DPP – 3 (WEP)

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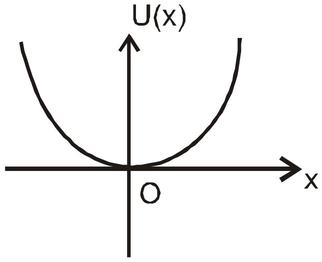
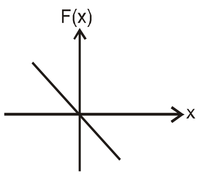
Q 1. Figure shows a plot of potential energy function $U(x) = kx^2$ where x = displacement and k = constant. Identify the correct conservative force function F(x)



(a)


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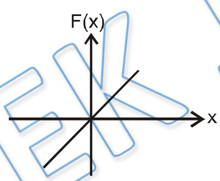

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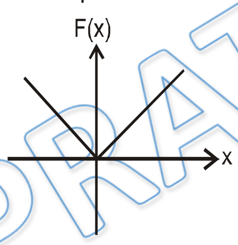
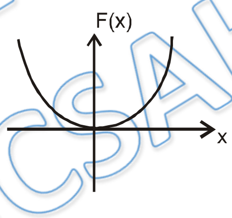
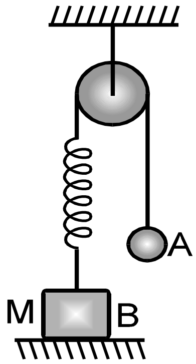


(d)


Q 2. In the Figure, the ball A is released from rest when the spring is at its natural length. For the block B, of mass M to leave contact with the ground at some stage, the minimum mass of A must be:



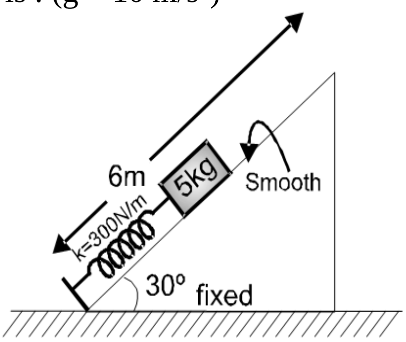
(a) 2 M (b) M (c) M/2
(d) A function of M and the force constant of the spring.

Q 3. Which of the following quantities is/are frame dependent?

(a) Kinetic energy (b) Work done by a force on a particle
(c) Potential energy (d) None of these

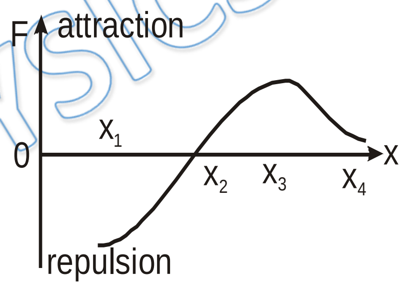
Q 4. One of the forces acting on a particle is conservative then which of the following statement(s) are true about this conservative force
(a) Its work is zero when the particle moves exactly once around any closed path.
(b) Its work equals the change in the kinetic energy of the particle
(c) Then that particular force must be constant.
(d) Its work depends on the end points of the motion, not on the path between.

Q 5. A block of mass 5 kg is released from rest when compression in spring is 2m. Block is not attached with the spring and natural length of the spring is 4m. Maximum height of block from ground is : (g = 10 m/s^2)



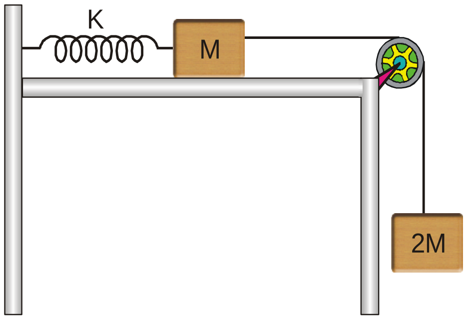
(a) 5.5 m (b) 4.5 m (c) 6 m (d) 7.5 m

Q 6. The diagram given shows how the interaction force (conservative) between two particles A and B is related to the distance between them varies from x_1 to x_4. Then:



(a) potential energy of the system increases from x_1 to x_2.
(b) potential energy of the system increases from x_2 to x_3.
(c) potential energy of the system increases from x_3 to x_4.
(d) KE. increases from x_1 to x_2 and decreases from x_2 to x_3.

Q 7 Two blocks, of masses M and 2M, are connected to a light spring of spring constant K that has one end fixed, as shown in figure. The horizontal surface and the pulley are frictionless. The blocks are released from rest when the spring is non deformed. The string is light.



(a) Maximum extension in the spring is $\frac{4Mg}{K}$.

(b) Maximum kinetic energy of the system is $\frac{2M^2g^2}{K}$

(c) Maximum energy stored in the spring is four times that of maximum kinetic energy of the system.

(d) When kinetic energy of system is maximum, energy stored in spring is $\frac{4M^2g^2}{K}$

Q 8. A particle is released from the top of two inclined smooth surfaces of height 'h' each. The angle of inclination of the two planes is 30^0 and 60^0 respectively. Let K_1 and K_2 be the kinetic energies of the particle at the bottom of the plane in two cases. Then

(a) $K_1 = K_2$ (b) $K_1 > K_2$

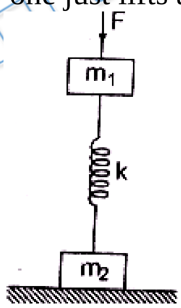
(c) $K_1 < K_2$ (d) data insufficient

Q 9. A body of mass 2 kg is moved from a point A to a point B by an external agent in a conservative force field. If the velocity of the body at the points A and B are 5 m/s and 3 m/s respectively and the work done by the external agent is - 10 J, then the change in potential energy between points A and B is

(a) 6 J (b) 36 J

(c) 16 J (d) none of these

Q 10. A system consists of two cubes of masses m_1 and m_2 respectively connected by a spring of force constant k. The force (F) that should be applied to the upper cube for which the lower one just lifts after the force is removed is



(a) m_1 g (b) $\frac{m_1m_2}{m_1+m_2}$g (c) $(m_1 + m_2)$g (d) m_2g

Q 11. The potential energy U in joule of a particle of mass I kg moving in x-y plane obeys the law U = 3x + 4y, where (x, y) are the co-ordinates of the particle in metre. If the particle is at rest at (6,4) at time t = 0 then

(a) the particle has constant acceleration

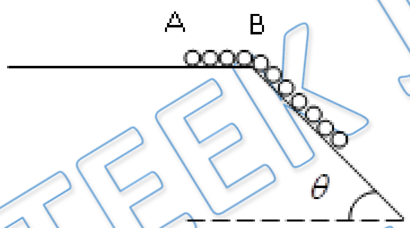
(b) the particle has zero acceleration

(c) the speed of particle when it crosses the y-axis is 10 m/s
(d) co-ordinates of particle at t = 1s are (4.5, 2)

