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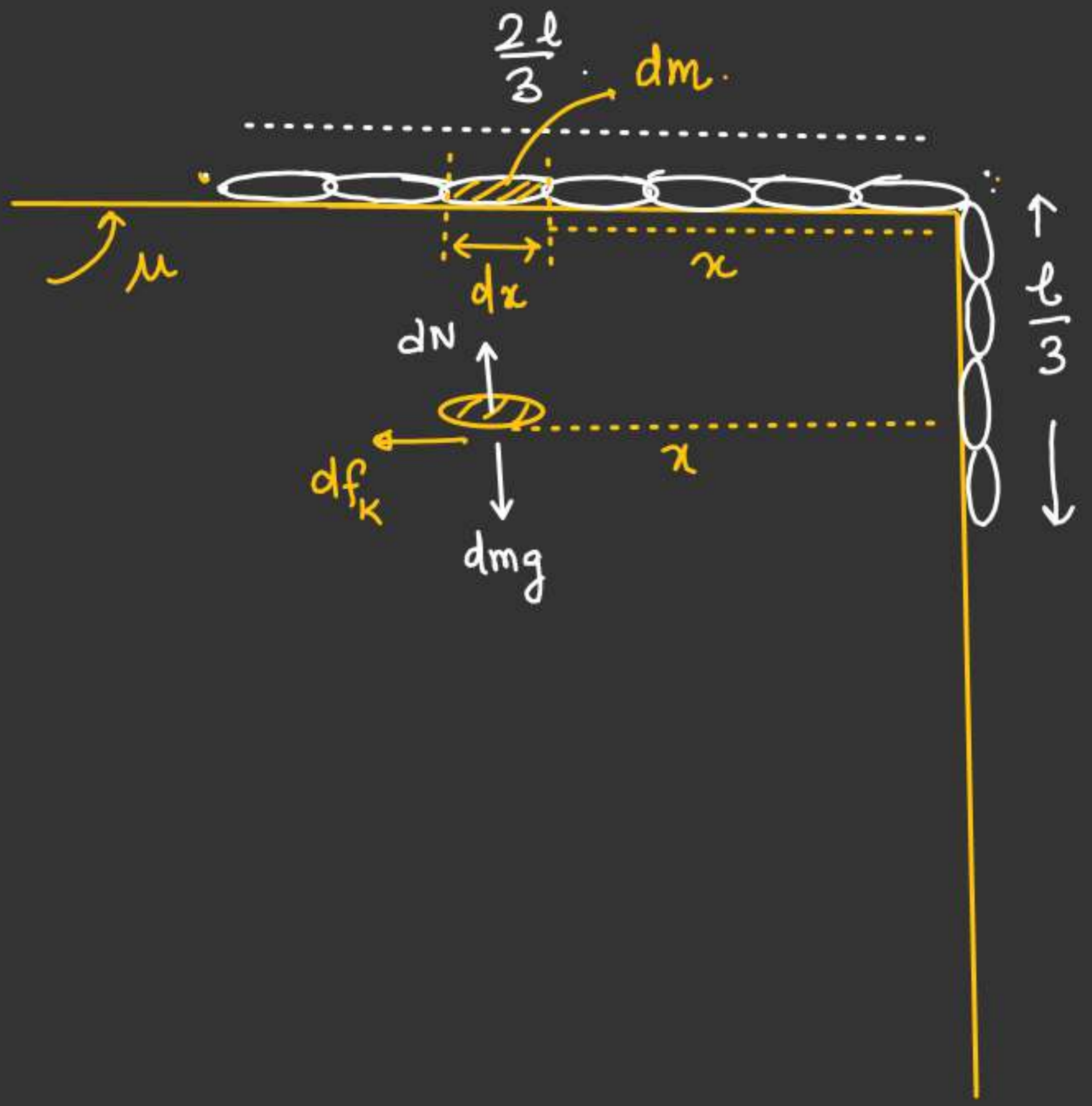
\# Chain starts slipping when its overhanging part is $l/3$. Find the kinetic energy of the chain when it just leaves the table.



Sol^n:- friction force is changing due to change in normal reaction as mass of the chain on the table is decreasing

$$W_{f_k} \quad df_k = \mu dN = \mu dmg = g\mu\left(\frac{M}{L}dx\right)$$

$$\int_{0} dW_{f_k} = -\frac{\mu M g}{L}\int_0^{2l/3} x\,dx$$

$$W_{f_k} = -\frac{\mu mg}{L}\left(\frac{4l^2}{18}\right) = \left(-\frac{2\mu mgl}{9}\right) J$$

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$$W_{gravity} = \frac{mg\ell}{18}$$

By work- Energy theorem

$$W_{gravity} + W_{f_k} = (\Delta K.E)$$

$$\left(\frac{4mg\ell}{9} - \frac{2\mu mg\ell}{9}\right) = K.E_f - \underset{\substack{\Downarrow \\ 0}}{K.E_i}$$

$$K.E_f = \frac{2mg\ell}{9}(2-\mu)$$

$$W_{gravity} = -\Delta U$$
$$= (U_i - U_f)$$

$$U_i = -\frac{M}{3} g \frac{L}{6}$$

$$U_i = -\frac{MgL}{18}$$

$$U_f = -\frac{MgL}{2}.$$

$$\Delta U = (U_f - U_i)$$
$$= -\frac{MgL}{2} + \frac{MgL}{18}$$
$$= \frac{-8Mg\ell}{18} = \left(-\frac{4mg\ell}{9}\right)$$
$$-\Delta U = \left(\frac{4Mg\ell}{9}\right)$$

