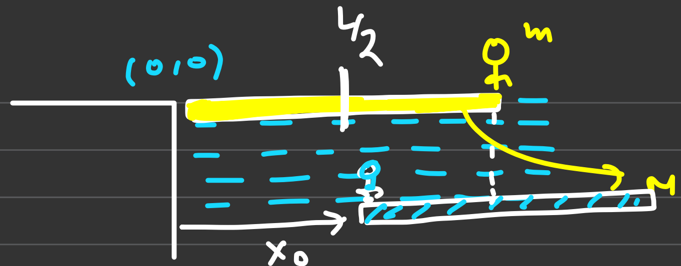
Problem solving E&M

VMC Vidyamandir Classes SINCE 1986

IIT JEE | MEDICAL | FOUNDATION

Q)



initially both are at rest

Now man starts walking towards bank

find displacement of plank when man is on other side of plank.

$F_{ext} = 0 \Rightarrow a_{cm} = 0$

if $a_{cm} = 0$

$V_{cm} = 0 \Rightarrow x_{cm} = \text{fixed}$

$V_{cm} = \text{const} \Rightarrow x \neq \text{const}$

as $\{\underline{F_{ext} = 0}$ and $\underline{V_{cm} = 0}\}$ hence $\underline{\underline{x_{cm} = \text{const}}}$

$$(x_{cm})_i = \frac{M \times L/2 + m \times L}{m + M} \quad \text{—— (1)}$$

$$(x_{cm})_f = \frac{m x_0 + M(x_0 + L/2)}{m+M} \quad \text{--- (11)}$$

$$(x_{cm})_i = (x_{cm})_f$$

$$\cancel{M \times L/2} + mL = m x_0 + \cancel{M(x_0 + L/2)}$$

$$mL = (m+M)\, x_0$$

$$x_0 = \left(\frac{mL}{m+M}\right)$$

$F_{ext} = 0$ and $v_{cm} = 0$

method 2:

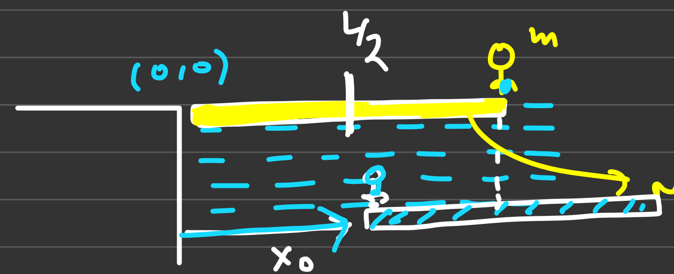
$$\Rightarrow x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

$$\Delta(x_{cm}) = \frac{m_1(\Delta x_1) + m_2(\Delta x_2)}{m_1 + m_2}$$

$$0 = m_1 \Delta x_1 + m_2 \Delta x_2$$

$$\# \quad \boxed{m_1 \Delta x_1 + m_2 \Delta x_2 = 0}$$

$$\Delta = f - i$$



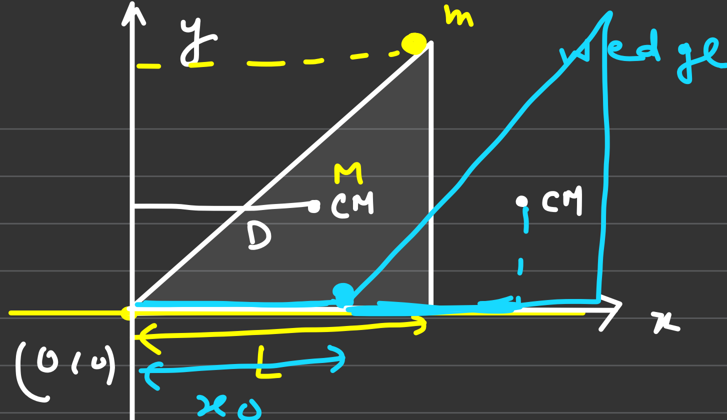
$$m(x_0 - L) + M\left(x_0 + \cancel{\frac{L}{2}} - \cancel{L/2}\right) = 0$$

$$m x_0 - mL + M x_0 = 0$$

$$\boxed{x_0 = \frac{mL}{m+M}}$$

Ans

θ)



\# initially System is at rest

\# find displacement of wedge when point mass is at bottom of wedge?

