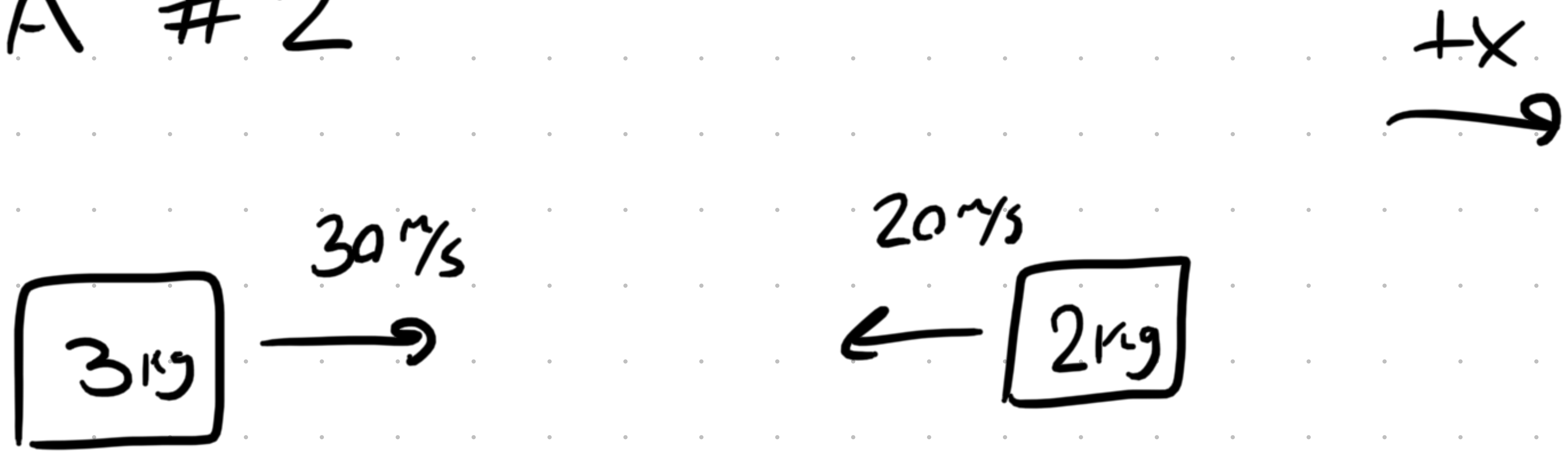
2018A #2



$V_{cm} = ?$ after collision

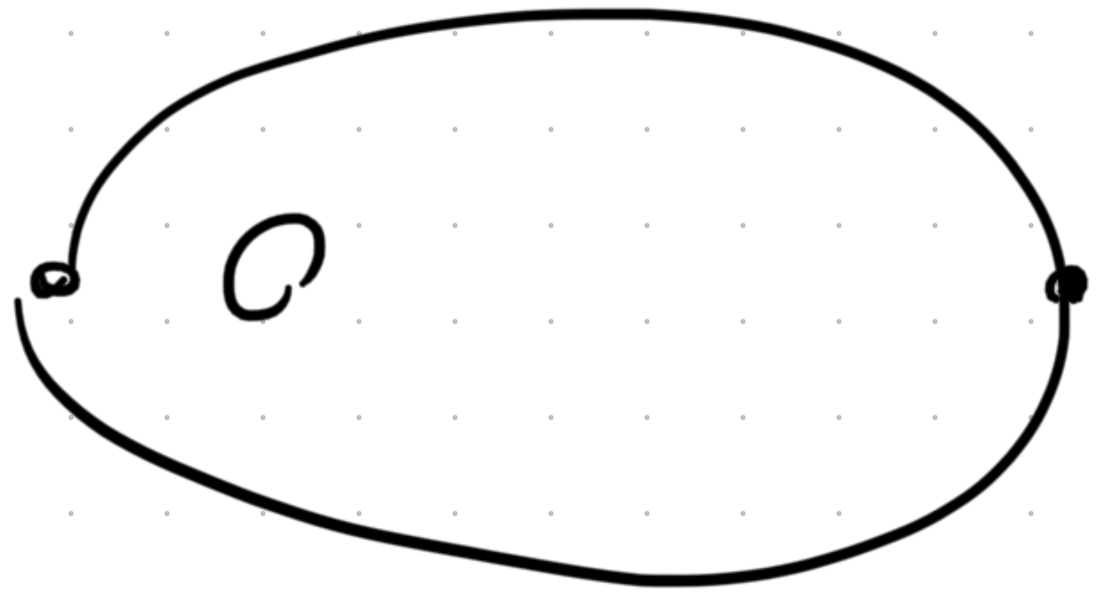
$$P_o = 3kg(30\,m/s) + 2kg(-20\,m/s) = +50\,kg\,m/s$$