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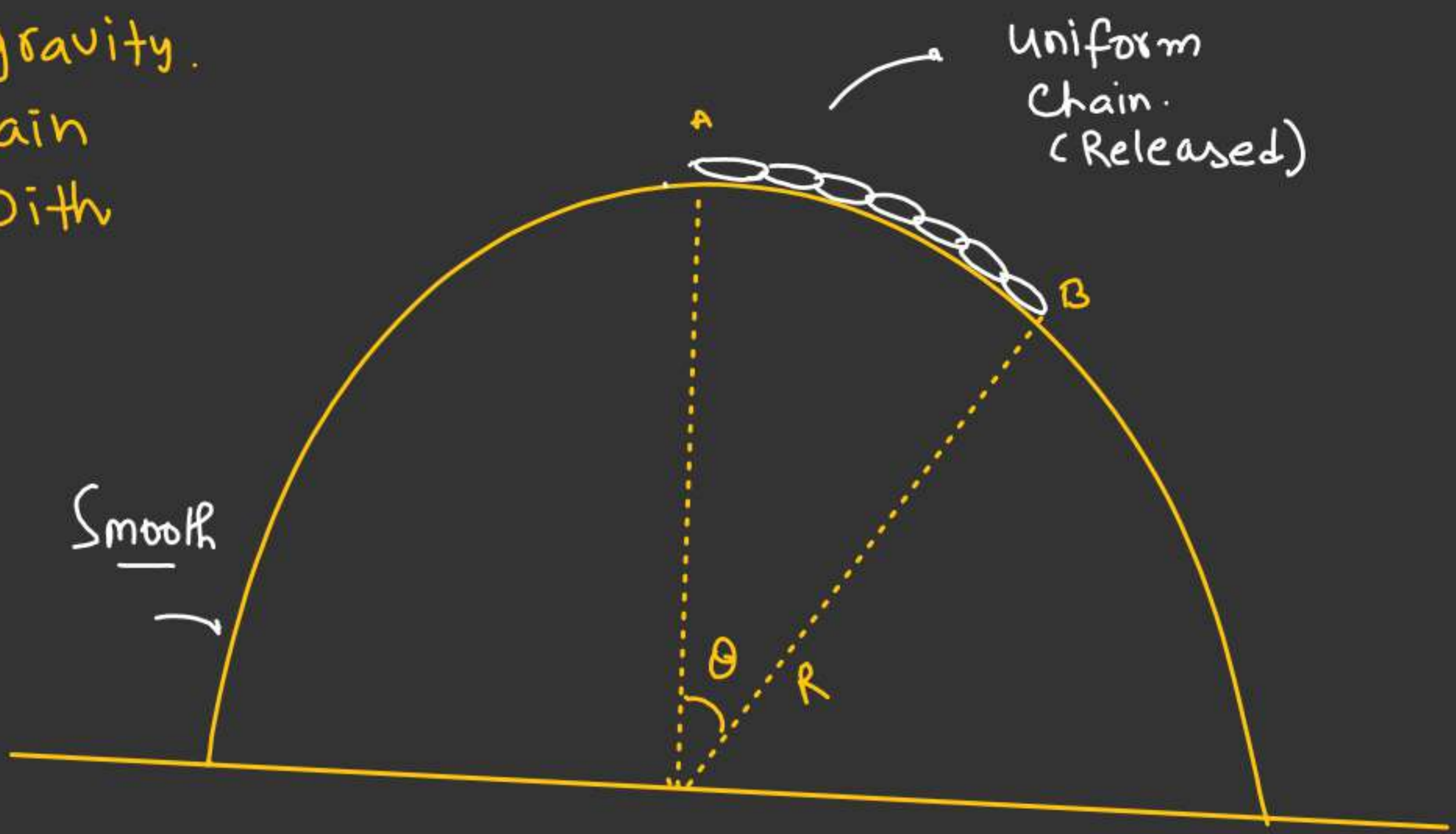
\# Find the work done by gravity. When upper end of the chain makes an angle α with vertical.

M = Total mass of the Chain.