(given) $(F_{ext})_x = 0 \Rightarrow (a_{cm})_x = 0$

$(v_{cm})_x = 0$

then $x_{cm} =$ Const

On System

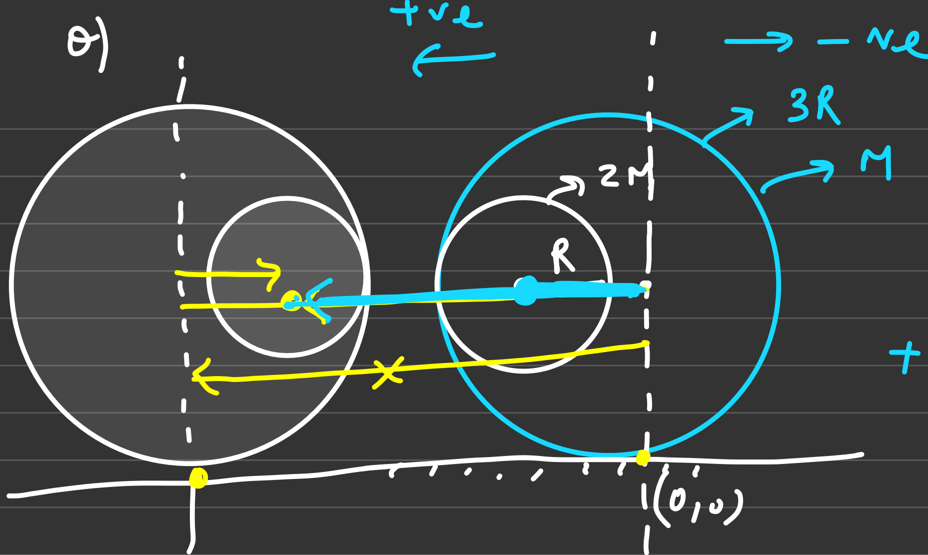
$$m_1 \Delta x_1 + m_2 \Delta x_2 = 0$$

$$m\{x_0 - L\} + M\{x_0 + D - D\} = 0$$

$$m x_0 - mL + M x_0 = 0$$

$$x_0 = \left(\frac{mL}{m+M}\right) \text{ Ans}$$

Q)



all smooth and Released from rest

find displacement of bigger sphere when small sphere is at other side of bigger sphere

$+(x-2R)-2R$

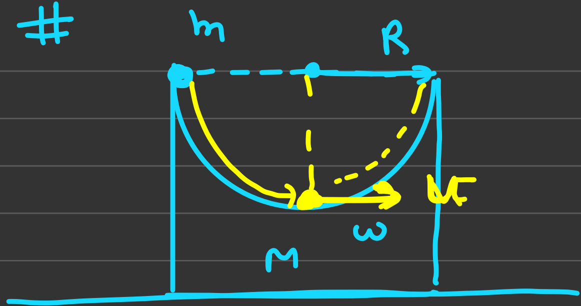
$$M(x-0)+2M((x-2R)-2R)=0$$

$$Mx+2Mx-8MR=0$$

$$3\cancel{M}x=8\cancel{M}R$$

$$x=+\left(\frac{8R}{3}\right)$$ Ans

Q)



initially rest # smooth
find displacement of wedge when point mass is at other end of wedge?

