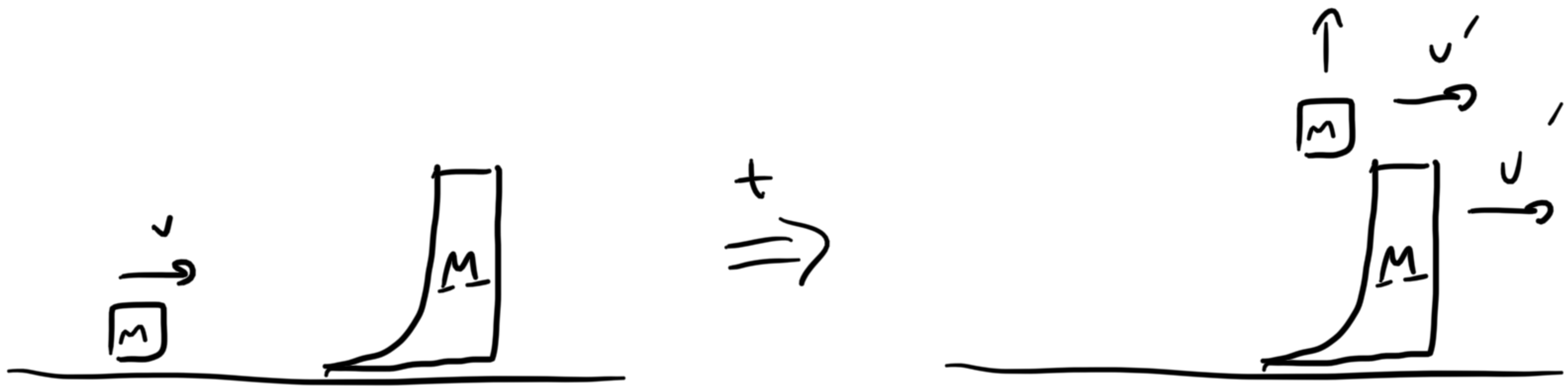
# #3




$N = 0$

$$mv = (m+M)v' \Rightarrow v' = \frac{m}{m+M}v$$

$$\frac{1}{2}mv^2 = mgh + \frac{m+M}{2}(v')^2$$

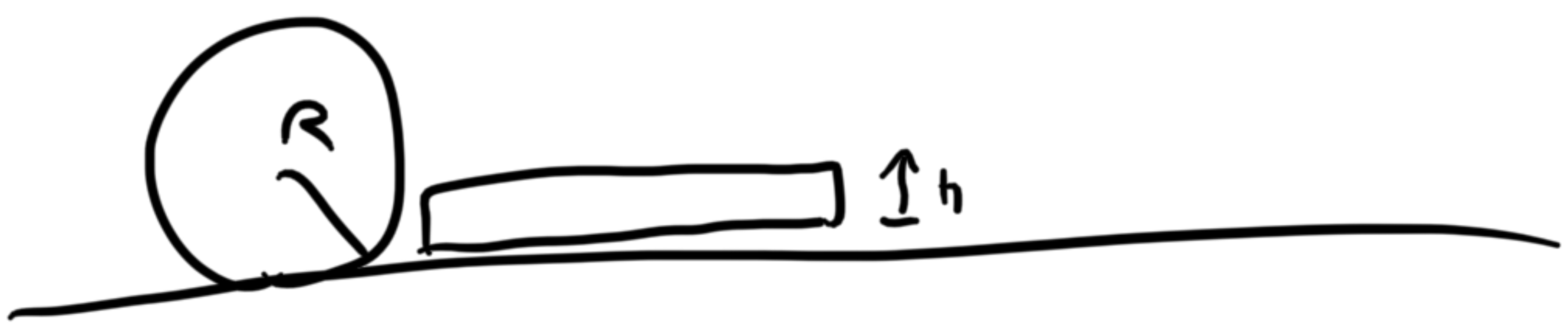
$$= mgh + \frac{m+M}{2}\left(\frac{m}{m+M}v\right)^2$$