$P_f = P_o$ momentum is conserved.

$$V_{cm} = \frac{P_f}{M} = \frac{P_o}{M} = \frac{+50\,kg\,m/s}{5\,kg} = +10\,m/s$$

B

2018 A #4



How to use an impulse to maximize satellite energy?

$J = \Delta p = m \Delta v$

must be in direction of velocity

$\Delta KE = \frac{1}{2} m \left[(v_0 + \Delta v)^2 - v_0^2 \right]$

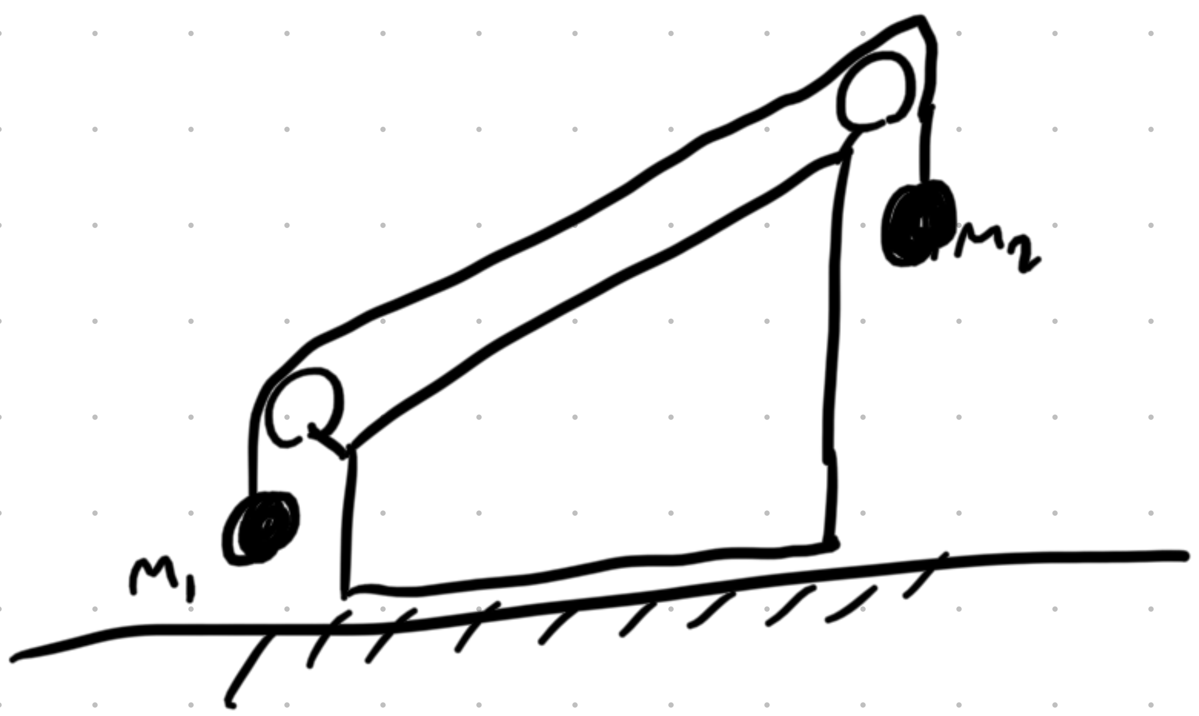
$= \text{const} + m v_0 \Delta v$

So, we want to apply the impulse when v_0 is highest.