Q 12. A single conservative force acts on a body of mass 1 kg that moves along the x-axis. The potential energy U(x) is given by $U(x) = 20 + (x-2)^2$ where x is in meters. At x = 5.0 m the particle has a kinetic energy of 20 J then –

Column-I	Column-II
(A) minimum value of x in meters	(P) 29
(B) maximum value of x in meters	(Q) 7.38
(C) maximum potential energy in joules	(R) 49
(D) maximum kinetic Energy in joules	(S) – 3.38

Q 13. A chain of length 'L' and mass 'M' is placed on a smooth surface. The length BA = L – b. When the end A reaches B, the velocity of the chain is

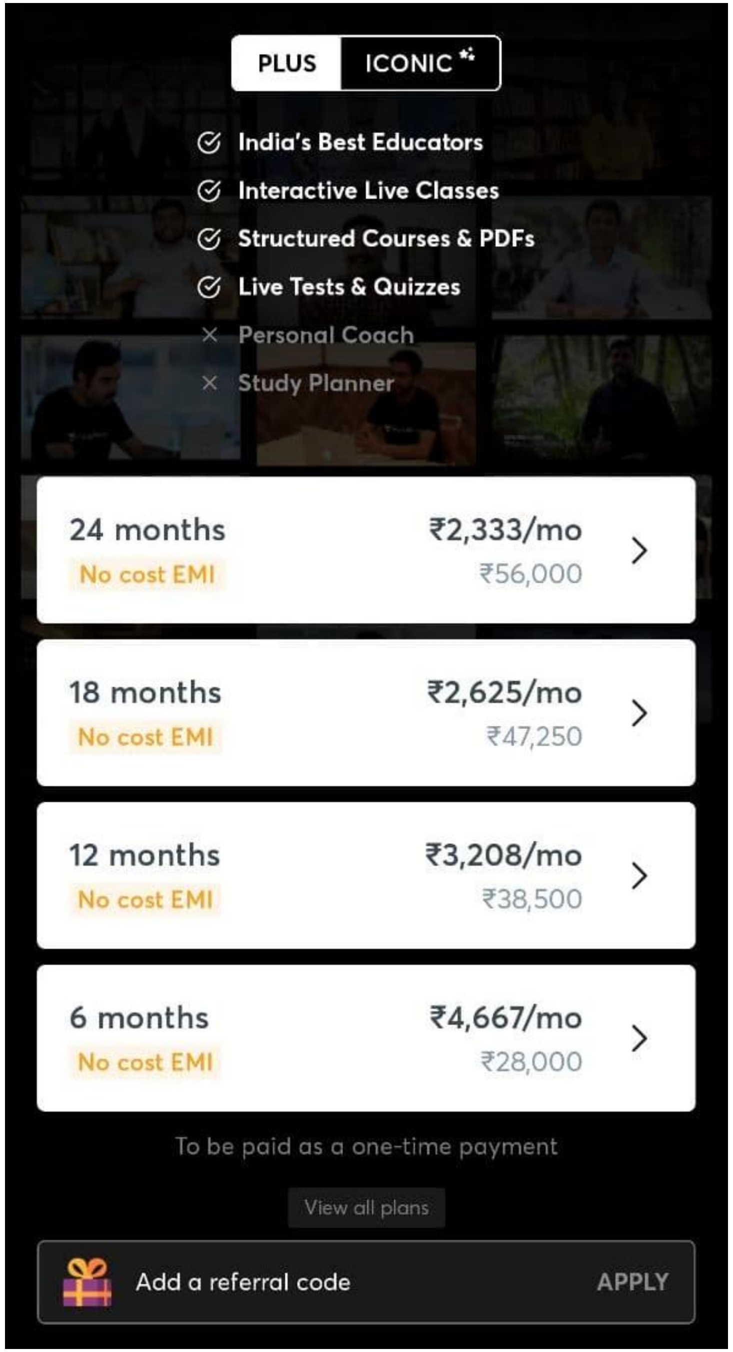


(a) $\sqrt{g \sin\theta \,(L-b)}$ (b) $\sqrt{g \sin\theta \frac{(L^2-b^2)}{L}}$

(c) $\sqrt{g \sin\theta \frac{(L-b)^2}{L}}$ (d) $\sqrt{g \sin\theta \frac{(L^2+b^2)}{L}}$

Answer Key

Q.1 a	Q.2 c	Q.3 a, b, c	Q.4 a, d	Q.5 a
Q.6 b, c	Q.7 a, b, c	Q.8 a	Q.9 a	Q.10 c
Q.11 a, c, d	Q.12 A(S) B(Q) C(R) D(P)	Q.13 b		



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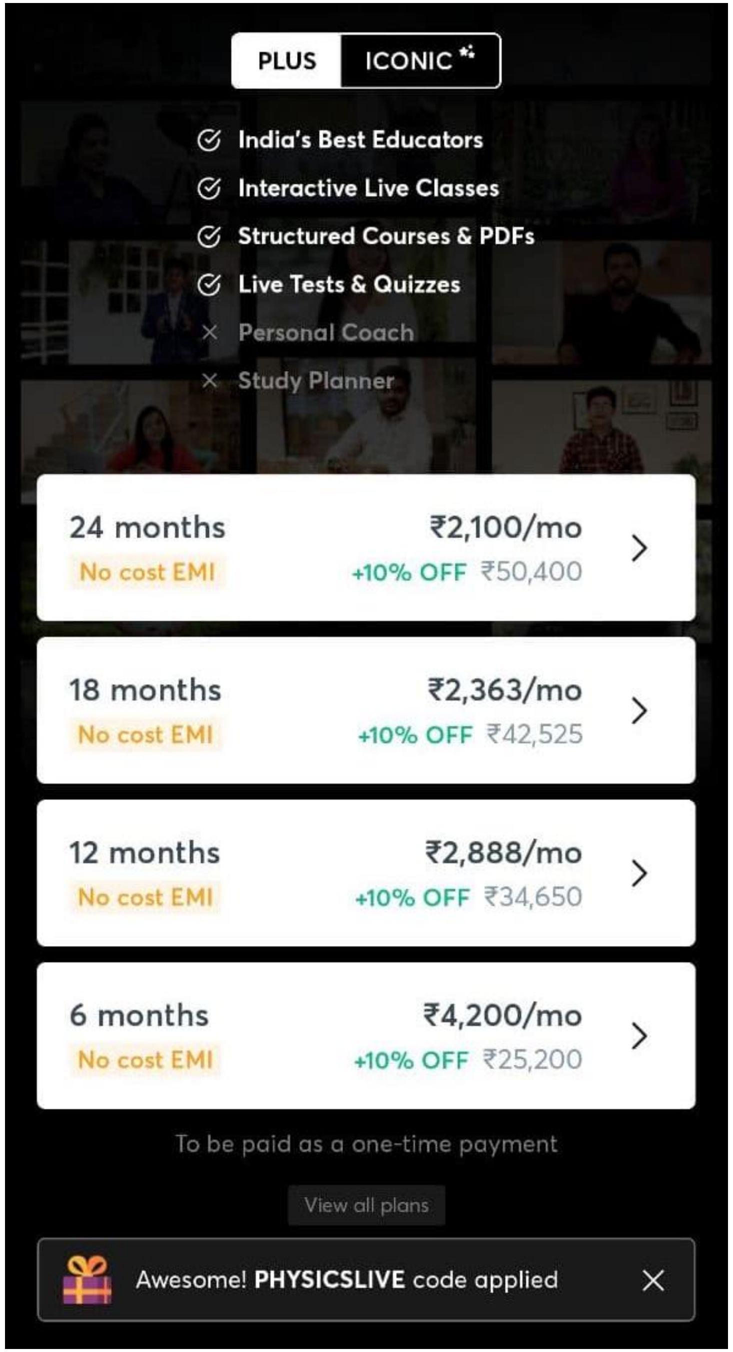