find max speed of wedge

≠

#

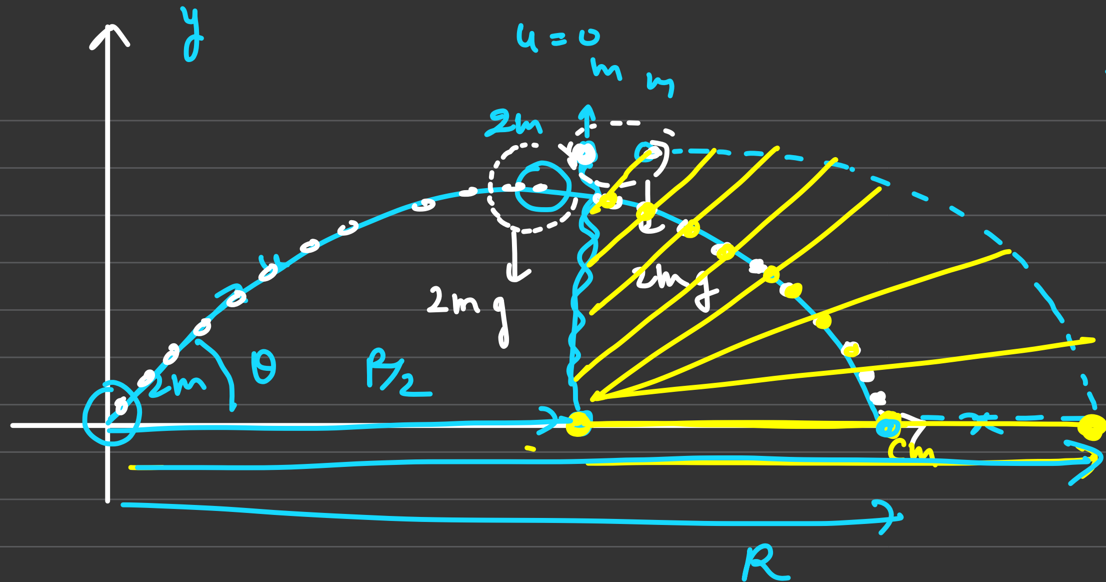
L. of Conservation of energy

$$mgR = \frac{1}{2} M v_{max}^2 + \frac{1}{2} m u_r^2$$

L. of Con of momentum

$$m u - M V_{max} = 0 + 0$$

Q)



find location of second particle?

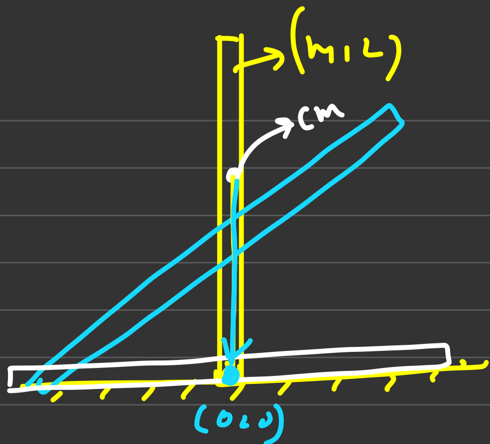
$$R = \frac{u^2 \sin 2\theta}{g}$$

$$+R = \frac{\cancel{m} \times \frac{R}{2} + \cancel{m}\,(x_0)}{2\cancel{m}}$$

$$2(R) = \frac{R}{2} + x_0 \Rightarrow x_0 = \frac{3R}{2}$$

$$x_0 = 1.5R$$

Q)

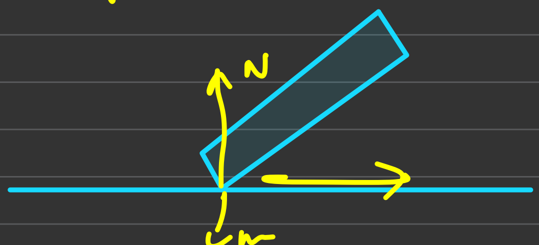


find final location of COM

rod is released from rest

smooth surface

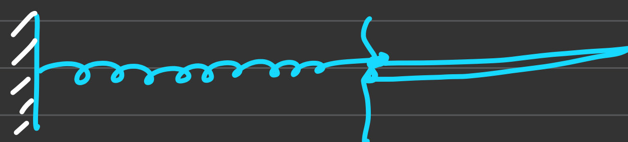
as no ext force along horizontal hence C.M is going move downwards



; Conservative force & Non-Conservative :