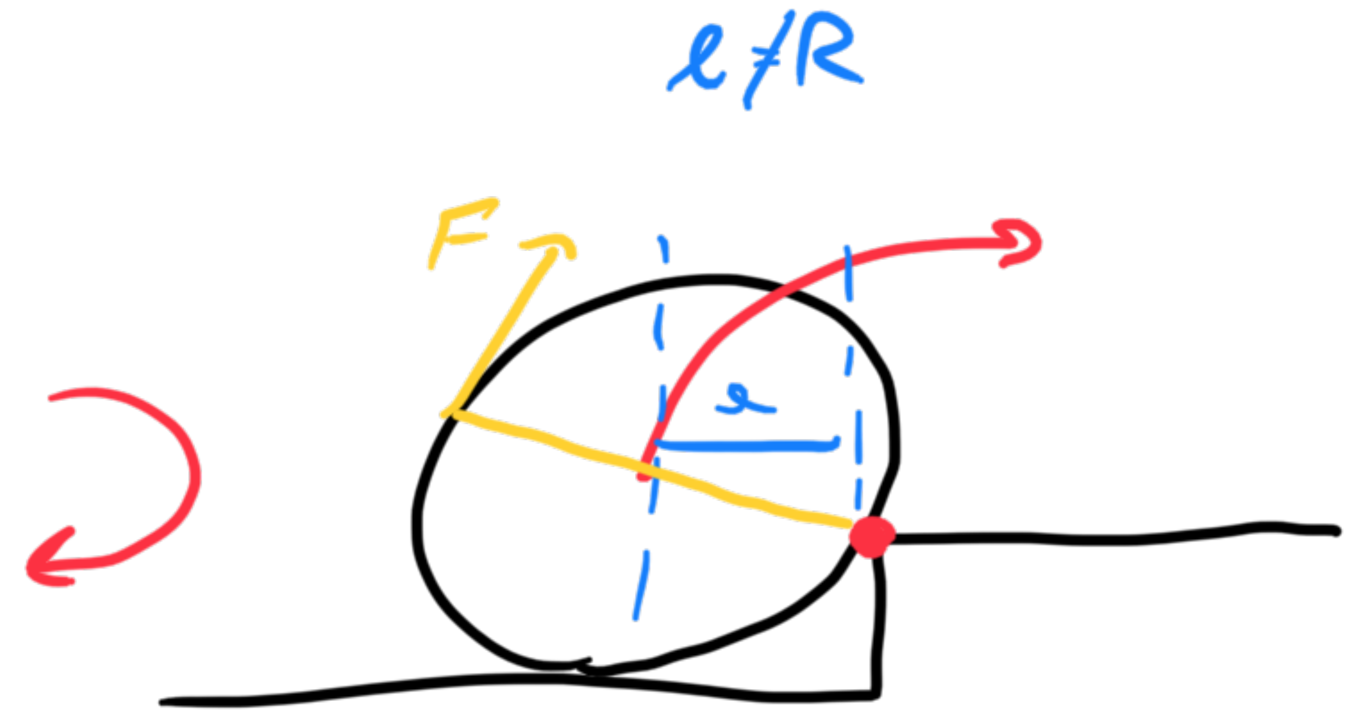
$$\frac{1}{2}mv^2 = mgh + \frac{m^2v^2}{2(m+M)}$$

$$\frac{1}{2}mv^2\left(1 - \frac{m}{m+M}\right) = mgh \Rightarrow h = \frac{v^2}{2g}\,\frac{M}{m+M}$$

