frac{dy}{dx} + y\frac{d}{dx}(x)$

$\frac{dy_1}{dx} = x\frac{dy}{dx} + y.$

$dy_1 = x\,dy + y\,dx$ ✓

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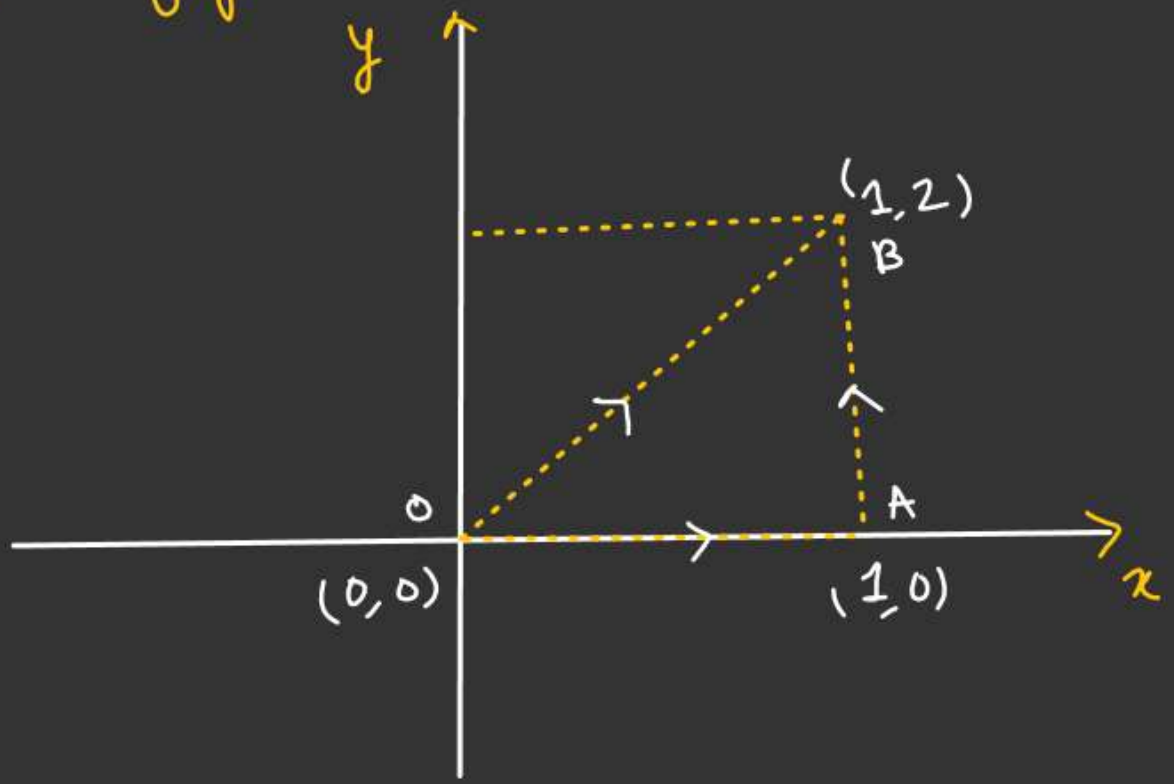
Q:

$$\vec{F} = (y^2\hat{i} + x\hat{j})$$

Find work done by this force along the path Shown in fig.

$W_{OB} = ?$

$W_{OAB} = ?$



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Potential Energy

Work done against the System force or −ve of the work done by System force is Stored in Some useful amount of energy within the body. This energy is called Potential energy

$$\boxed{-W_{system} = +W_{ext\,agent} = \Delta U}$$

Change in P.E $= (U_f - U_i)$

Note :- [P.E is defined only for Conservative force]