Conservation: Work done by Conservative in a loop is always = 0

$$(W_{CF})_{Loop} = 0$$



\# Spring, gravity

\# Electrostatic

\# magnetic

Non-Conservative force: work done by Non-Conservative force in a loop is never = 0

$$(W_{NCF})_{loop} = 0$$

frictional

viscous

Tension

$$w_f = f_k \times (\text{distance})$$

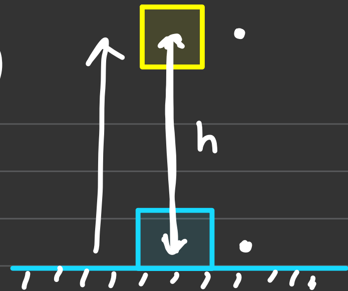
Conservative force:

$$\left\{ du = -\vec{F}_c \cdot \vec{dr} \right\}$$

Basic definition

$(F_c)_x = -\dfrac{du}{dx} \Rightarrow F_c = -\dfrac{du}{dr}$

Q) a)



$$\Delta u = +mgh$$

\# $$\Delta u = -\vec{F_c}\cdot\vec{dr}$$

$$\Delta u = -[-mgh]$$

$$\Delta u = +mgh$$

$$\Delta u = -mgh$$

$$\Delta u = -\vec{F_c}\cdot dr$$

$$\Delta u = -[mgh] = \underline{\underline{-mgh}}$$

#

$U(r)$

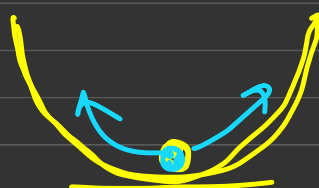
$\Downarrow$

$F_c = -\dfrac{du}{dr}$

$\Downarrow$

$F_c = 0$ Equilibrium

Stable Equilibrium



$U(r)$

$\Downarrow$

$F_c = -\dfrac{du}{dr}$

it can restore it

Unstable Equilibrium

$F_c = -\dfrac{du}{dr}$

it can nev

Nuetral Equilibrium

$F_c = 0$

$\left\{ \dfrac{d^2u}{dr^2} = 0 \right.$

$\Rightarrow$

Equilibrium position

$\dfrac{d^2u}{dr^2} > 0$

if P.E $\Rightarrow$ min then only we can stable equilibrium

restore eqb pos.

$\dfrac{d^2u}{dr^2} < 0$

It attains new eqb position

if PE = max the only unstable equilibrium

Q) $U(r) = \frac{a}{r^2} - \frac{b}{r^3}$ {a, b +ve constant}

find position of equilibrium

find particle is at stable or unstable equilibrium

$F = -\frac{du}{dr} = -\left(-\frac{2a}{r^3} + \frac{3b}{r^4}\right) = 0$

$$\frac{2a}{r^3} = \frac{3b}{r^4}$$

$$\boxed{r_0 = \frac{3b}{2a}}$$ Ans

#

$$\left(\frac{d^2u}{dr^2}\right)_{at\ eq} = \left\{\frac{6a}{r^4} - \frac{12b}{r^5}\right\}$$

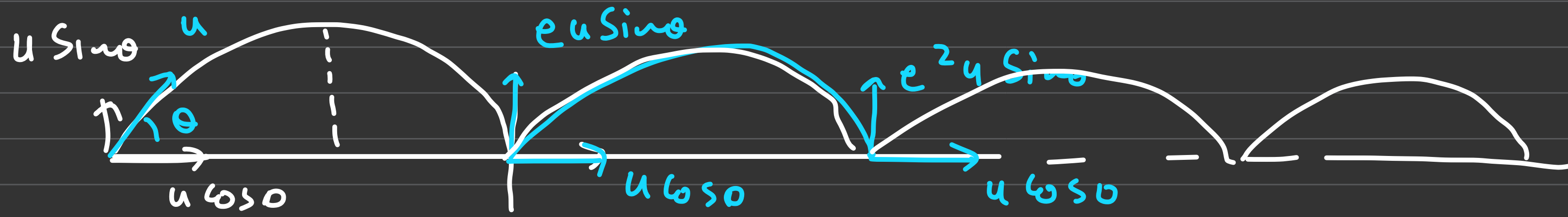
$$= \frac{1}{r^4}\left[6a - \frac{12\cancel{b}\times 2a}{3\cancel{b}}\right]$$