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$$\lambda = \left(\frac{M}{R\theta}\right) \qquad l_{AB} = (R\theta) \qquad \text{if } l_{AB} = L$$

$$L = R\theta.$$

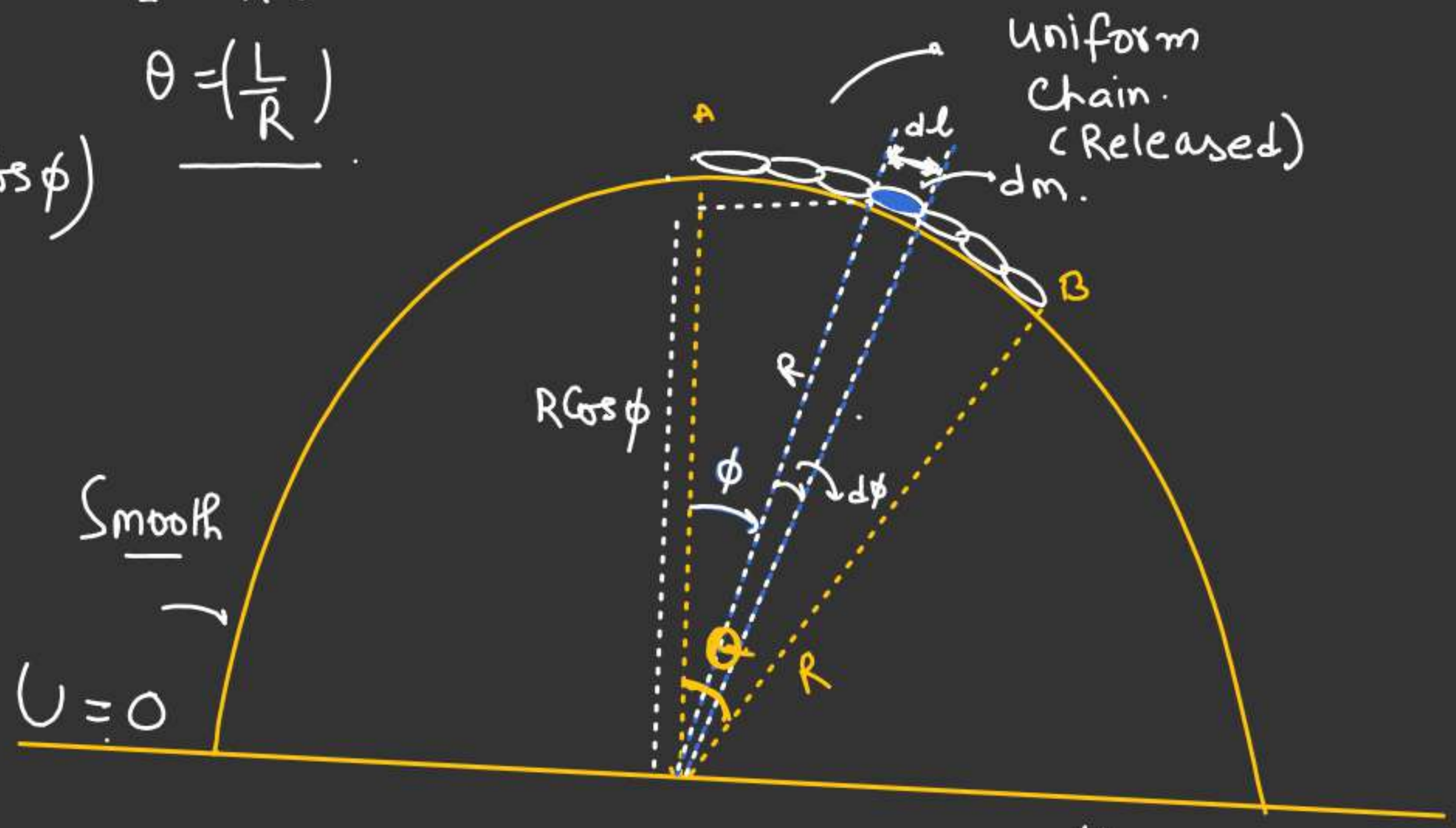
$$\theta = \left(\frac{L}{R}\right)$$

$$dl = (R\,d\phi)$$

$$(h = R\cos\phi)$$

$$dm = \lambda\,dl$$

$$dm = \frac{M}{R\theta} \times R\,d\phi = \left(\frac{M}{\theta}\,d\phi\right)$$



$$dU = dmgh$$

$$dU = \left(\frac{M}{\theta}\,d\phi\right) g\,(R\cos\phi) \checkmark$$

$$\int_0^{U_i} dU = \frac{MgR}{\theta}\int_0^{\theta}\cos\phi\,d\phi \Rightarrow U_i = \frac{MgR}{\theta}(\sin\theta)$$

$$dl = R\,d\phi$$

$$U_i = \frac{MgR}{L/R}\sin\left(\frac{L}{R}\right) = \frac{MgR^2}{L}\sin\left(\frac{L}{R}\right)$$