E

# #5




$$\tau_g = G\ell = G\sqrt{R^2-(R-h)^2}$$

$$= G\sqrt{2Rh-h^2}$$

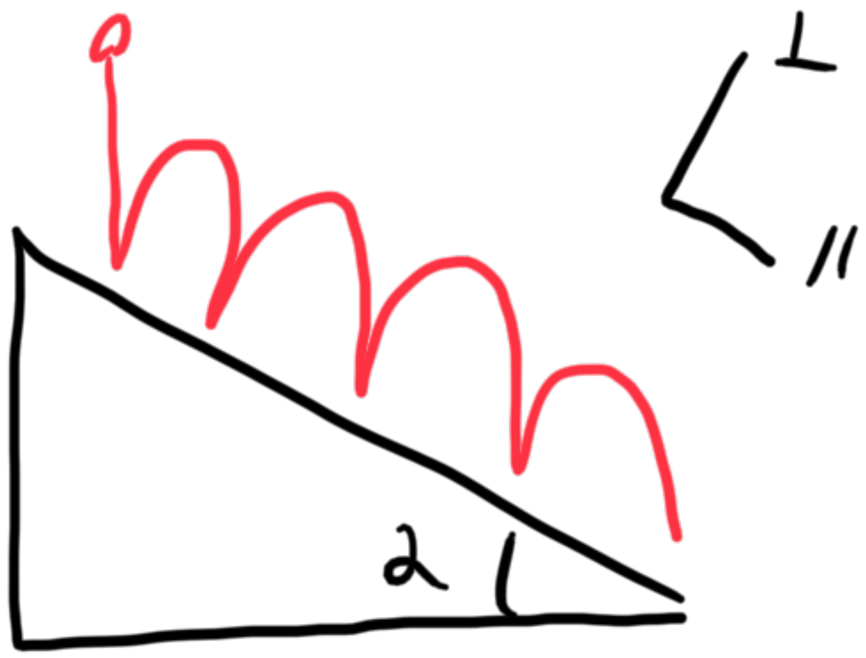
$$\tau_{app} = G\sqrt{2Rh-h^2}$$

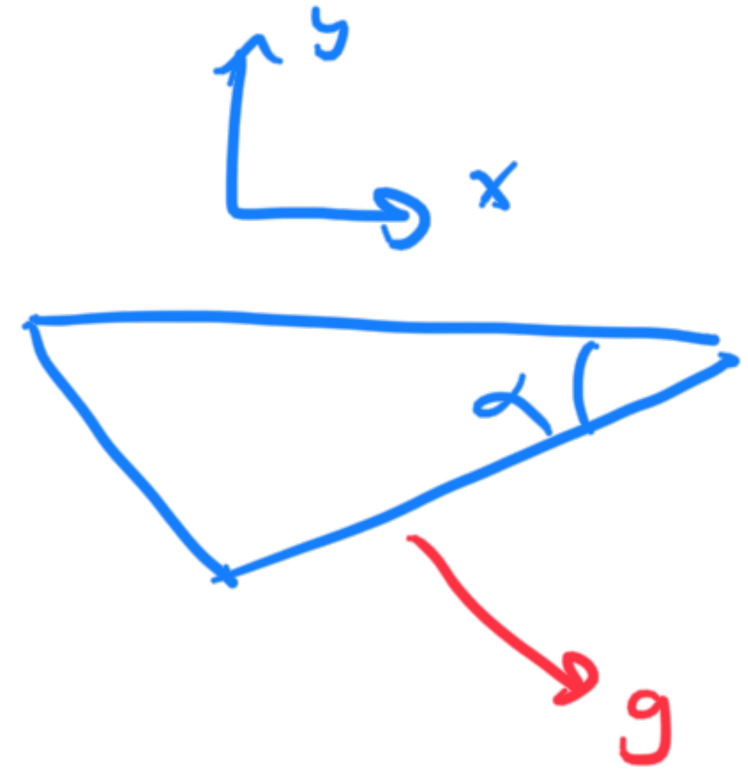
at the point opp to contact

$$F_{app} = \frac{\tau_g}{2R} = \frac{G\sqrt{2Rh-h^2}}{2R}$$

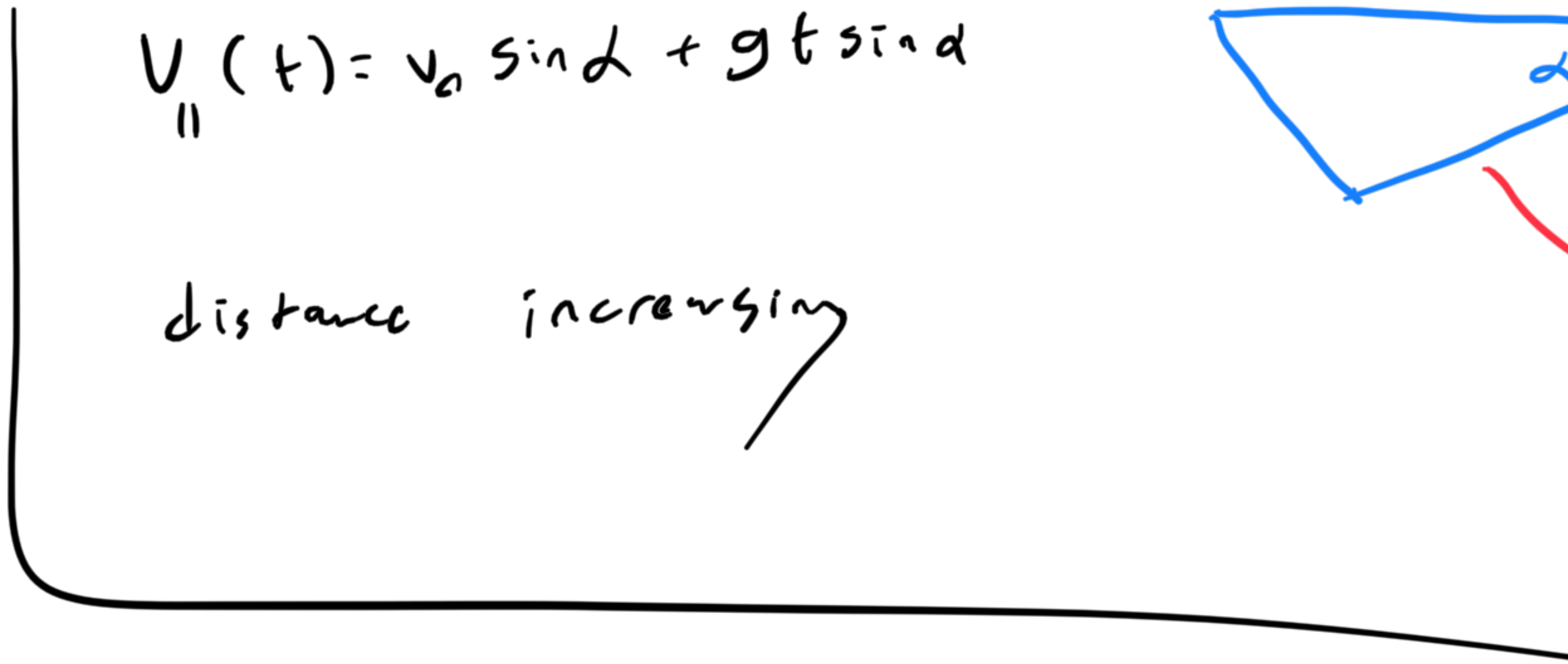
C

# #6




$V_{\parallel}(t) = v_0 \sin\alpha + g t \sin\alpha$