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Written Solution

DPP-3 WEP: Conservative & Non Conservative Forces, Potential Energy, Law of Conservation of Energy

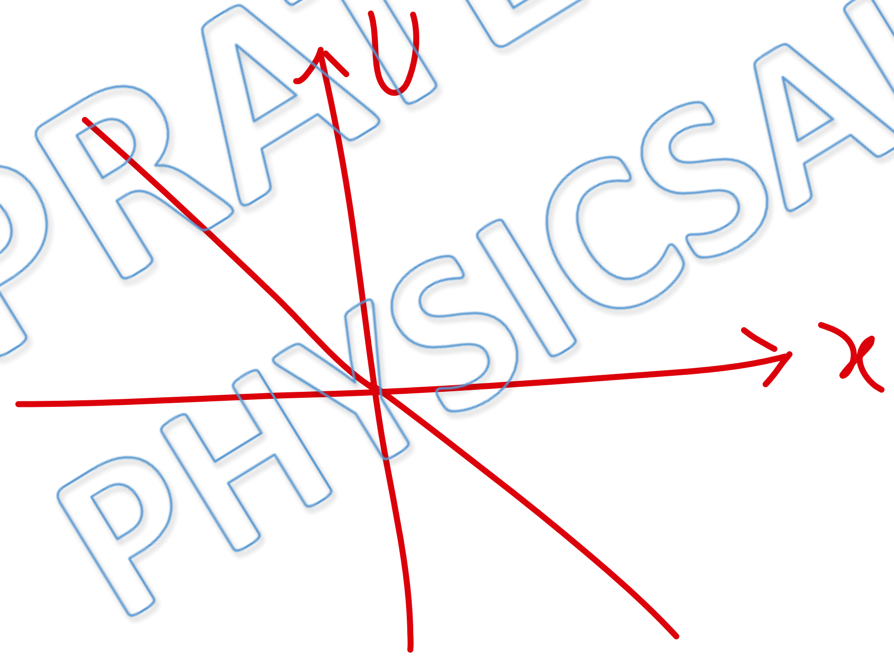
By Physicsaholics Team

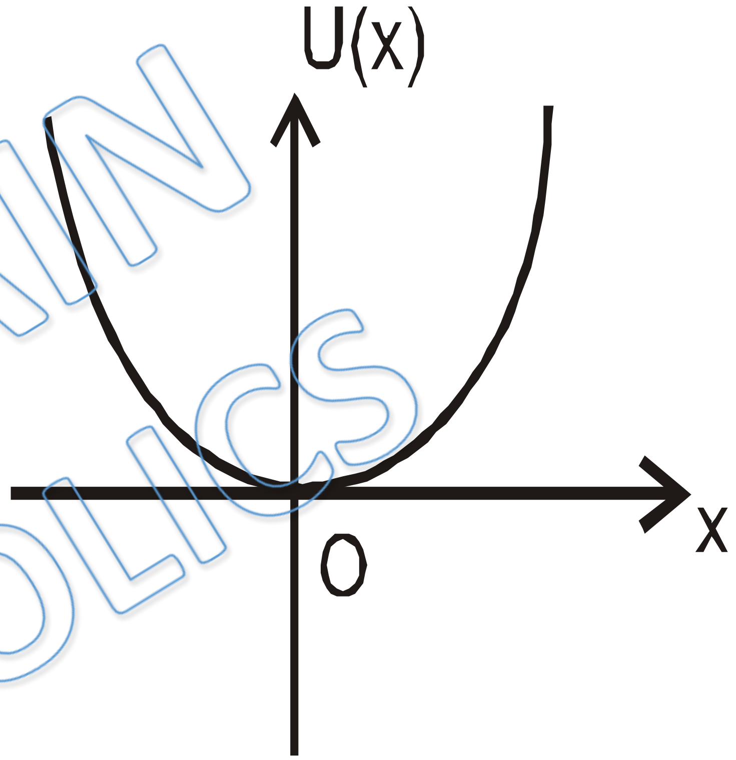
Solution:1

$$U = kx^2$$

$$\Rightarrow \quad \frac{dU}{dx} = 2kx$$

$$\Rightarrow \quad F = -2kx$$





Ans (a)