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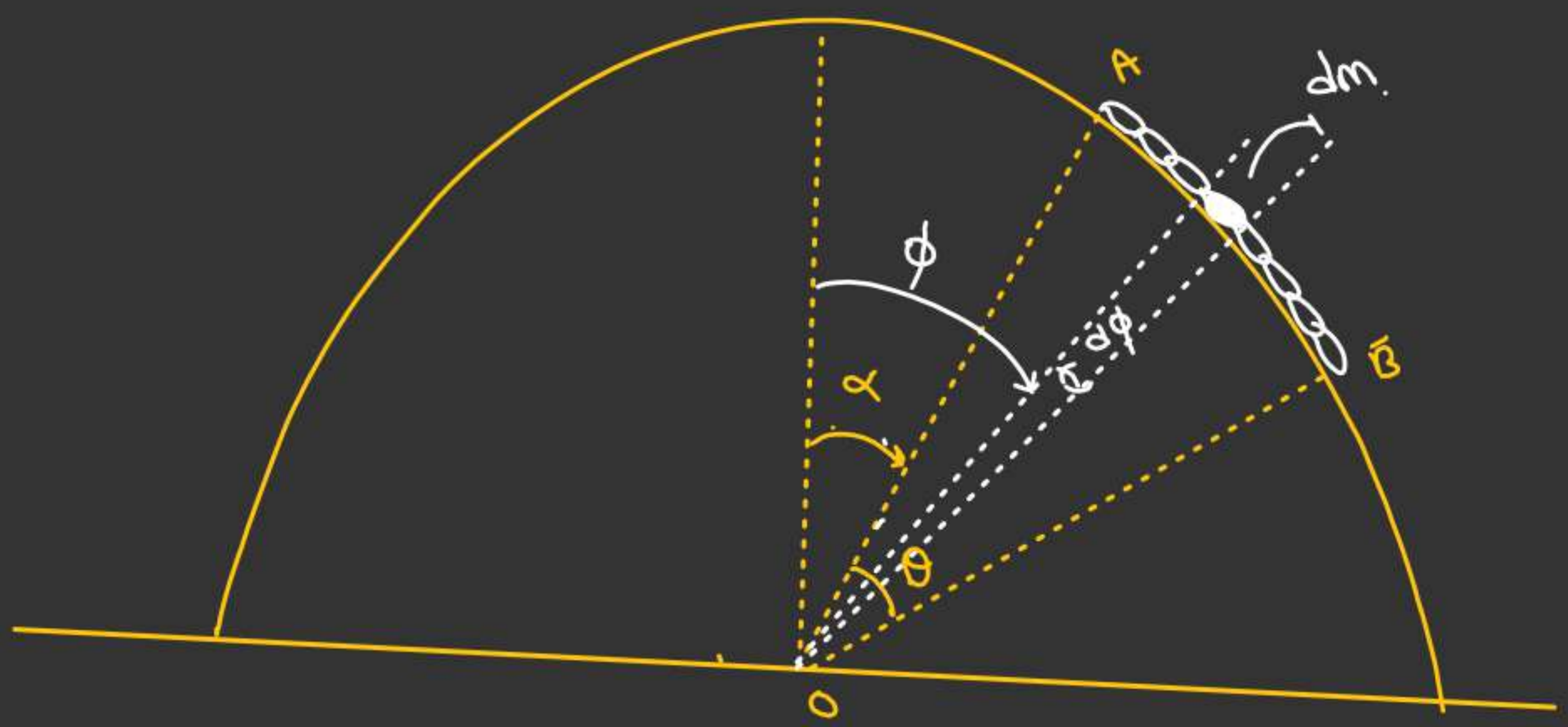
$$\int_{0}^{U_f} dU_f = \frac{MgR}{\theta}\int_{\alpha}^{(\alpha+\theta)} \cos\phi \cdot d\phi$$