$$= \left(\frac{1}{r_0}\right)^{+ve}\left\{\frac{6a - \frac{24a}{3}}{-ve}\right\}$$

$$\frac{d^2u}{dr^2} < 0$$

{Unstable equilb}

$\theta)$



\# $T_0 = \dfrac{2u\sin\theta}{g}$ $\qquad T_1 = \dfrac{2eu\sin\theta}{g} = eT_0$

\# $H_{max} = \dfrac{u^2\sin^2\theta}{2g} = H_m \qquad H_{max} = \dfrac{e^2u^2\sin^2\theta}{2g} = e^2 H_{max}$

\# $Rang = \dfrac{u^2\sin 2\theta}{g} = R_0 \qquad Range = \left\{ \underline{u\cos\theta} \times e\underline{T_0} \right\} = eR_0$

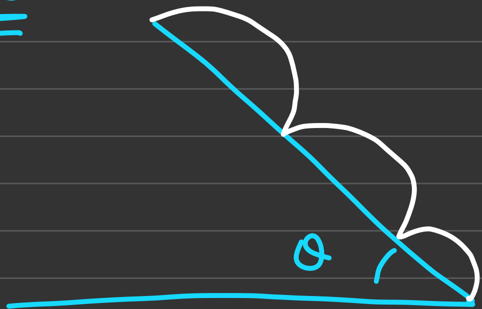
$\rightarrow$ 1st collision $\qquad$ 2nd collision

Time $\rightarrow$ T_0 $\qquad eT_0 \qquad e^2T_0 \qquad e^3T_0 \quad \ldots \quad e^nT_0$

$H_{max} \rightarrow H_m \qquad e^2H_m \qquad e^4H_m \qquad e^6H_{max} \qquad e^{2n}H_{max}$

$R_{enq} = R_0 \{ \quad e R_0 \quad e^2 R_0 \quad e^3 R_0 \quad e^n R_0$

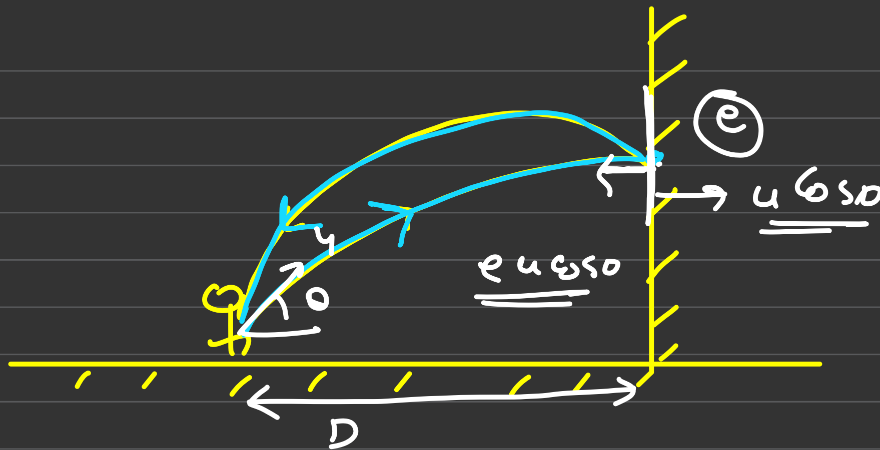
H.W



find general condition for $(T, \; R, \; H_{max})$

Q)

find condition for which ball come back in hand of observer?



