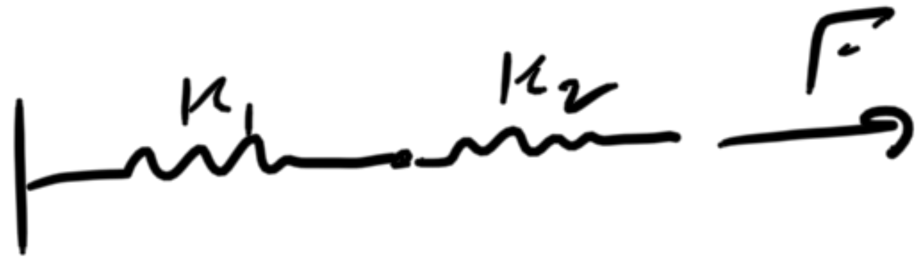
2019 B #3



$U_1/U_2 = ?$

$$U = \frac{1}{2}kx^2$$

$$\frac{U_1}{U_2} = \frac{k_1 x_1^2}{k_2 x_2^2}$$

$$F = kx$$

$$x = F/k$$

$$\boxed{F_1 = F_2}$$

$$F_1 = k_1 x_1 \qquad x_1 = F_1/k_1$$

$$F_2 = k_2 x_2 \qquad x_2 = F_2/k_2$$

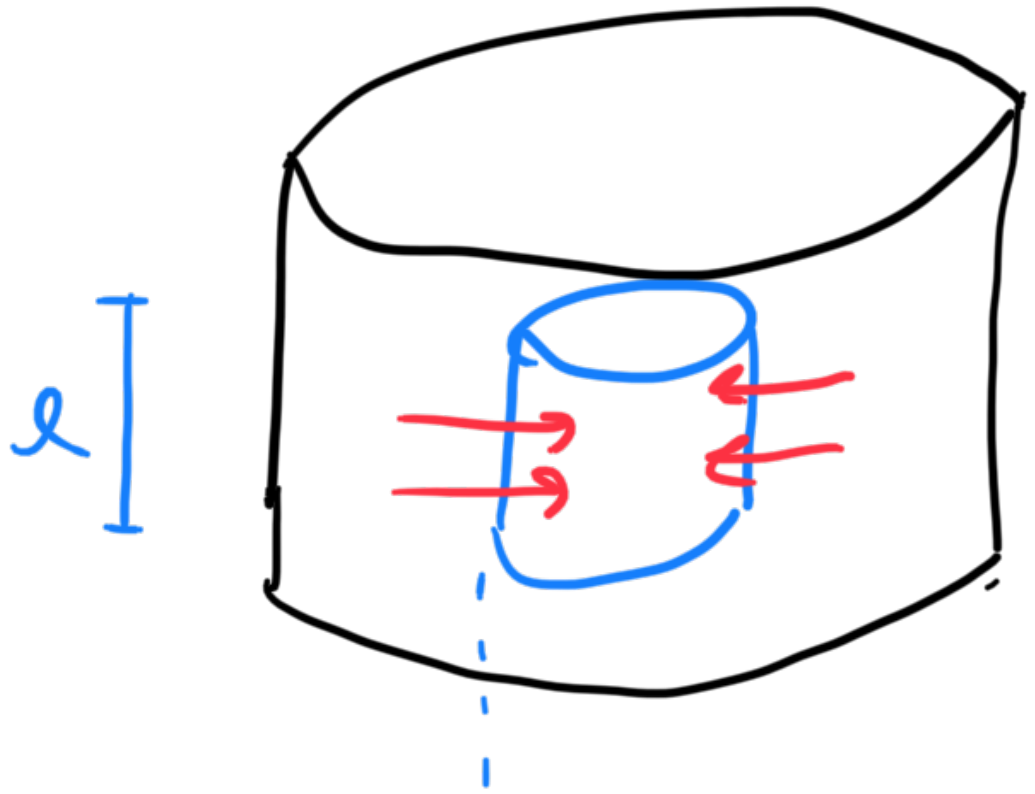
$$\frac{U_1}{U_2} = \frac{k_1 \, F_1^2/k_1^2}{k_2 \, F_2^2/k_2^2} = \boxed{\frac{k_2}{k_1}}$$

#6

only held by grav.