$\theta = \left(\frac{L}{R}\right)$



$$U_f = \frac{MgR}{\theta}\left[\sin\phi\right]_{\alpha}^{(\alpha+\theta)}$$

$$U_f = \frac{MgR}{\theta}\left[\sin(\alpha+\theta) - \sin(\alpha)\right]$$

$$U_f = \frac{MgR^2}{L}\left[\sin\left(\alpha + L/R\right) - \sin\alpha\right]$$

$$W_{gravity} = -\Delta U = (U_i - U_f)$$

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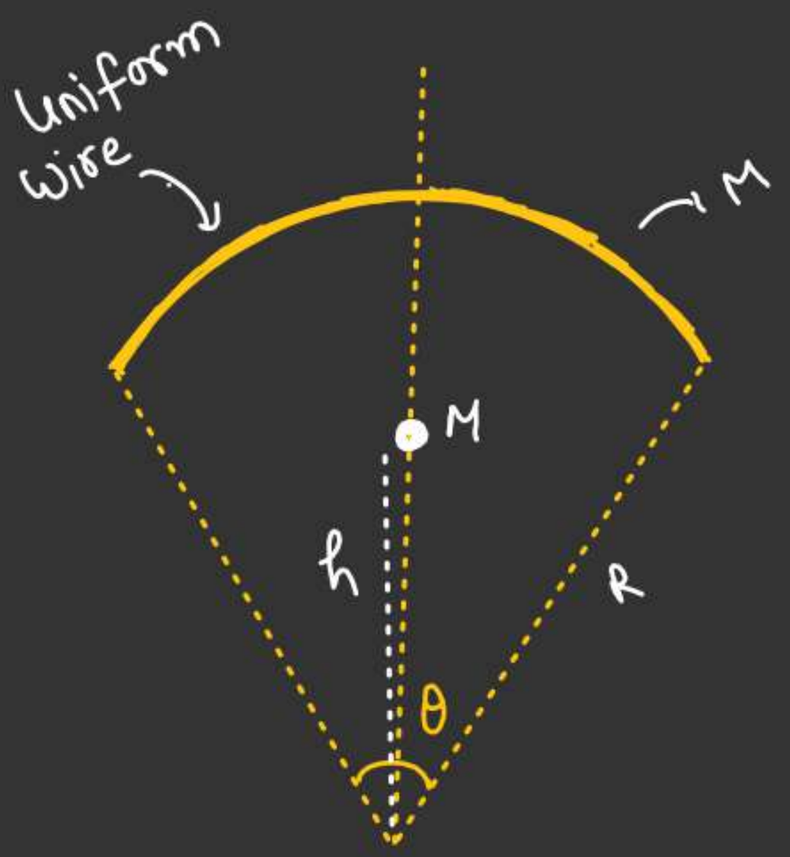
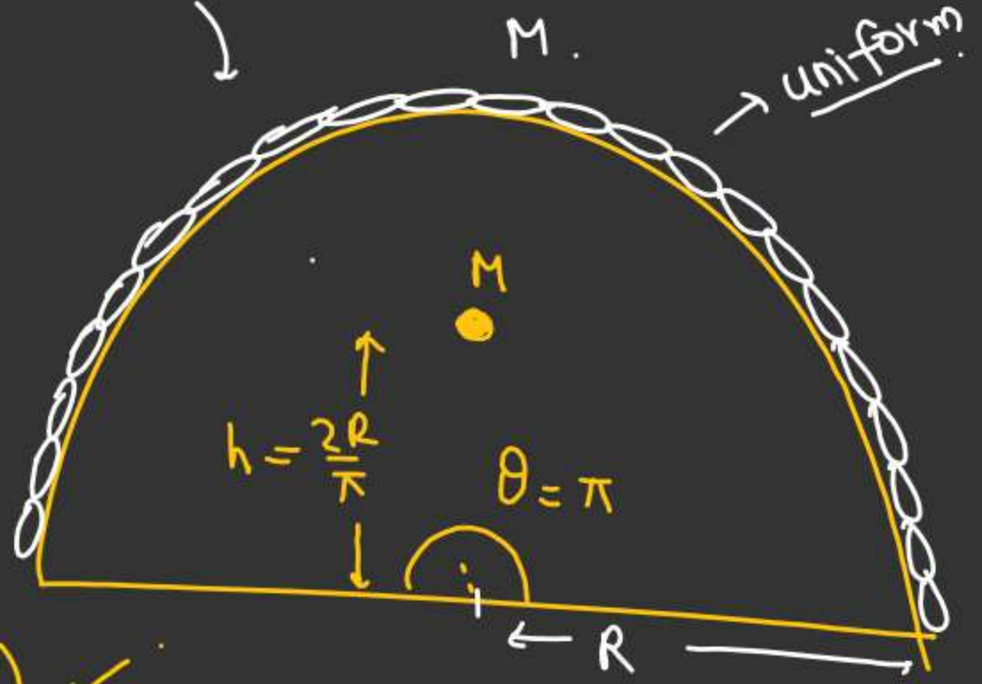
TRICK (Proof in next Chapter)



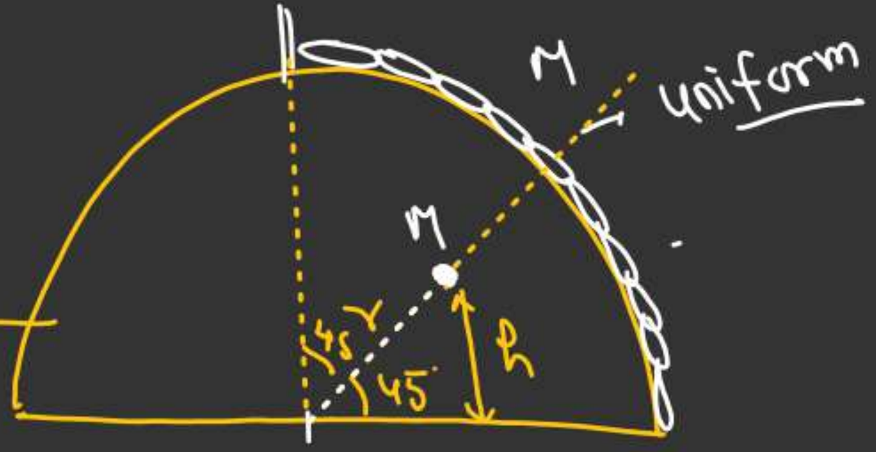
$$\boxed{h = \frac{2R}{\theta}\sin\left(\frac{\theta}{2}\right)}$$

$U = ??$



$$U = \left(Mg\,\frac{2R}{\pi}\right) \checkmark$$

$\theta = \pi/2$



$$r = \frac{2R}{\pi/2}\cdot\sin\frac{\pi}{4}$$

$$r = \frac{4R}{\pi}\times\frac{1}{\sqrt{2}} = \frac{2\sqrt{2}R}{\pi}$$

$$h = \frac{r}{\sqrt{2}}$$

$$h = \left(\frac{2R}{\pi}\right) \checkmark$$

$$U = \left(\frac{mg\,2R}{\pi}\right)$$

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Find the Kinetic Energy of the Chain when chain become horizontal.

uniform Chain.

M = Mass of chain.