$V_{\perp}(0^-) = -v_0 \cos\alpha$

with $v_0 = \sqrt{2gh}$

$V_{\perp}(0^+) = v_0 \cos\alpha$

$V_{\perp}(t) = v_0 \cos\alpha - g t \cos\alpha$

$y_{\perp}(t) = v_0 \cos\alpha \, t - \frac{1}{2} g t^2 \cos\alpha$

$y_{\perp}(T) = 0 \Rightarrow \quad T = \frac{2v}{g}$

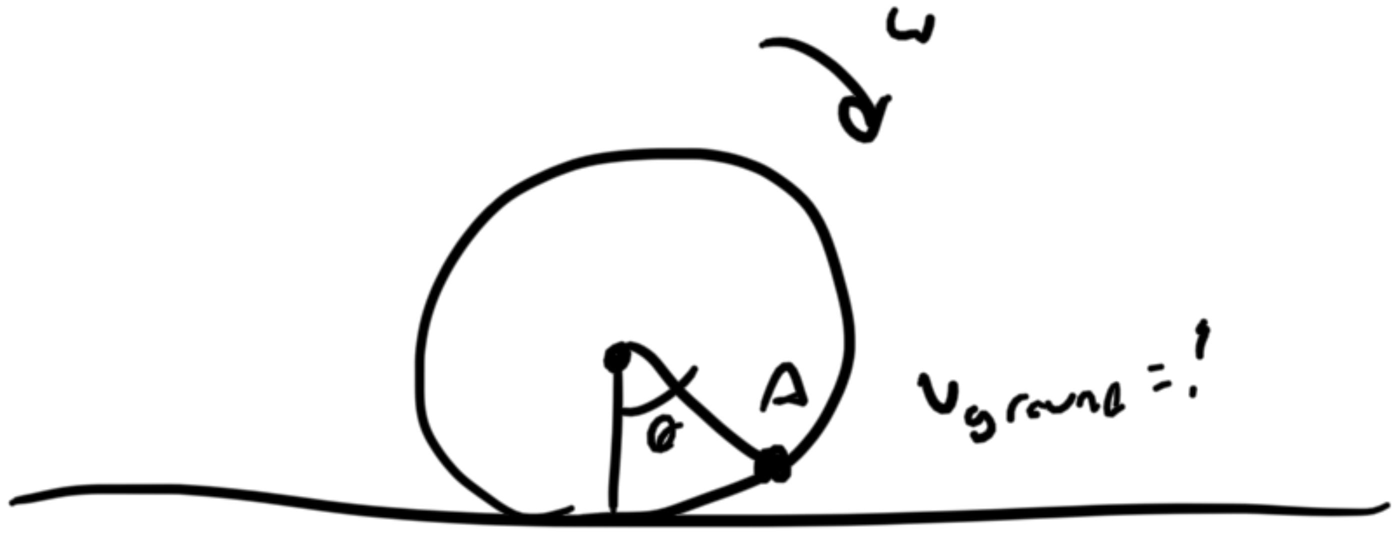
$V_{\perp}(T + 0^-) = v_0 \cos\alpha - g \frac{2v}{g} \cos\alpha$