Change vertical velocity with wall or without wall is going to same as net external force = mg { No - impulse during collision in upward direction }

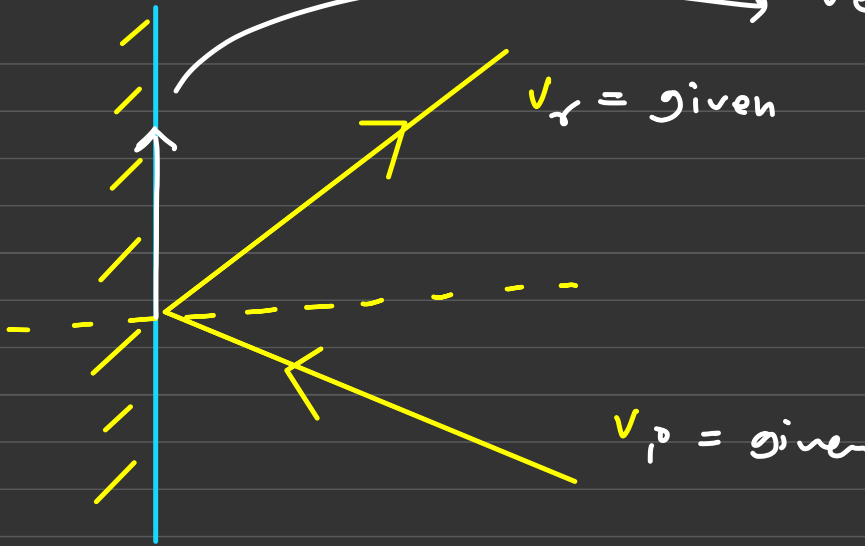
$$\# \quad \boxed{\frac{2u\sin\theta}{g} = \frac{D}{u\cos\theta} + \frac{D}{eu\cos\theta}} \quad \text{Ans}$$

#

find condition such ball comes back in hand of obs.

$$\# \quad \frac{2u\sin\theta}{g} = \frac{d_1}{u\cos\theta} + \frac{d_1+d_2}{e\,u\cos\theta} + \frac{d_2}{e^2 u\cos\theta}$$

#



"velocity along the surface must NOT change",

#

$$\hat{r}_t = x\hat{i} + y\hat{j}$$

$$\sqrt{x^2 + y^2} = 1 \Rightarrow x^2 + y^2 = 1 \quad \text{--- (1)}$$

Unit vector along wall

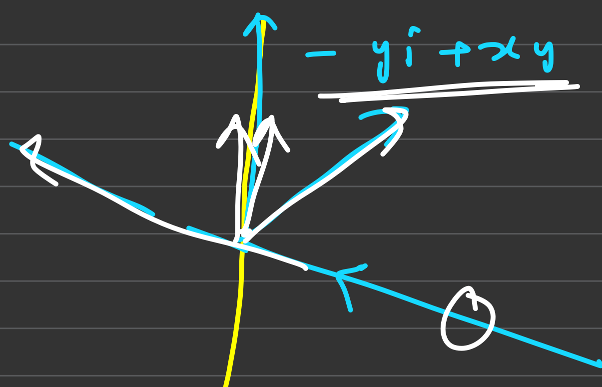
$$r_{11} = x'i + y'j$$

$$-xy + xy = 0$$

$$x'x + yy' = 0$$

$x' = -y \quad y' = x$

$$\underline{r_{11} = -yi + xj}$$

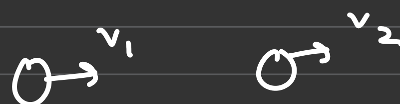


$\dfrac{\vec{v}_i \cdot \vec{r}_{11}}{|\vec{r}_{11}|} = \dfrac{\vec{v}_r \cdot \vec{r}_{11}}{|\vec{r}_{11}|}$ — (11)

Solve (1) and (11)
get x and y
and get $(r_\perp)$ & r_{11}

Q)

all collision are elastic



$v_2 - v_1 = 1 \times u$ —— (i)

$2\cancel{m} \times u = 2\cancel{m} v_1 + \cancel{m} v_2$

$2u = 2v_1 + v_2$ —— (ii)

$2u = 3v_1$ $\quad v_1 = u/3$

$v_2 = v_1 + u$

$v_2 = \frac{4u}{3}$

#

3 collision

6 Collision

#

#