$\theta = \frac{\pi}{3}$

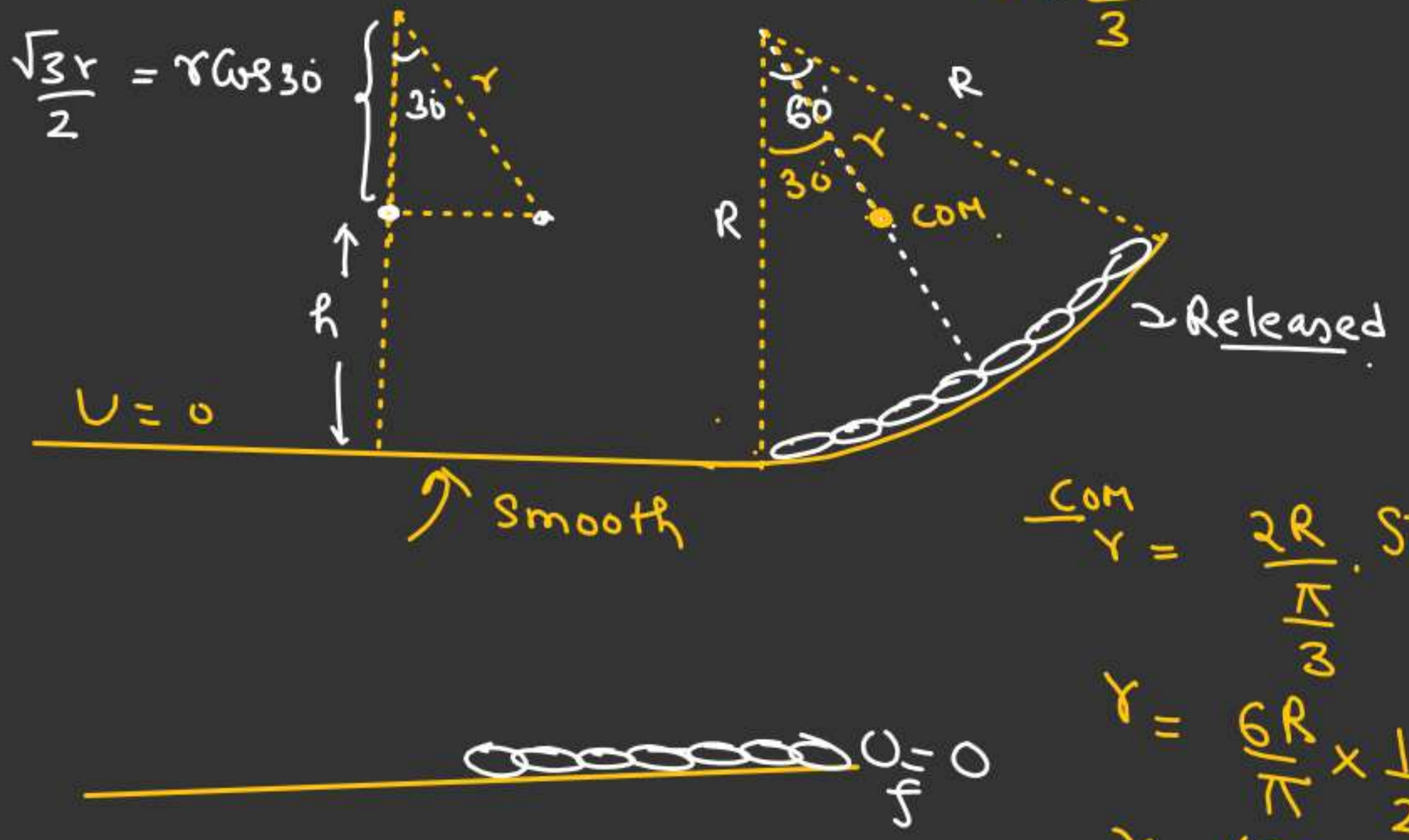
$$U_i + \cancel{K.E_i}^{\,0} = \cancel{U_f}^{\,0} + K.E_f$$