$\rho(r) = ?$

λ = length density



$r \to g = \omega^2 r$

Gauss's Law

$$\oint\!\!\oint g \cdot dA = 4\pi G M_{enc.}$$

$$\| $$

$$g A_{cyl.} = 2\pi r \ell g$$

$$g = \frac{2GM}{r\ell} = \frac{2G\lambda}{r}$$

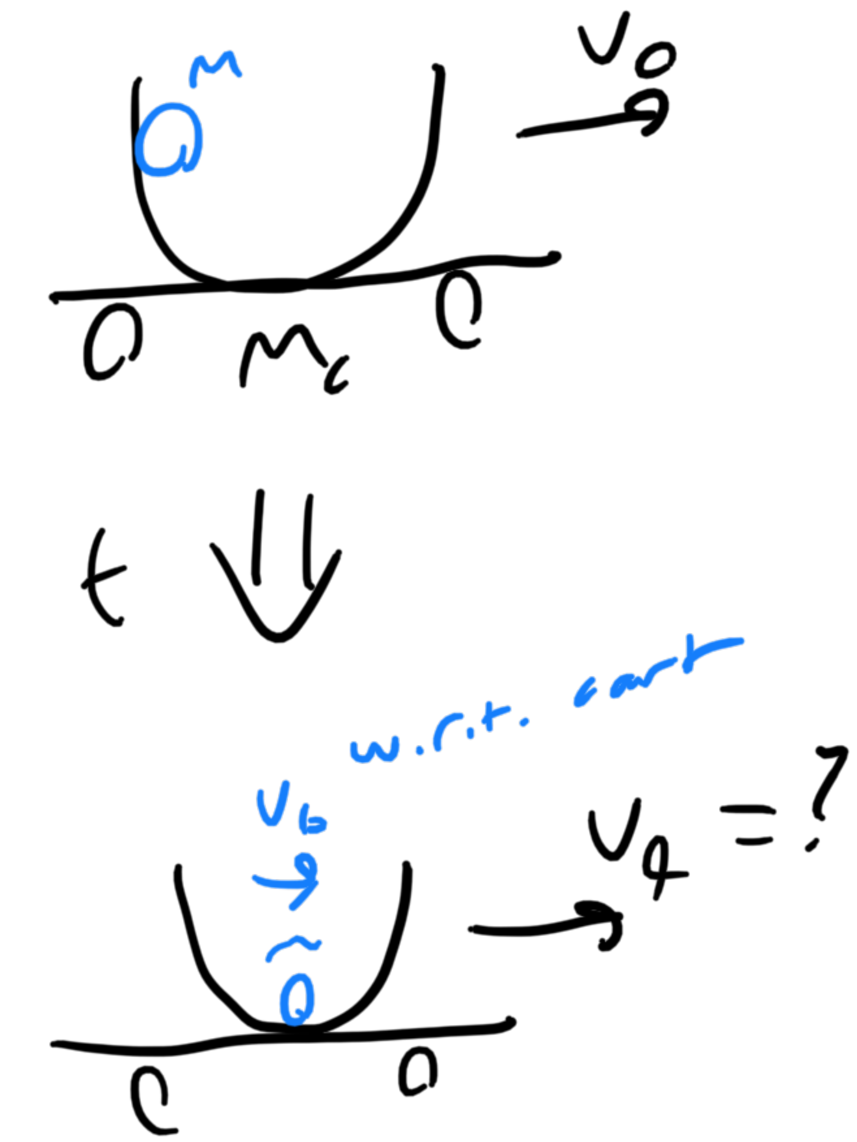
$$= \omega^2 r$$

$$\frac{2G\lambda}{r} = \omega^2 r$$

$$\lambda = \frac{\omega^2 r^2}{2G} = \frac{\omega^2}{2\pi G} A \not\propto r$$

$$A = \pi r^2$$

#10



$$\Sigma F_x = 0 \Rightarrow P_{x_i} = P_{x_f}$$

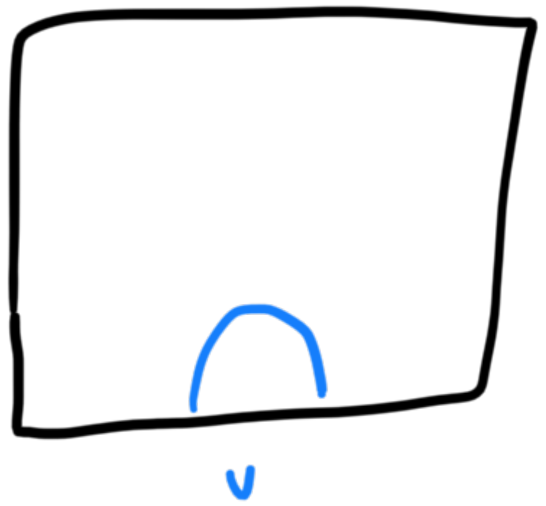
$$P_{x_i} = (M_c + m) v_0$$

$$= P_{x_f} = (M_c + m) v_f + m v_b$$

w.r.t. cart

$$\Rightarrow v_f = \frac{(M_c + m) v_0 - m v_b}{(M_c + m)}$$

#13



$v = 2v$

how does wet region change?