Solution:2

To just lift B

$$Kx = Mg \Rightarrow x = \frac{Mg}{K}$$

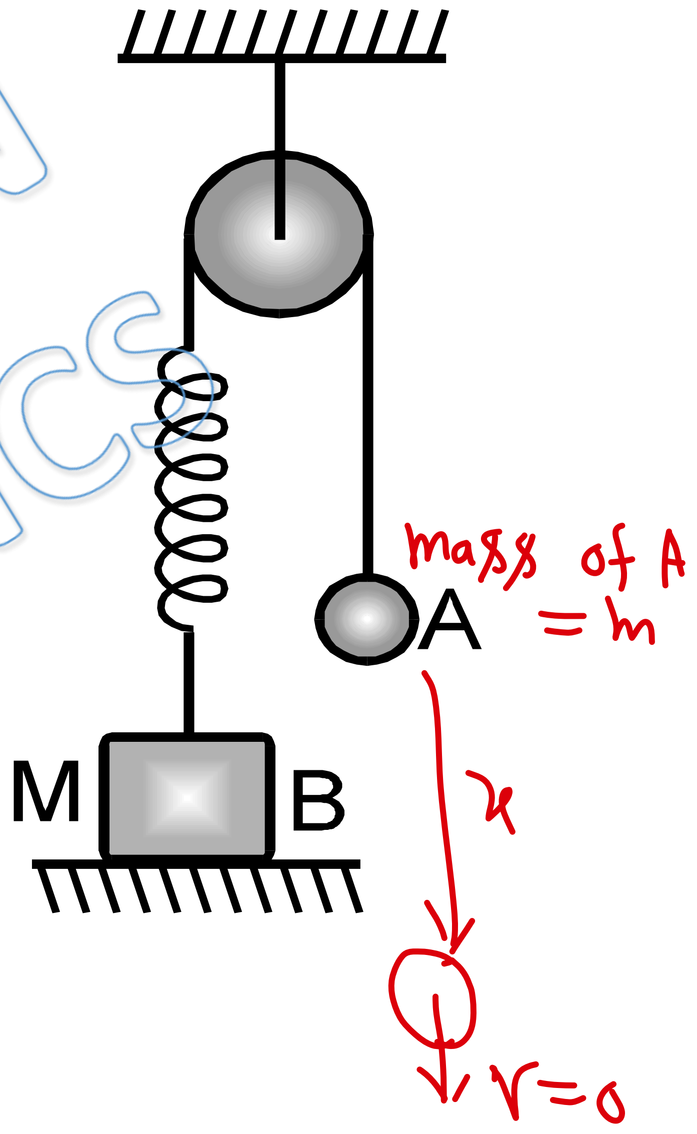
by Conservation of mechanical energy →

loss in gravitational P.E. = gain in spring energy

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

$$\Rightarrow x = \frac{2mg}{K} = \frac{Mg}{K}$$

$$\Rightarrow m = \frac{M}{2}$$



Ans (c)

Solution:3

Kinetic Energy $= \frac{1}{2}mv^2 \Rightarrow$ V is frame dependent therefore K.E. is frame dependent.

work done by a force $= \vec{F} \cdot \vec{\Delta r} \Rightarrow \vec{\Delta r}$ is frame dependent therefore work done by force is frame dependent.

Potential energy depends on our choice of reference position.

Ans (a, b, c)

Solution:4

Work done by Conservative force does not depend on path of motion. It depends on initial & final points only.

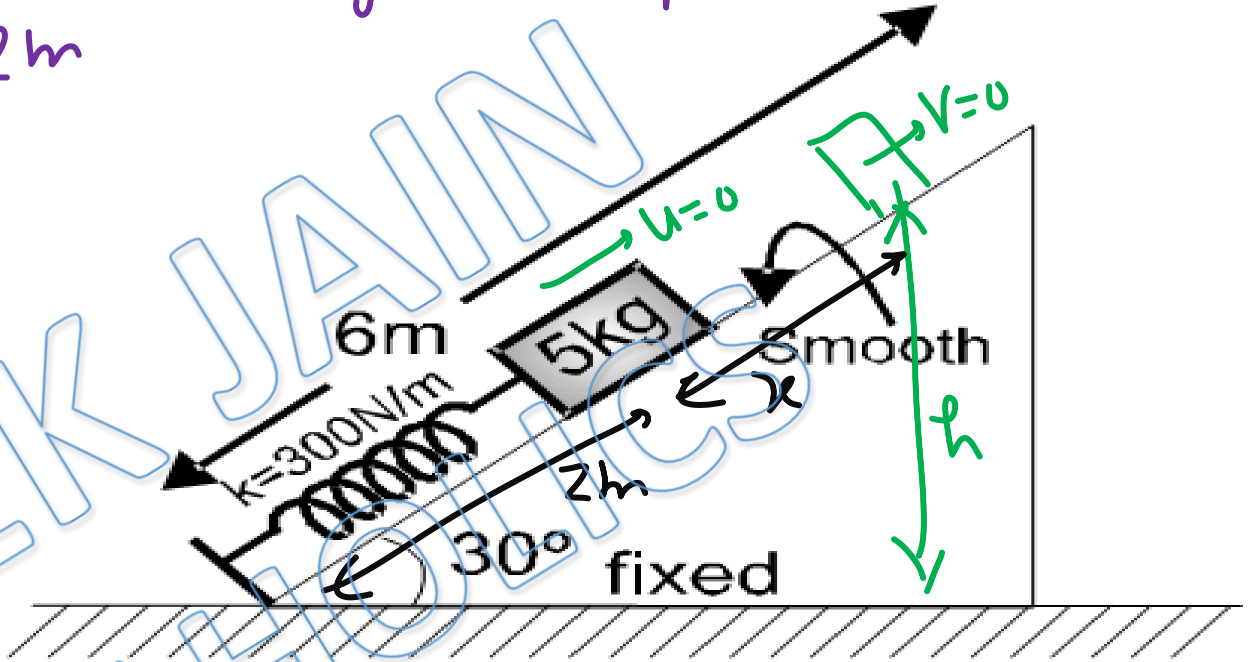
⇒ Work done by Conservative force in one round is equal to work done in zero displacement means zero.

Ans (a, d)

Solution:5 Initial length of spring = natural length − Compression

= 2m

At natural length position block will leave contact with spring & move alone.



by Conservation of machenical energy →

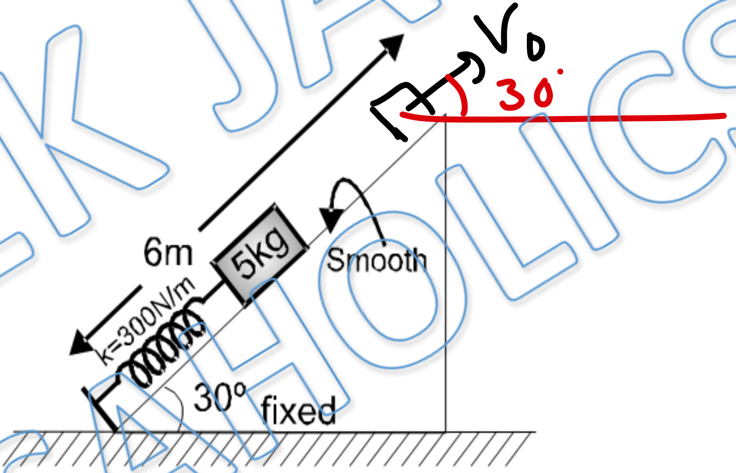
Gain in G.P.E = loss in spring P.E.

$$5g \times \sin 30 = \frac{1}{2} \times 300 \times 2^2$$

$$x = 24$$

but length of inclined plane is only 6m.