$$h = R - \frac{\sqrt{3}}{2} r$$

$$h = R - \frac{\sqrt{3}}{2} \times \frac{3R}{\pi}$$

$$h = \left(R - \frac{3\sqrt{3}R}{2\pi}\right)$$

$$Mg\left(R - \frac{3\sqrt{3}R}{2\pi}\right) = \left(K.E_f\right)$$



$$r_{COM} = \frac{2R}{\frac{\pi}{3}} \cdot \sin\left(\frac{\pi}{6}\right)$$

$$r = \frac{6R}{\pi} \times \frac{1}{2}$$

$$r = \left(\frac{3R}{\pi}\right)$$

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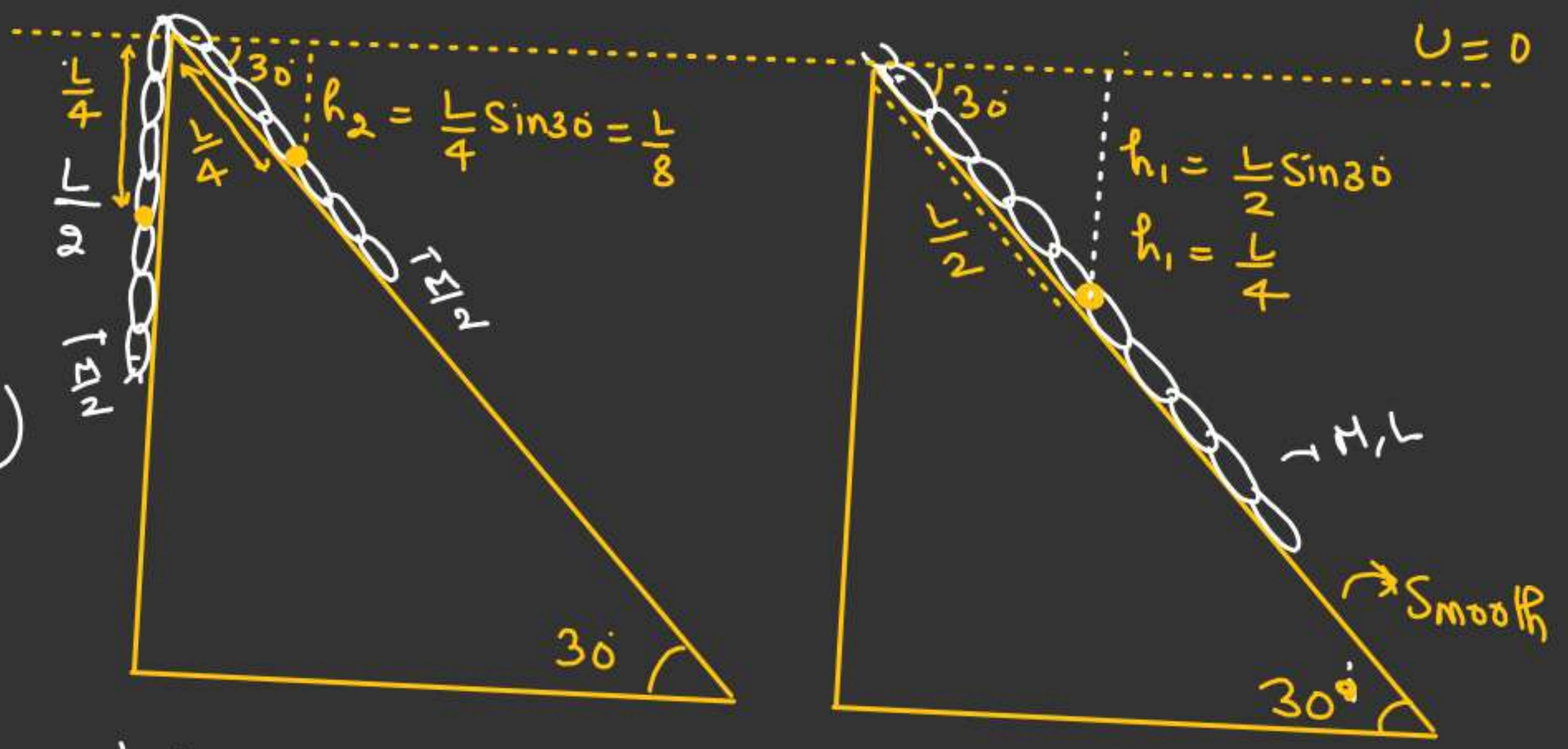
* Snake assumed to be uniform. It crawl and half of its length become vertical.

Find work done by snake against gravity.