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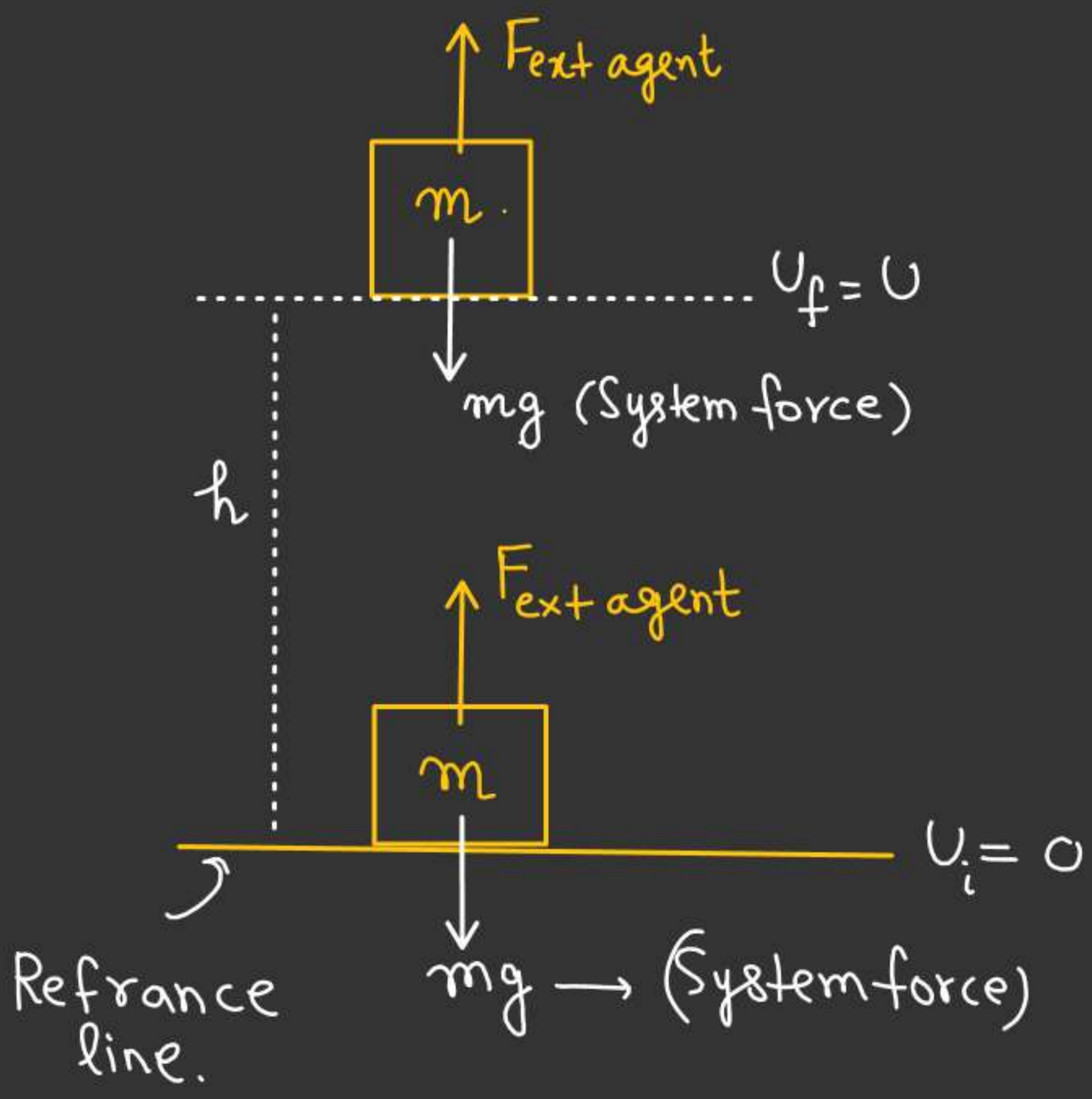
① Gravitational Potential Energy



For block to move very slowly

$F_{ext\ agent} = mg$

$$W_{ext\ agent} = (F_{ext\ agent} \cdot h)$$

$$\Delta U = +mgh$$

$$U_f - U_i = mgh$$

$$\boxed{U = mgh}$$

U → Gravitational P.E.