$= -v_0 \cos\alpha = V_{\perp}(0^-)$

$T = \text{const}$

A

# #9




$v_x = v_c - \omega R\cos\theta = \omega R(1-\cos\theta)$

$v_y = -\omega R\sin\theta$

$v_A = \omega R\sqrt{2(1-\cos\theta)}$

$= \omega R\sqrt{2\cdot\left(2\sin^2\left(\frac{\theta}{2}\right)\right)}$

$= 2\omega R\sin\frac{|\theta|}{2}$

E

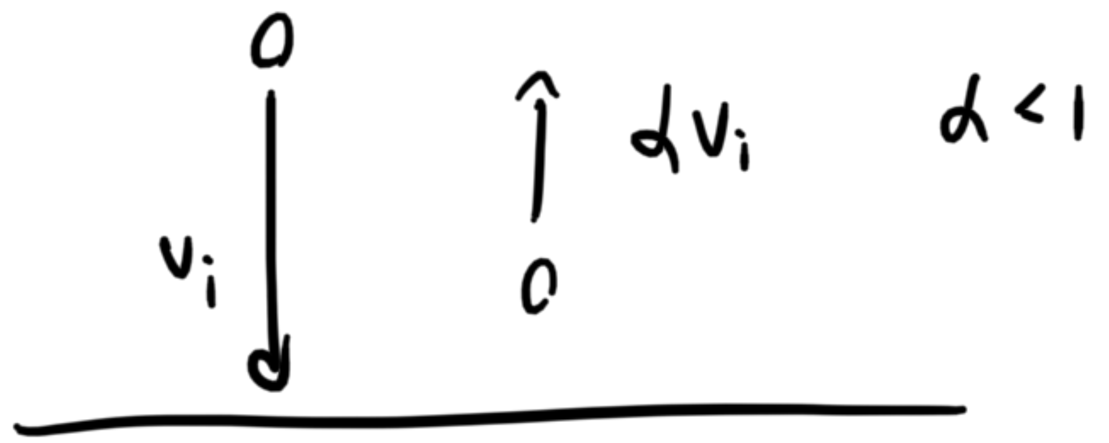
half-angle identities!

$1-\cos\theta = 1-\cos\left(2\frac{\theta}{2}\right)$

$= 1-\cos^2\frac{\theta}{2}+\sin^2\frac{\theta}{2}$ !

$= 2\sin^2\frac{\theta}{2}$

# #12

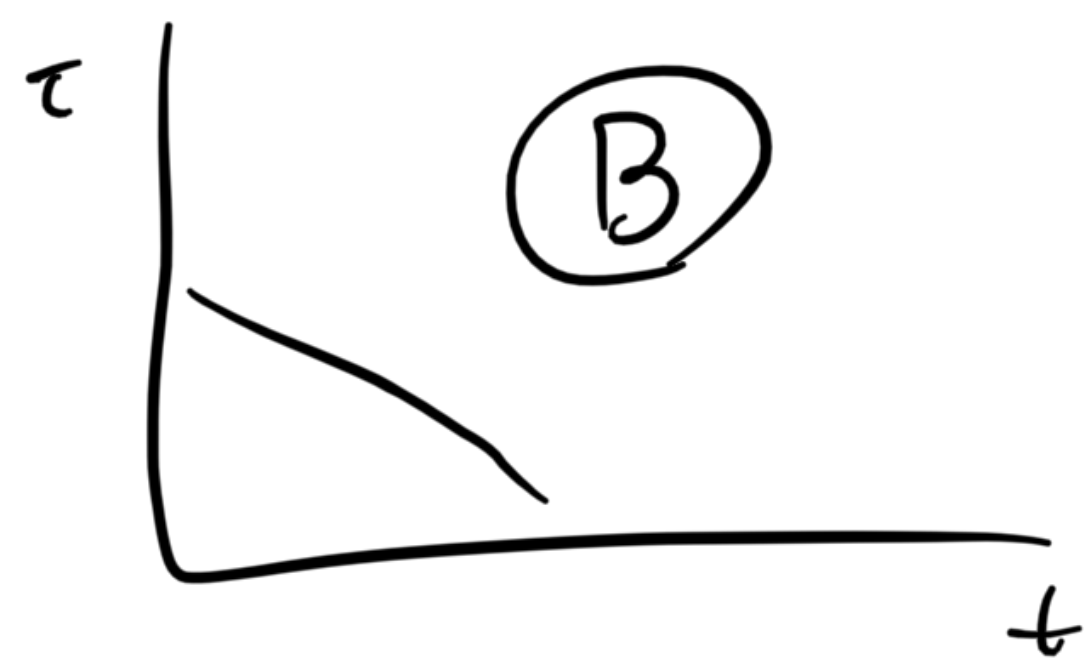



how does time between bounces evolve?

$$\tau_n = \frac{2v_n}{g} = \frac{2\alpha^n v_0}{g} = \tau_0 \alpha^n \qquad \tau_0 = \frac{2v_0}{g}$$

$$t_n = \sum_{i=1}^{n} t_i = \tau_0 \sum_{i=1}^{n} \alpha^n = \tau_0 \frac{\alpha(1-\alpha^{n-1})}{1-\alpha} = \frac{\tau_1 - \tau_n}{1-\alpha}$$