$v = m/s$

$g = m/s^2$

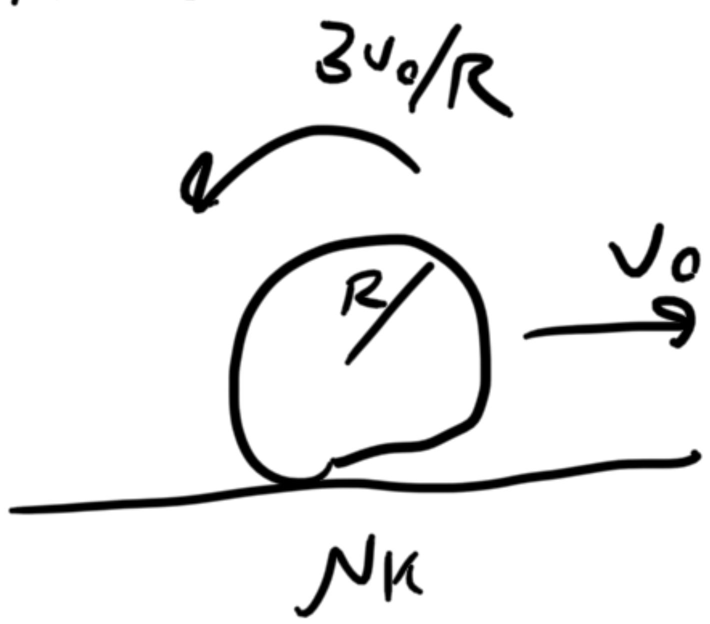
$L = v^2/g \to v^2$ (D)

$h = \frac{1}{2} v t = v^2/2g$

$D = v\sin\theta \cdot \frac{2v\cos\theta}{g} = \frac{v^2 \sin 2\theta}{g}$

$\propto v^2$ (D)

16



T to return to starting position?

Slipping:

$a = F_k/m$ $\alpha = -F_k r/I$ $F_k = -\mu g$

$v(t) = v_0 + at$ $\omega(t) = \omega_0 + \alpha t$

$v(T) = r\omega(T)$

$v_0 - \mu g T = \left(-\frac{3v_0}{r} + \mu g T/r\right) r$

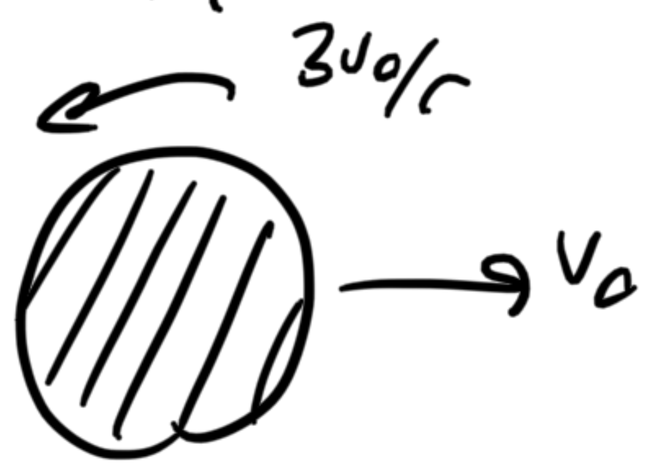
$T = 2v_0/\mu g$ after T, $v = v(T)$

$v(2v_0/\mu g) = v_0 - \mu g \frac{2v_0}{\mu g} = -v_0$

$x(T) = v_0 T + \frac{1}{2} a T^2 = v_0 \frac{2v_0}{\mu g} - \frac{1}{2}\mu g\left(\frac{2v_0}{\mu g}\right)^2$

$= 0$ ✓

#17



$T_{disk} \stackrel{?}{=} T_{hoop}$

$\alpha' = 2\mu g/r$ (since $I' = I/2$)

$\tau' = \tau$ ← F_μ stays the same

$$\boxed{T' = \frac{4v_0}{3\mu g}}$$ stops slipping too soon.