$W_{system} = -mgh$

$$-W_{system} = mgh$$

$$\Downarrow$$

$$\Delta U = mgh$$

$$U_f - U_i = mgh$$

$$\boxed{U = mgh}$$

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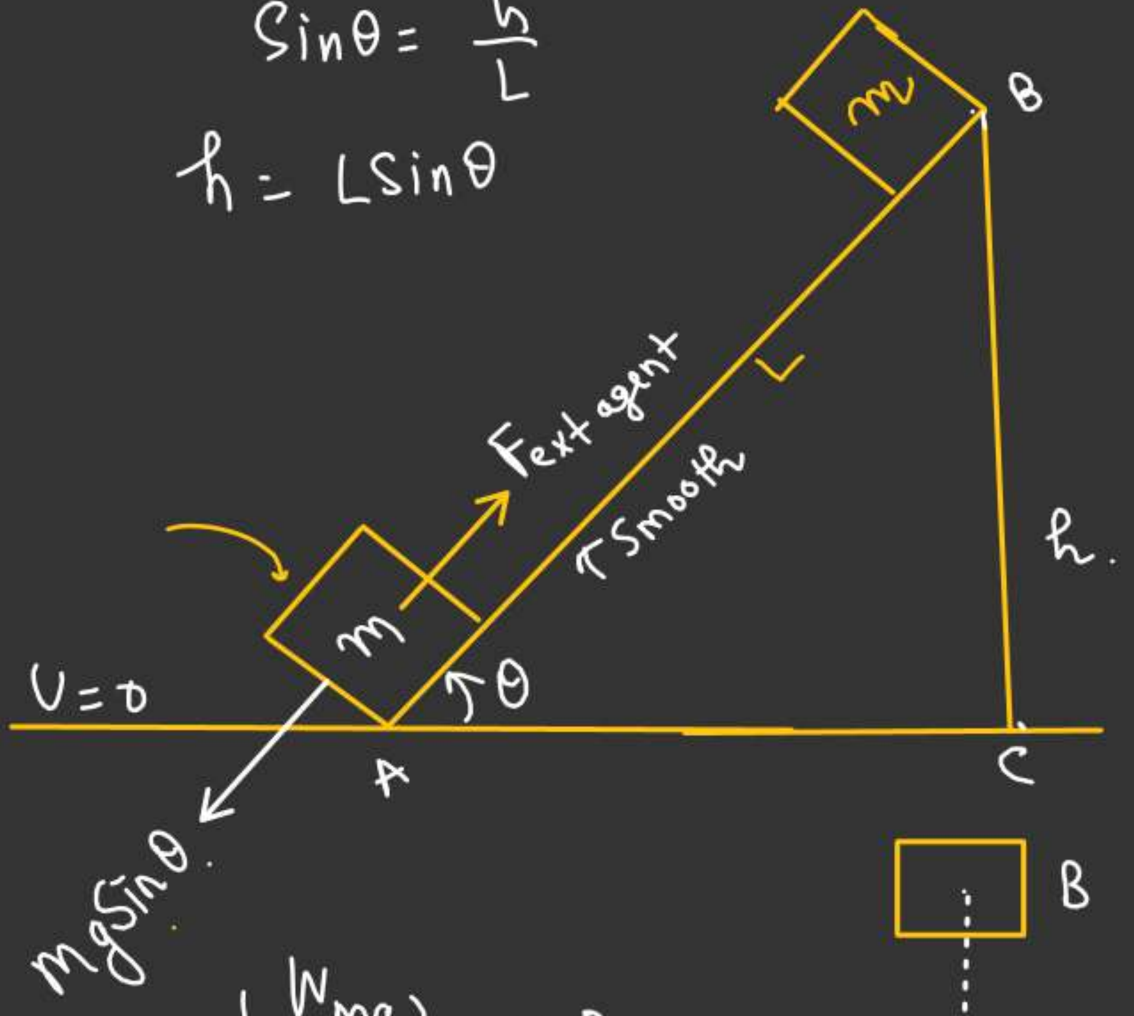
$W_{AB} = W_{ABC} = Mgh$

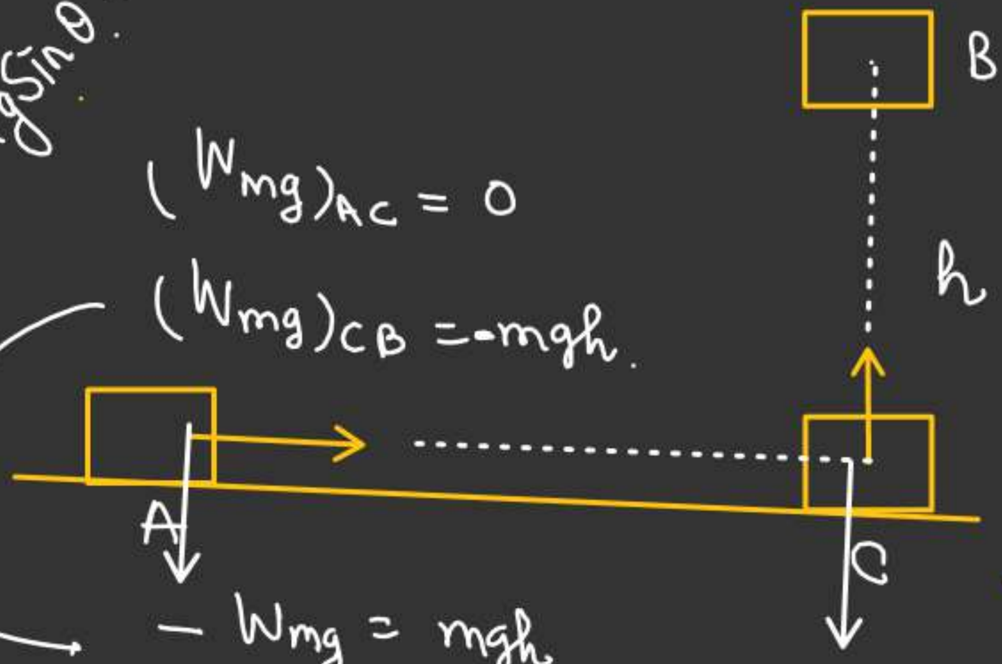
$\sin\theta = \frac{h}{L}$

$h = L\sin\theta$



$(W_{mg})_{AC} = 0$

$(W_{mg})_{CB} = -mgh.$



$-W_{mg} = mgh$

$\Delta U = mgh$ ✓.