⇒ block will start projectile motion from topmost point of inclined plane.



by Conservation of mechanical energy →

$$\frac{1}{2} \times 300 \times 2^2 = 5 \times 10 \times (6-2)\sin 30^\circ + \frac{1}{2} \times 5\, v_0^2$$

$$600 = 100 + \frac{5}{2} v_0^2$$

$$\frac{5}{2} v_0^2 = 500$$

$$v_0^2 = 200$$

Maximum Height of block

$$H = 6\sin 30^\circ + \frac{V_0^2 \sin^2 30^\circ}{2g}$$

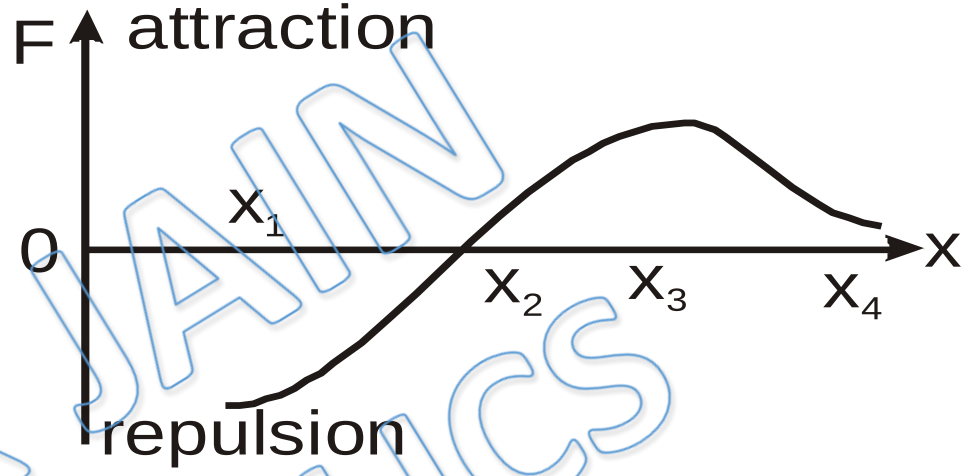
$$= 6 \times \frac{1}{2} + \frac{200 \times 1/4}{2 \times 10}$$

$$= 3 + 2.5$$

$$= 5.5\,m$$

Ans(a)

Solution:6



$F \propto x$ (handwritten: $F = +Vx$)

$\Rightarrow -\frac{dU}{dx} = +Vx$

$\Rightarrow \frac{dU}{dx} = -Vx$

$\Rightarrow$ U is decreasing on increasing x.

Similarly $F = -Vx \Rightarrow$ U is increasing on increasing x.

x_1 to $x_2 \rightarrow$ U is increasing $\Rightarrow$ KE is decreasing

x_2 to $x_3 \rightarrow$ U is decreasing $\Rightarrow$ " " increasing

x_3 to $x_4 \rightarrow$ U " "

Ans.b,c

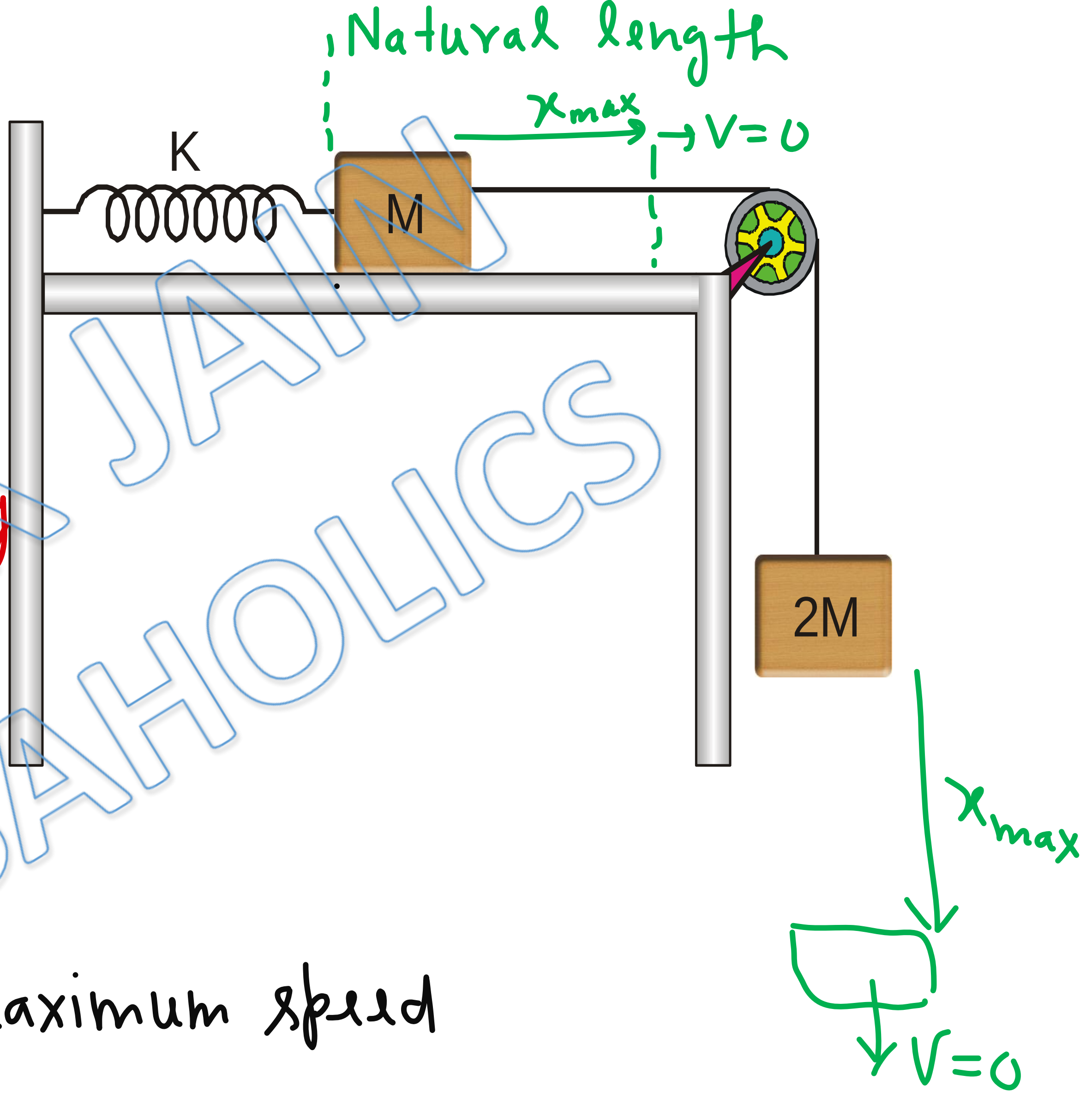
Solution:7

(a) At maximum extension in spring, $V = 0$.