$$\tau_n = \tau_1 - (1-\alpha) t_n$$

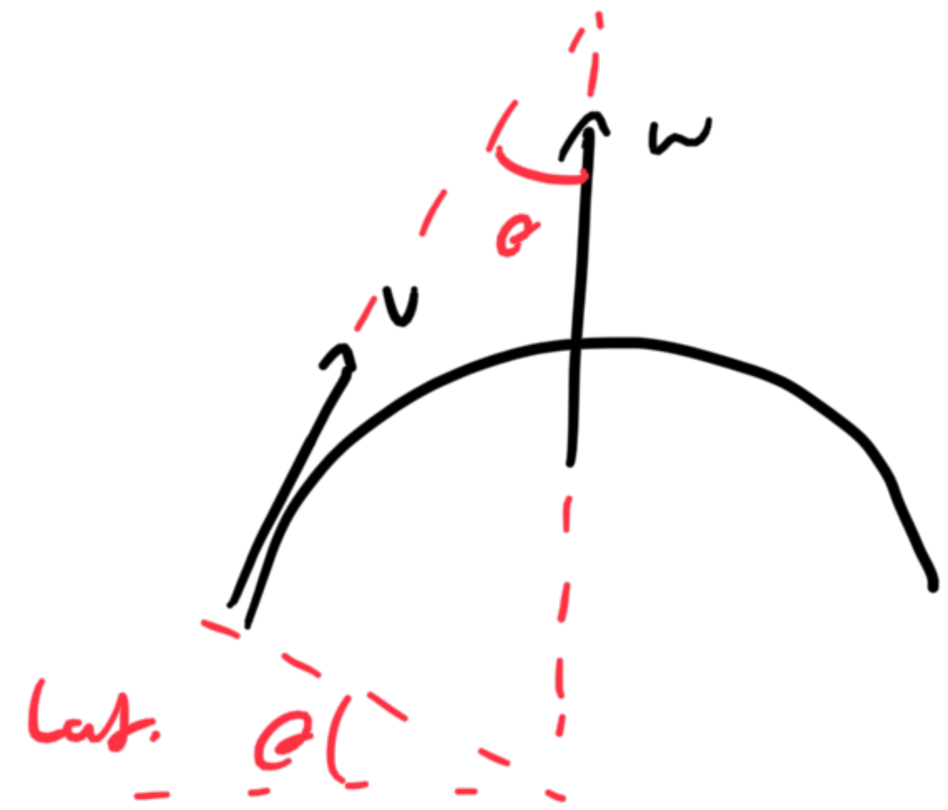



B

# #14

$\vec{a}_{cor} = -2\vec{\omega} \times \vec{v}$

$\theta$ = latitude




$\vec{\omega} = \frac{2\pi \text{ rad}}{\text{day}}$

$d = \frac{a_{cor} t^2}{2} = \frac{2\omega v \sin\theta \, (L/v)^2}{2} = \frac{L^2 \omega \sin\theta}{v} = 1.8\text{ mm}$

East D

#15

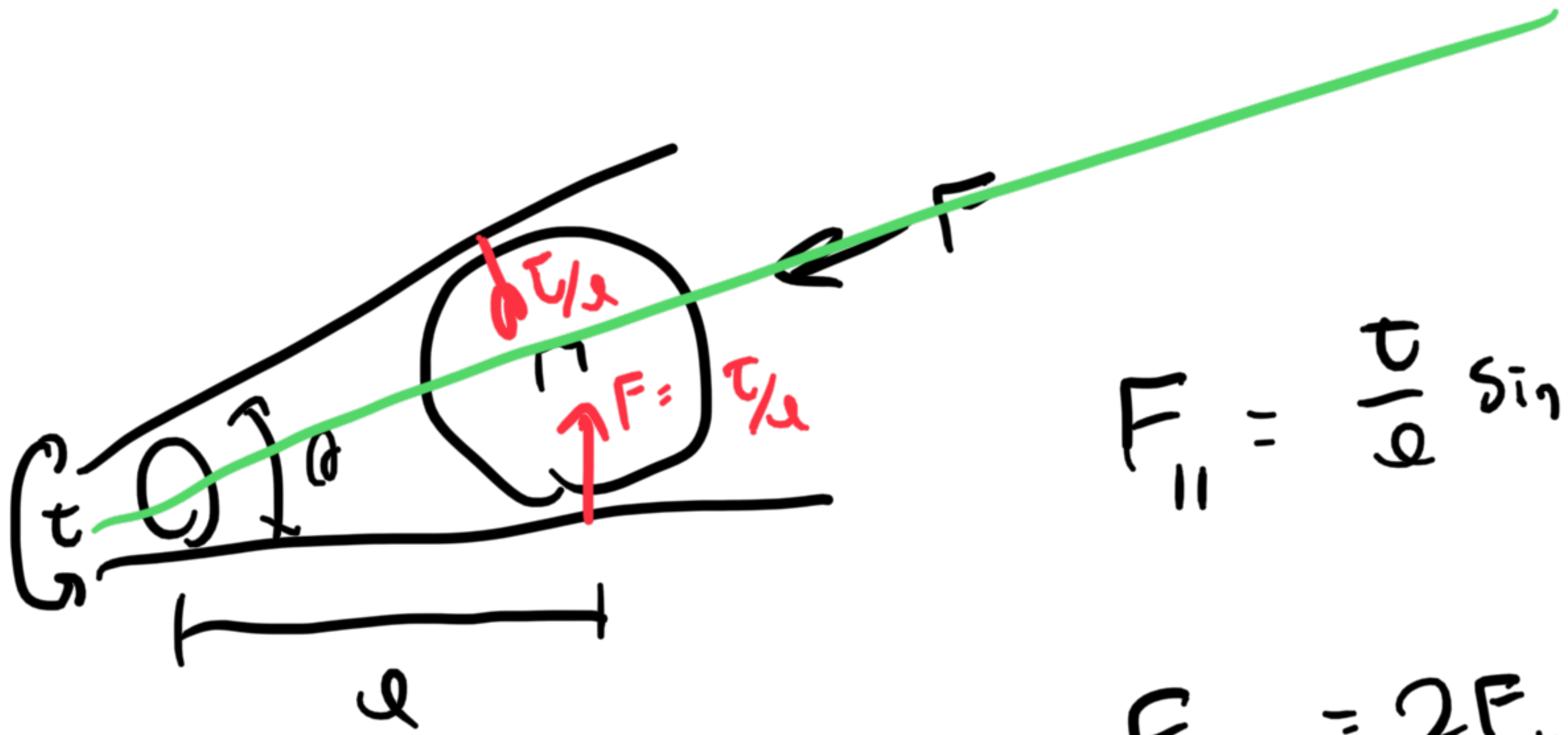
$$t = \frac{2v}{g} = \frac{2\pi}{\omega}$$