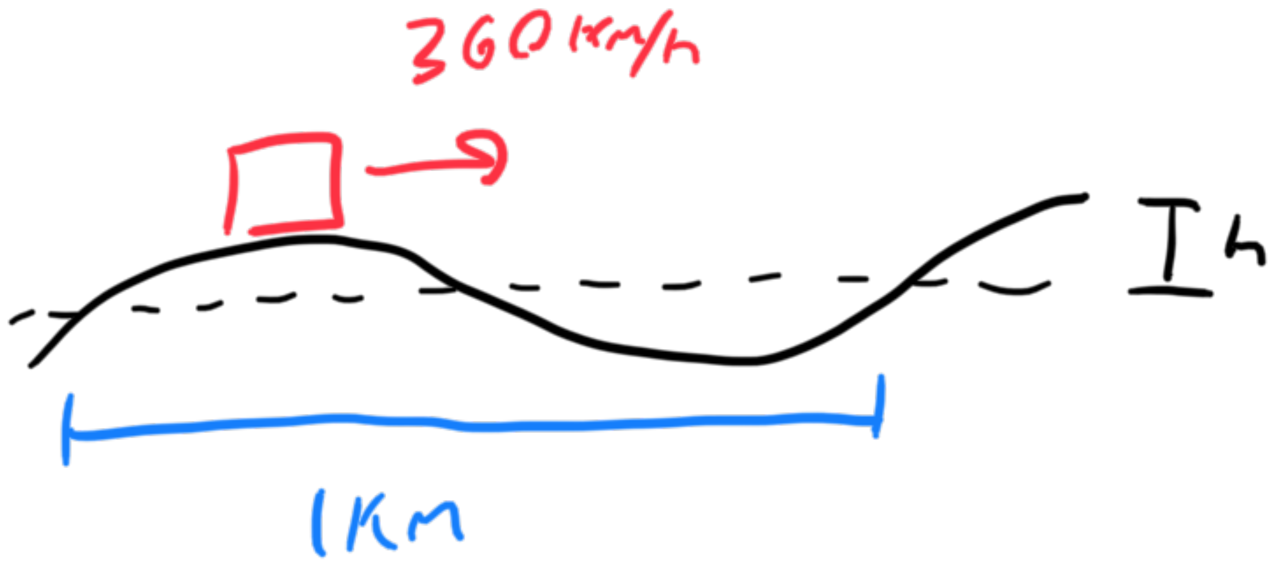
$v(T) = -v_0/3$ $x(T) = 4v_0^2/9\mu g$

$$T_{tot} = T' + \left|\frac{x(T)}{v(T)}\right| = \frac{4v_0}{3\mu g} + \frac{4v_0}{3\mu g}$$

$$= \frac{8v_0}{3\mu g} \neq T$$

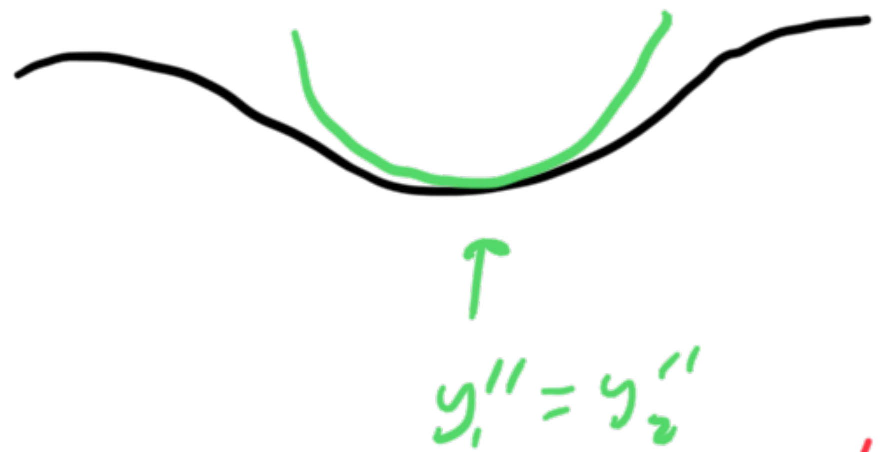
(D)

#23



$a_{max} = 0.1\ m/s$

max $h = ?$



$$T = 1km / 360 km/h = 10 s$$

$$= 2\pi\sqrt{k/m} \Rightarrow k = 4\pi^2 m / T^2$$

$$a = \frac{F}{m} = \frac{kh}{m} = 4\pi^2 h / T^2$$

$$h \leq T^2 a_{max} / 4\pi^2$$

$$h = 25cm$$

$$y(t) = h\sin(2\pi t/T)$$

$$y''(t) = -\frac{4\pi^2 h}{T^2}\sin(2\pi t/T)$$

$$a_{max} \leq \frac{4\pi^2 h}{T^2}$$

$$h \leq T^2 a_{max} / 4\pi^2$$