by Conservation of mechanical energy

$$2Mg\,x_{max} = \frac{1}{2}K x_{max}^2$$

$$\Rightarrow \quad x_{max} = \frac{4Mg}{K}$$



(b) maximum Kinetic energy $\Rightarrow$ maximum speed

$$\Rightarrow \frac{dv}{dt} = 0 \Rightarrow a = 0 \Rightarrow F_{net} = 0$$

when speed is maximum

$$Kx_1 = 2Mg$$

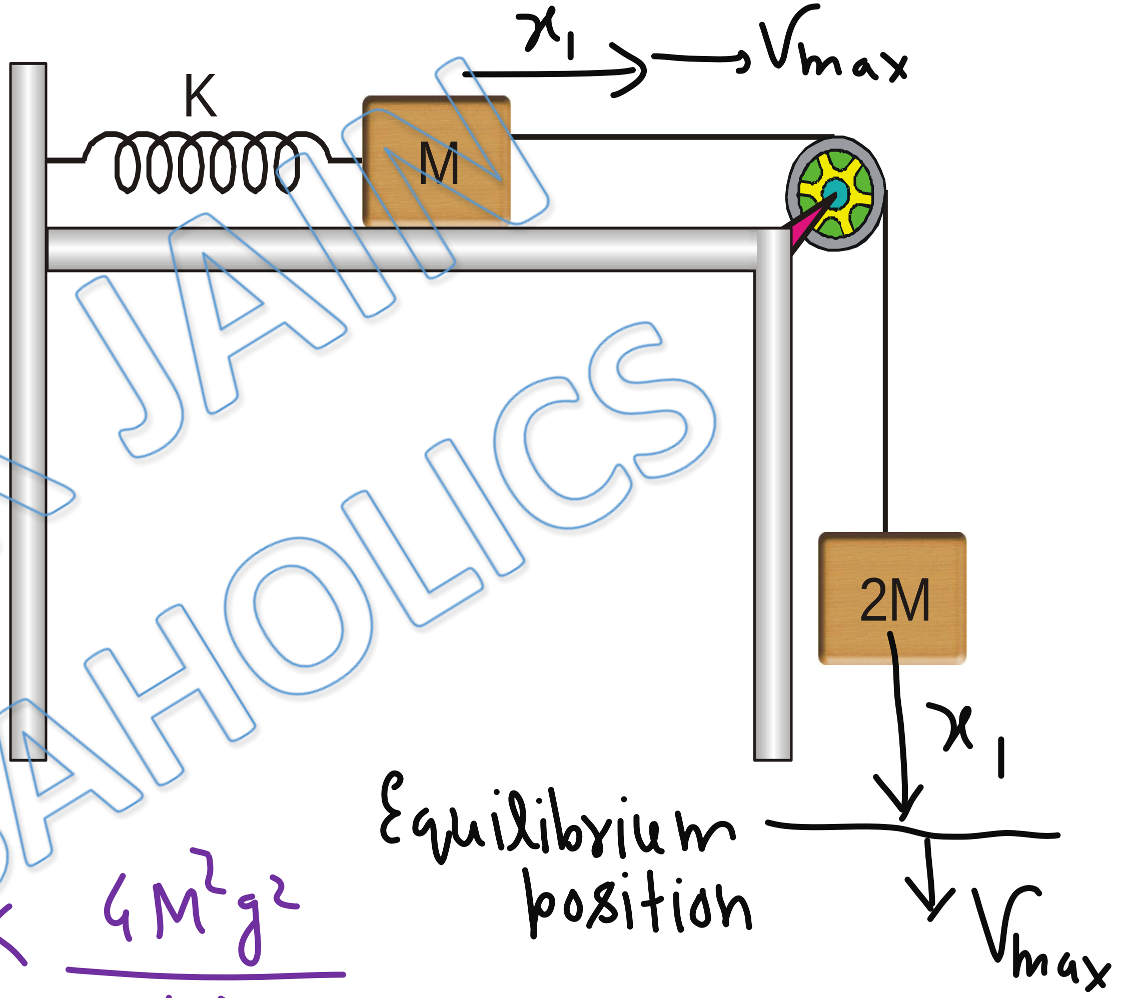
$$x_1 = 2Mg/K$$

by Conservation of mechanical energy

$$2Mgx_1 = \frac{1}{2}Kx_1^2 + KE_{max}$$

$$\Rightarrow KE_{max} = 2Mg \times \frac{2Mg}{K} - \frac{1}{2}K\frac{4M^2g^2}{K^2}$$

$$= \frac{2M^2g^2}{K}$$



(c) Maximum energy stored in spring

$$= \frac{1}{2} K x_{max}^2 = \frac{1}{2} K \left(\frac{4Mg}{K}\right)^2 = \frac{8M^2g^2}{K}$$

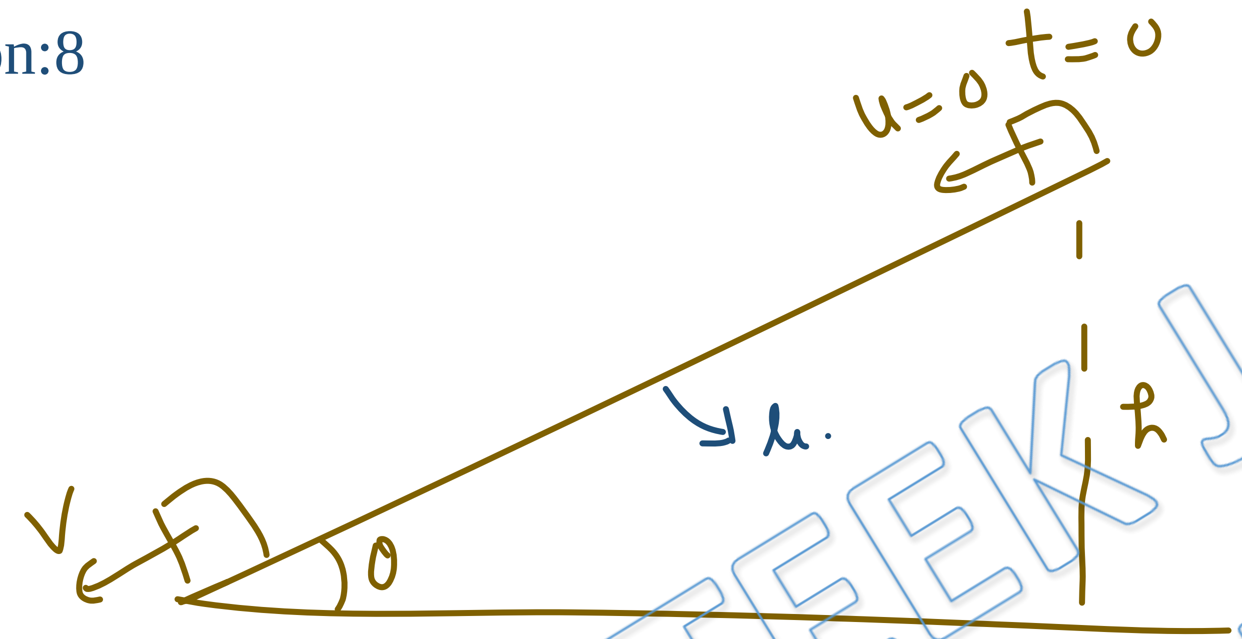
$= 4 \times$ maximum Kinetic Energy

(d) P.E of spring at maximum Kinetic energy

$$= \frac{1}{2} K x_1^2 = \frac{K}{2} \times \frac{4M^2g^2}{K^2} = \frac{2M^2g^2}{K}$$

Ans (a, b, c)

Solution:8



by Conservation of mechanical energy →

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

$KE = mgh \longrightarrow$ Independent of θ.