$$\omega = \frac{\pi g}{v}$$

$$v_x = \frac{\omega l}{2} = \frac{2\pi l}{2t} = \frac{\pi l g}{2v}$$

B

# #17




$$F_{\parallel} = \frac{\tau}{\ell} \sin\frac{\theta}{2}$$

$$F_{tot} = 2F_{\parallel} = \frac{2\tau}{\ell} \sin\frac{\theta}{2}$$

(A)

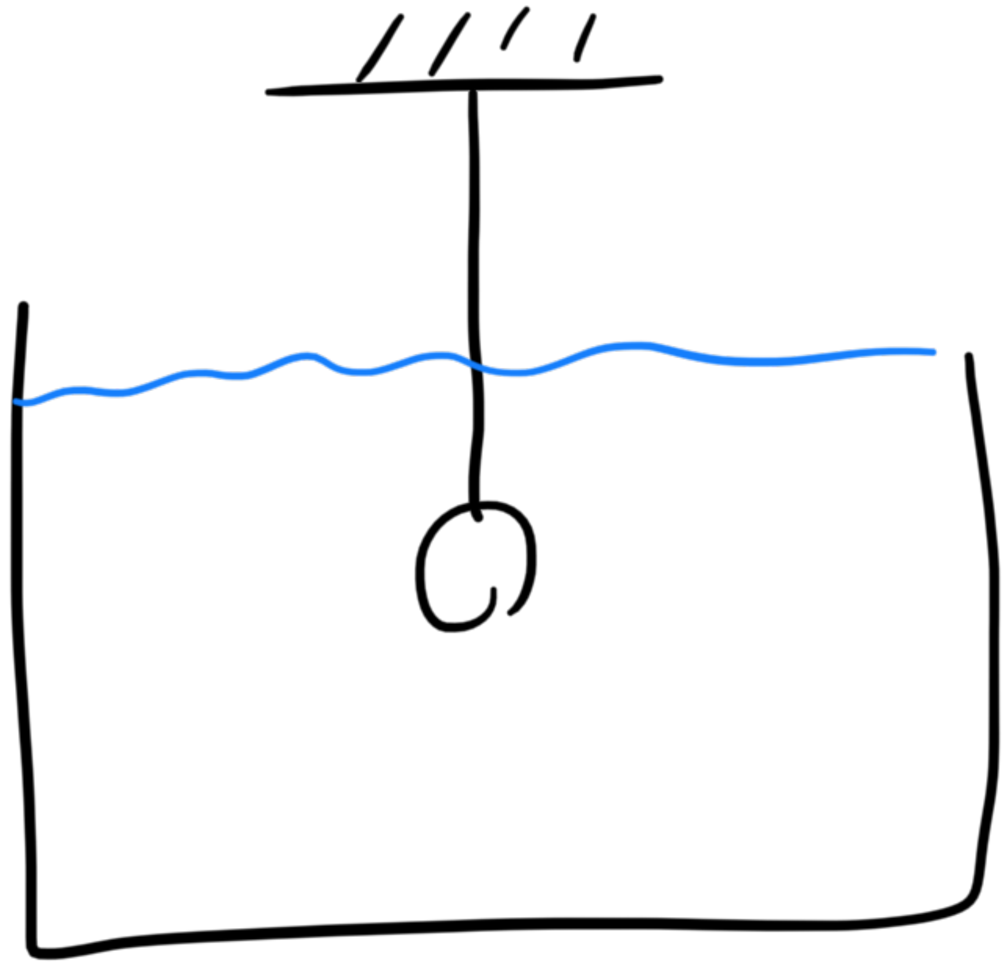
# #18


$E = \tau\theta \quad = Fd \quad$ "work"

$$\frac{mv^2}{2} = \tau\theta \Rightarrow v = \sqrt{\frac{2\tau\theta}{m}}$$

(D)