For block to move very Slowly.

$F_{ext\,agent} = (mg\sin\theta)$

$W_{ext\,agent} = F_{ext\,agent} \cdot L\cos 0$

$= mg\sin\theta \cdot L$

$W_{ext\,agent} = mgh.$

$\Downarrow$

$\Delta U = mgh$

$U_f - U_i = mgh$

$U - 0 = $

$\boxed{U = mgh}$

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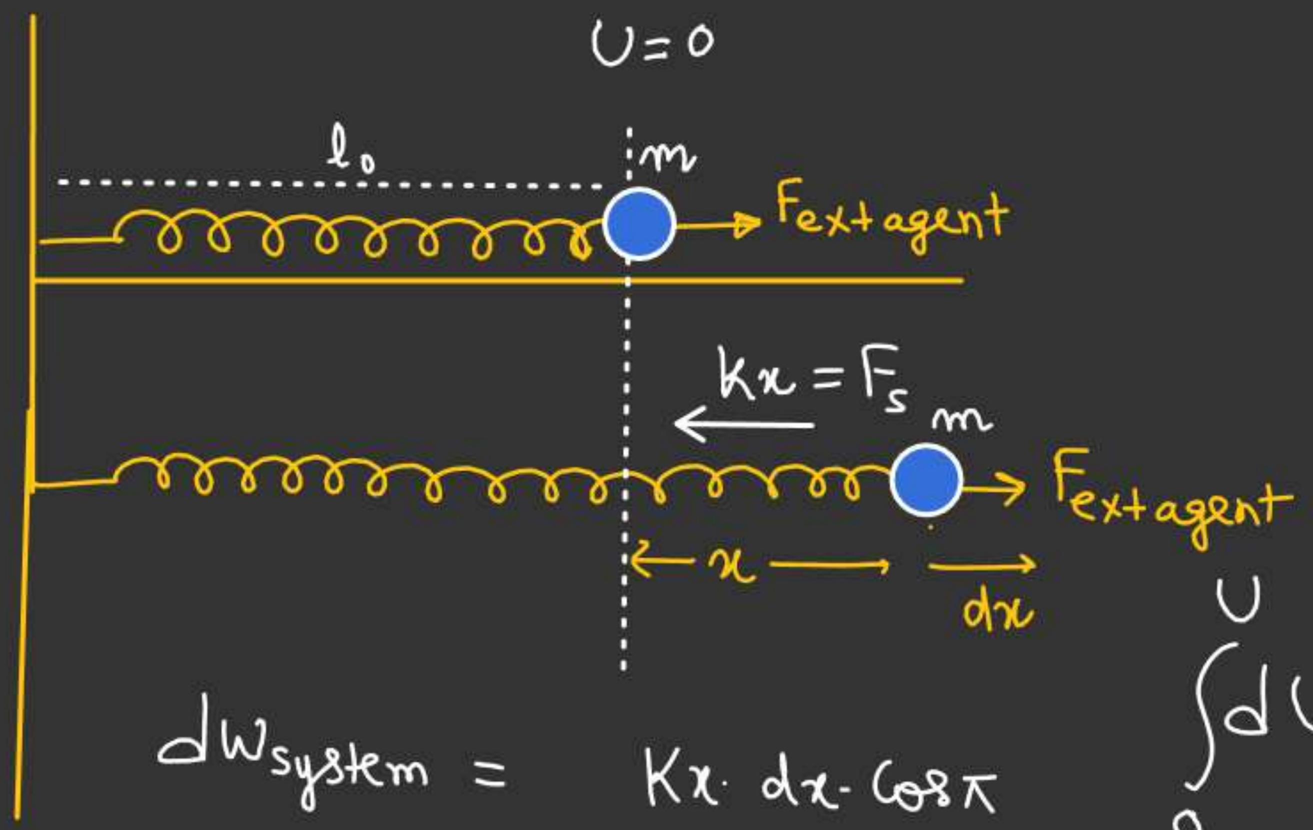
Spring Potential Energy



$dW_{system} = Kx \cdot dx \cdot \cos\pi$

$dW_{system} = -K\,x\,dx$

$\int_0^U dU = -dW_{system} = K\int_0^x x\,dx$

Pulled very slowly.

$F_{ext\,agent} = Kx.$

let, dW_{ext} be the work done by external agent.

$dW_{ext} = F_x\,dx$

$\int_0^U dU = dW_{ext} = K\int_0^x x\,dx$

$$\boxed{U = \frac{Kx^2}{2}}$$