Ans(a)

Solution:9

by Using work energy theorem

$$W_{ext} + W_{co} = K_f - K_i$$

$$\Rightarrow -10 + W_{co} = \frac{1}{2} \times 2 (3^2 - 5^2) = -16$$

$$\Rightarrow W_{co} = -6\,J$$

$$\Rightarrow \Delta U = -W_{co} = +6\,J$$

Ans(a)

Solution:10

To just lift lower block

$$Kx_1 = m_2 g \Rightarrow x_1 = \frac{m_2 g}{K}$$

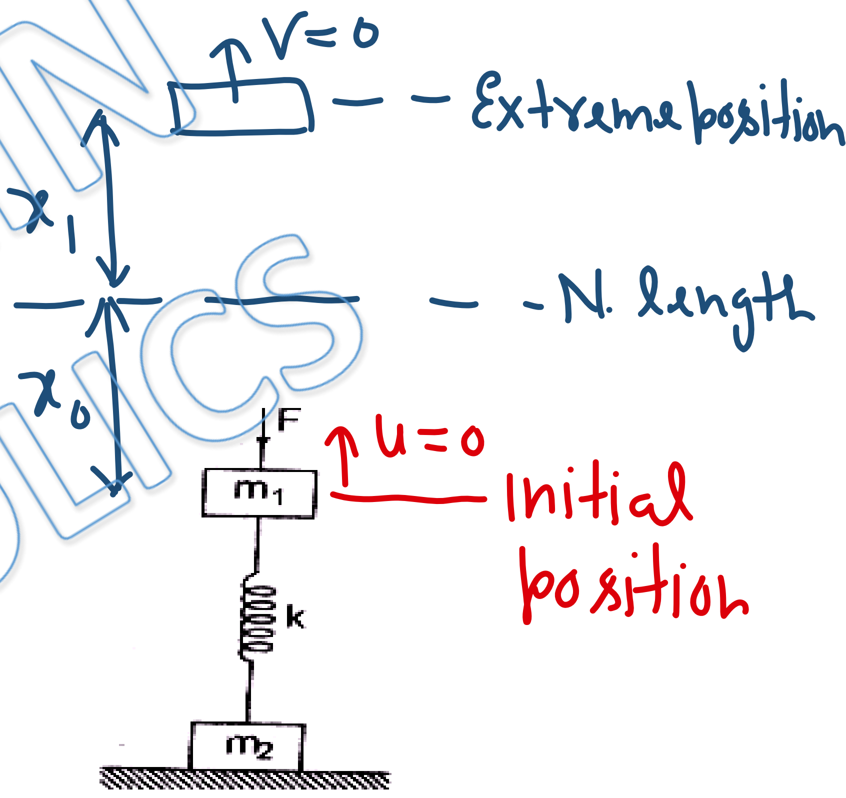
by Conservation of mechanical energy →

$$-m_1 g x_0 + 0 + \frac{1}{2}Kx_0^2 = +m_1 g x_1 + 0 + \frac{1}{2}Kx_1^2$$

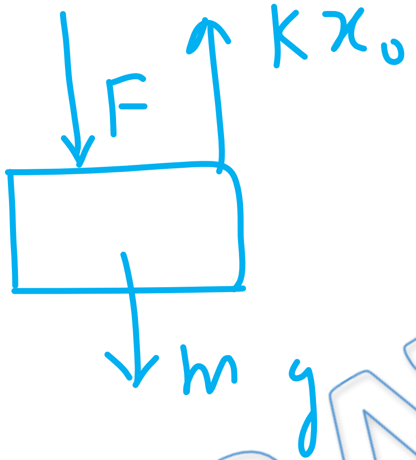
$$\frac{1}{2}K(x_0^2 - x_1^2) = m_1 g(x_1 + x_0)$$

$$\frac{K}{2}(x_0 - x_1) = m_1 g$$

$$x_0 = x_1 + \frac{2m_1 g}{K} = \frac{m_2 g}{K} + \frac{2m_1 g}{K}$$



At initial position



$$\Rightarrow F + m_1 g = K x_0$$

$$\Rightarrow F = K x_0 - m_1 g$$

$$= (m_2 g + 2m_1 g) - m_1 g$$

$$= (m_1 + m_2) g$$

Ans (c)