# #19



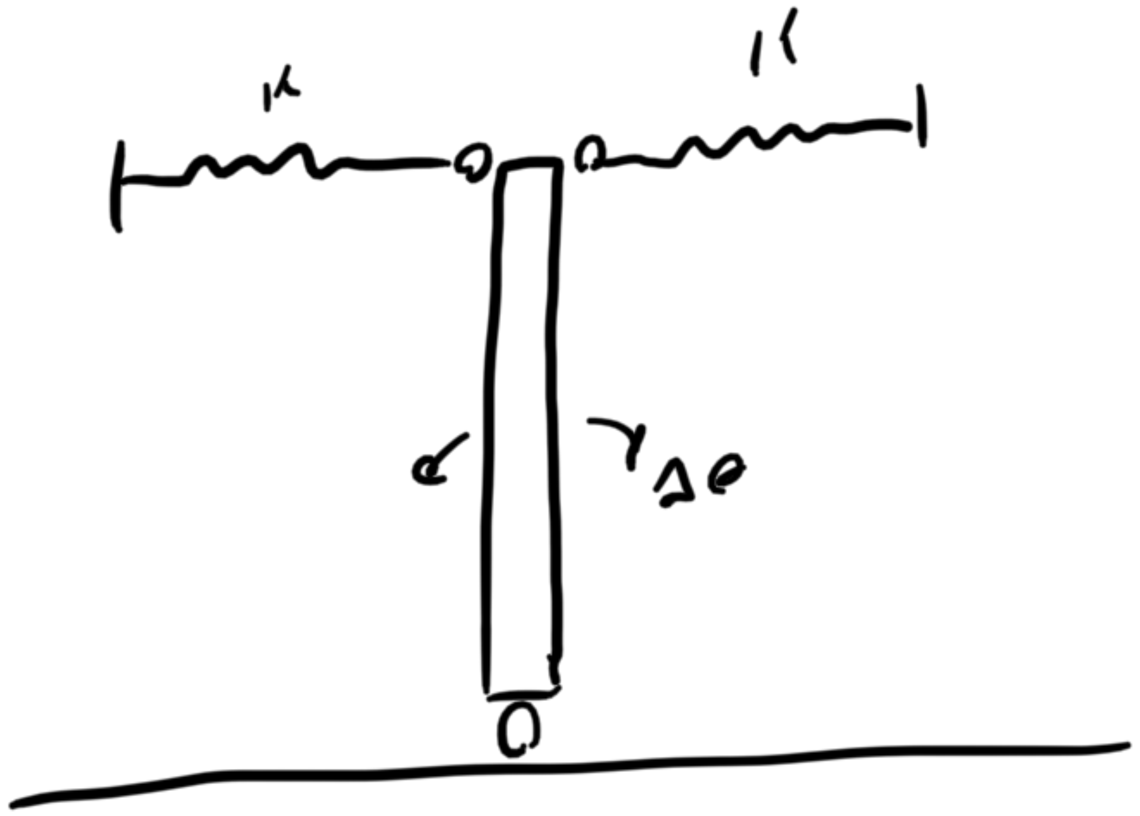
$g_{eff} = g/2$

$\omega = \sqrt{g/\ell} \Rightarrow \omega \sqrt{g_{eff}/\ell} = \sqrt{g/2\ell}$

$= \sqrt{10/10} \sim 1$

A

# #20




$\Delta x = L \sin = L\Delta\theta$

$F = 2k\Delta x = 2kL\Delta\theta$

$\tau_s = 2kL^2\Delta\theta$

$\tau_g = \frac{mgL}{2}\Delta\theta$

$2kL^2\Delta\theta > \frac{mgL}{2}\Delta\theta \Rightarrow mg < 4kL$ (A)

# #25

$$g_{car} = \vec{a}_c + \vec{g} = \frac{v^2}{r}\hat{i} - g\hat{j}$$


$$\theta = \tan^{-1}\frac{v^2}{gr}$$

$$h_{car} = h\cos\theta$$

$$P = \rho g_{car} h_{car} = \rho g h$$

$$\rho g h = \frac{\rho v^2}{2} \Rightarrow v = \sqrt{2gh}$$

A