$$W_{snake} = -\Delta U = -(U_f - U_i)$$
$$= (U_i - U_f)$$

$$U_i = -\left(Mg\frac{L}{4}\right)$$

$$U_f = -\left[\frac{M}{2}g\frac{L}{8} + \frac{M}{2}g\frac{L}{4}\right]$$

$$U_f = -\left[\frac{MgL}{16} + \frac{MgL}{8}\right]$$

$$U_f = -\left(\frac{3MgL}{16}\right)$$

$$W_{snake} = \left(-\frac{MgL}{4} + \frac{3MgL}{16}\right)$$

$$W_{snake} = \left(\frac{-MgL}{16}\right)$$

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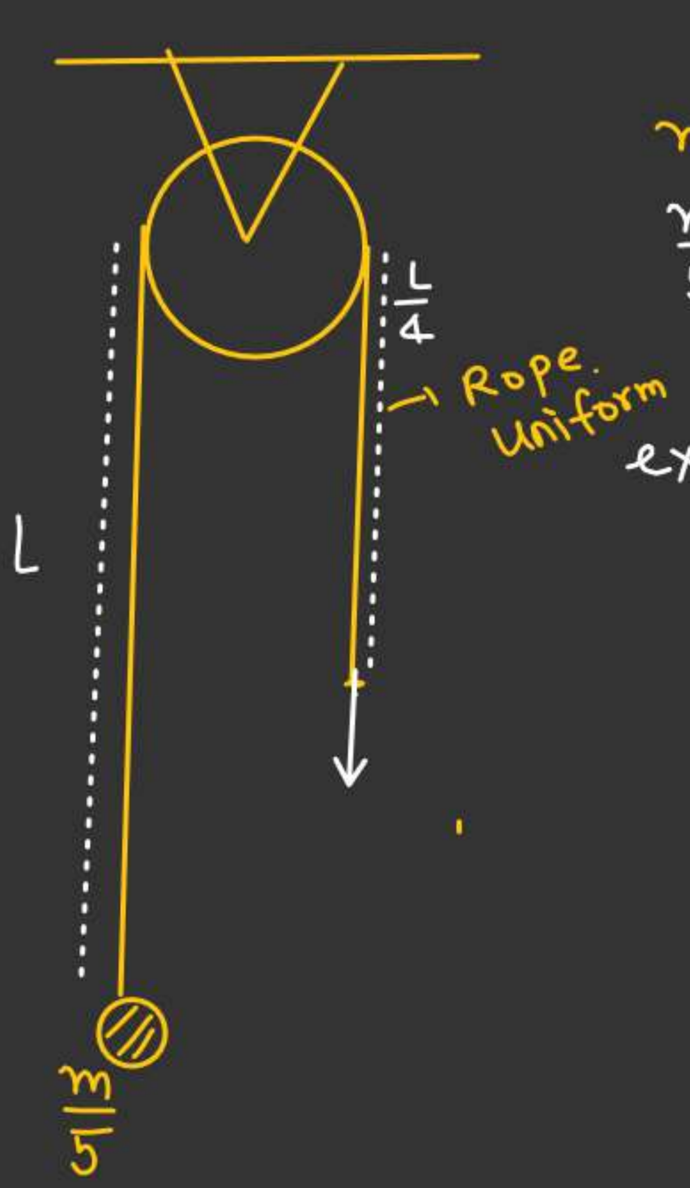
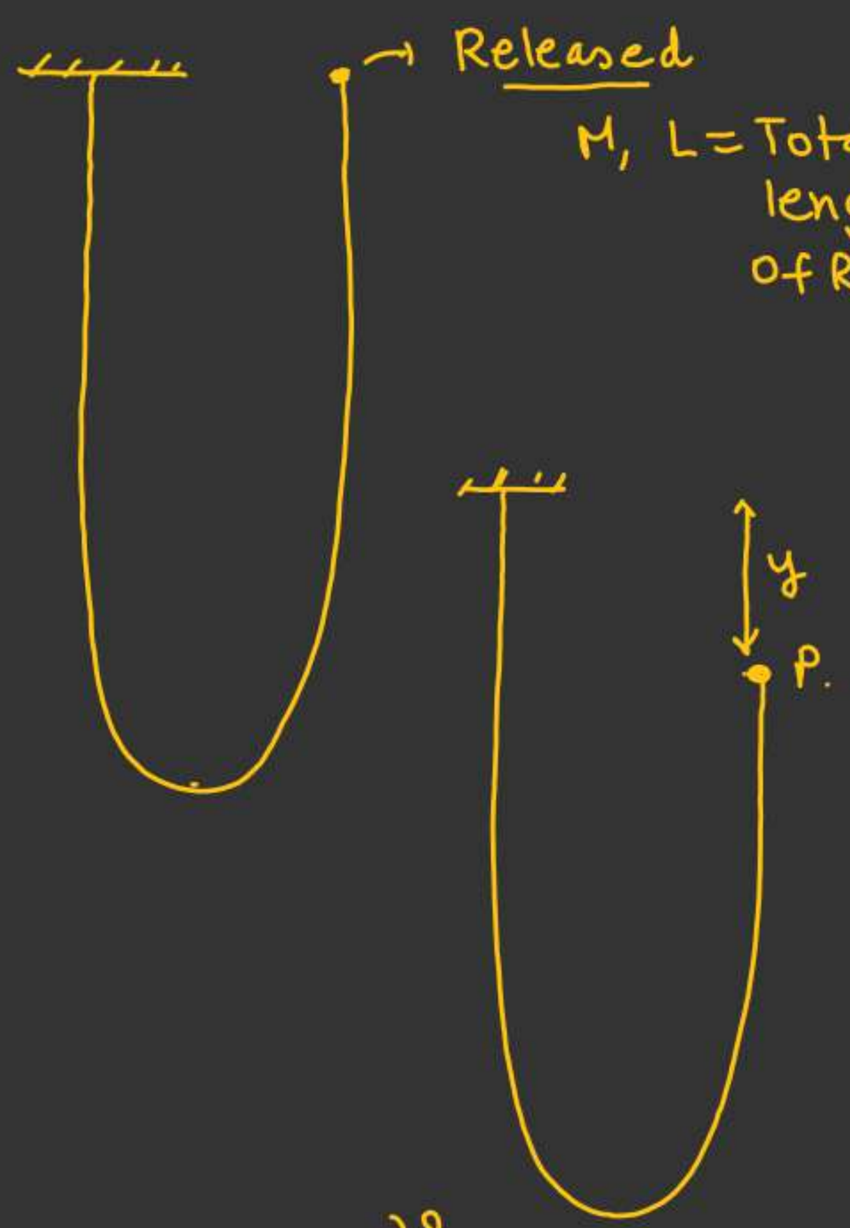


m = Mass of Rope

$\frac{m}{5}$ = Mass of ball.

Find min force applied by ext. agent to assure that ball reaches at pully.



M, L = Total length of Rope.

$v_P = f(y) = ??$

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Sheet

Don't attempt

Ex:- 1 Q-14.

Ex:- 2 Q-6, Q-10, Q-12,

Ex:- 3 Q-1, Q-7, Q-12, Q-13,
Q-14, Q-24, Q-25

Except theses
All have
to attempt from Ex 1, 2 & 3