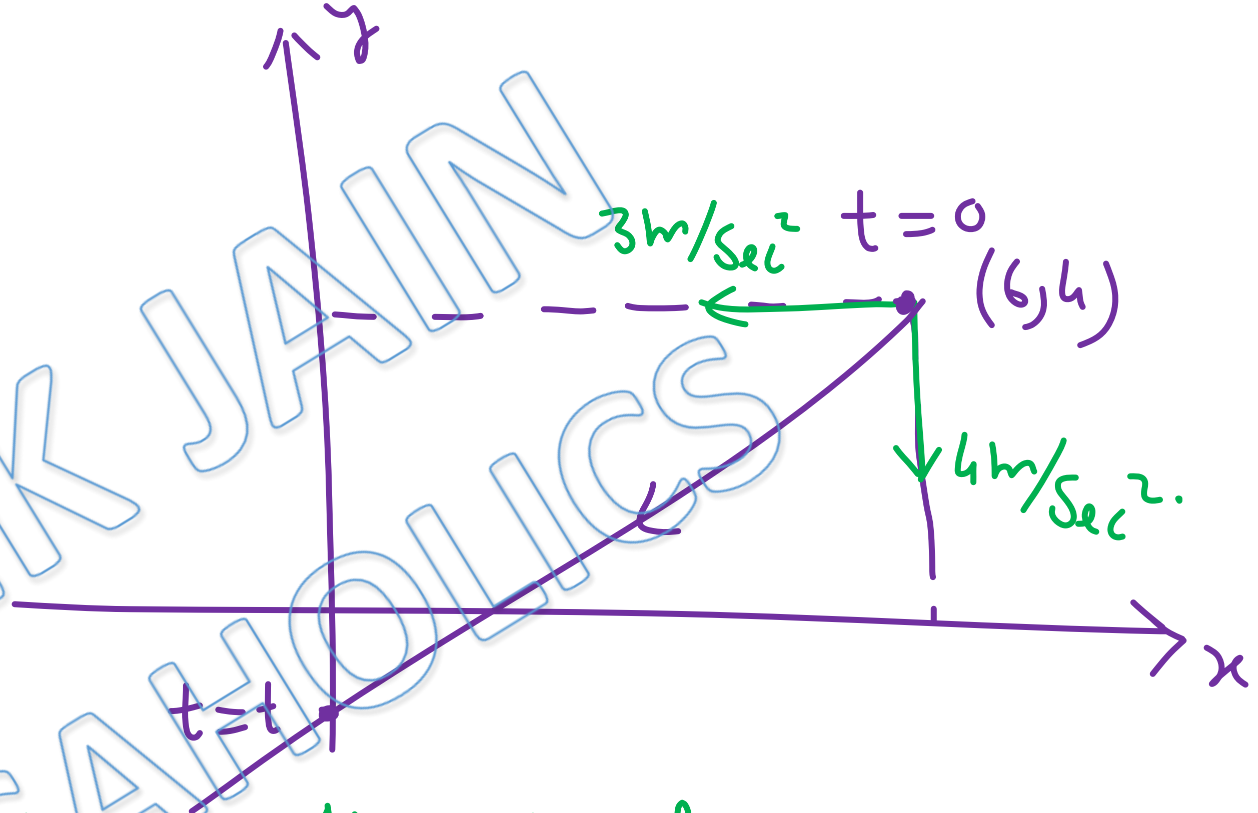
Solution:11

$$U = 3x + 4y$$

$$\Rightarrow \vec{F} = -\frac{\partial U}{\partial x}\hat{i} - \frac{\partial U}{\partial y}\hat{j}$$

$$\vec{F} = -3\hat{i} - 4\hat{j}$$

$$\Rightarrow \vec{a} = \frac{\vec{F}}{m} = -3\hat{i} - 4\hat{j}$$



when particle crosses y axis, $x=0$, $\Delta x = 6m$ along $(-x)$ axis.

for motion along x axis →

$$x = ut + \frac{1}{2}at^2 \Rightarrow 6 = \frac{1}{2} \times 3t^2 \Rightarrow t = 2\text{ Sec}$$

$$\text{at } t=2,\ \vec{V} = \vec{u} + \vec{a}t = 0 + (-3\hat{i} - 4\hat{j}) \times 2 \Rightarrow V = 10\text{ m/Sec}$$

$$\vec{\Delta r} = \vec{u}t + \frac{1}{2}\vec{a}t^2$$

$$\Rightarrow \quad \vec{r} - (6\hat{i} + 4\hat{j}) = 0 + \frac{1}{2}(-3\hat{i} - 4\hat{j}) \times 1^2 \quad \text{at } t = 1$$

$$\Rightarrow \quad \vec{r} - (6\hat{i} + 4\hat{j}) = -\frac{3}{2}\hat{i} - 2\hat{j}$$

$$\Rightarrow \quad \vec{r} = \frac{9}{2}\hat{i} + 2\hat{j}$$

$$= (4.5, 2)$$

Ans(a, c, d)

Solution: 12 At $x = 5$, $U = 20 + (5-2)^2 = 29\,J$

$KE = 20\,J$

$\Rightarrow$ Total Mechanical energy $= 29 + 20 = 49\,J$

for minimum value of x, $\frac{dx}{dt} = 0 \Rightarrow v = 0$

$\Rightarrow KE = 0 \Rightarrow PE = 49\,J$

$\Rightarrow 20 + (x-2)^2 = 49$

$\Rightarrow x - 2 = \pm\sqrt{29}$

$\Rightarrow x_{max} = 2 + \sqrt{29} = 7.38\,m$, $x_{min} = 2 - \sqrt{29} = -3.38\,m$

$TME = 49J$ & $U = 20 + (x-2)^2$

for maximum KE, PE should be minimum.

$U_{min} = 20J$ at $x = 2$

$\Rightarrow K_{max} = 49 - 20 = 29J$

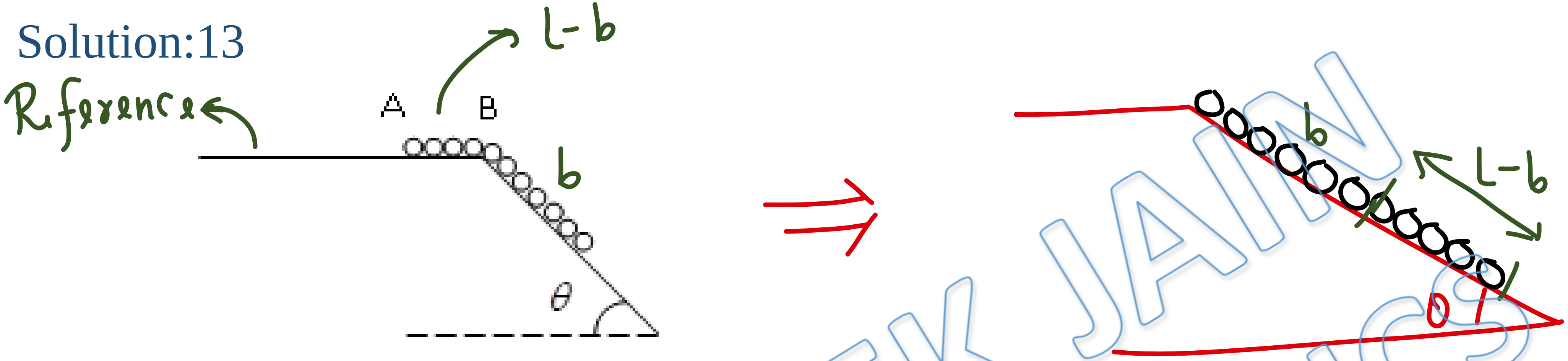
Maximum Potential energy $\Rightarrow$ minimum KE.

KE is minimum zero at extremes.

$\Rightarrow U_{max} = 49J.$

Ans. A(s) B(r) D(p)

Solution:13



Only length (L-b) has changed its position.

mass of length L-b $= \frac{M}{L}(L-b)$

Loss in PE $= \left[\frac{M}{L}(L-b)\right] g \left[\left(b + \frac{L-b}{2}\right)\sin\theta\right]$

$= \frac{Mg}{2L}(L^2 - b^2)\sin\theta$

by Conservation of machenical energy →

loss in PE = gain in KE

$$\Rightarrow \frac{Mg}{2L}(L^2 - b^2)\sin\theta = \frac{1}{2}Mv^2$$

$$\Rightarrow v = \sqrt{\frac{g}{L}(L^2 - b^2)\sin\theta}$$

Ans (b)

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