K2L: says that the satellite is fastest at perigee

$\Rightarrow$ A

2018 A #5

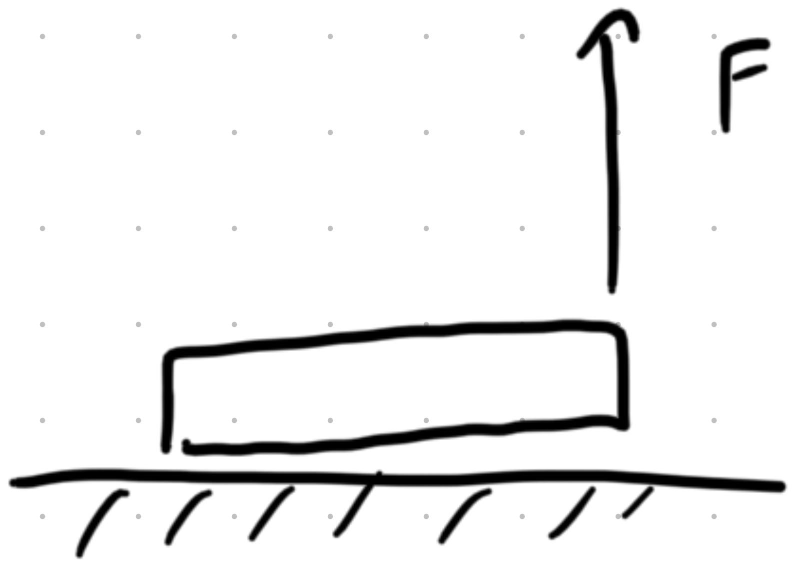


release masses from rest, how will the inclined plane move?

no external horizontal forces anywhere in this problem.

E

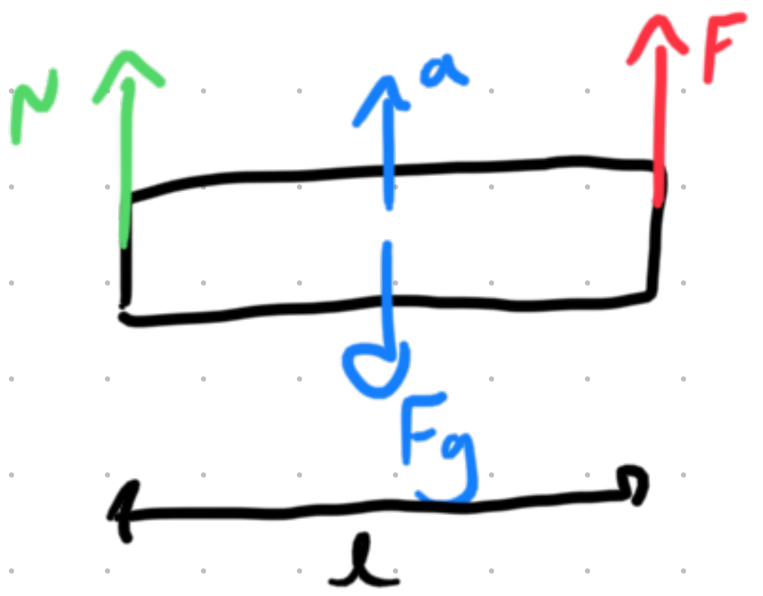
2018A #9



CM: $a < g$

N on right end of stick?

First, note the pivot is right edge.



$N = ?$

F, g given

$a = r\alpha = \alpha l/2$

$I = ml^2/3$

$\tau = Fl - \frac{1}{2}mgl = I\alpha$

$$\alpha = \tau/I = \frac{1}{l}\left(\frac{3}{m}F - \frac{3}{2}g\right)$$

$$2a = \alpha l = \frac{3}{m}F - \frac{3}{2}g$$

$$a = \frac{F}{m} - g + \frac{N}{m}$$

$$-2a + 3a = -\left(\frac{3}{m}F - \frac{3}{2}g\right) + 3\left(\frac{F}{m} - g + \frac{N}{m}\right)$$

$$a = 0F - \frac{3}{2}g + \frac{3}{m}N$$

$$N = \frac{1}{3}ma + \frac{1}{2}mg$$

$$mg > N > mg/2$$

B

2018A #11

Springs Topic in F=ma Physics

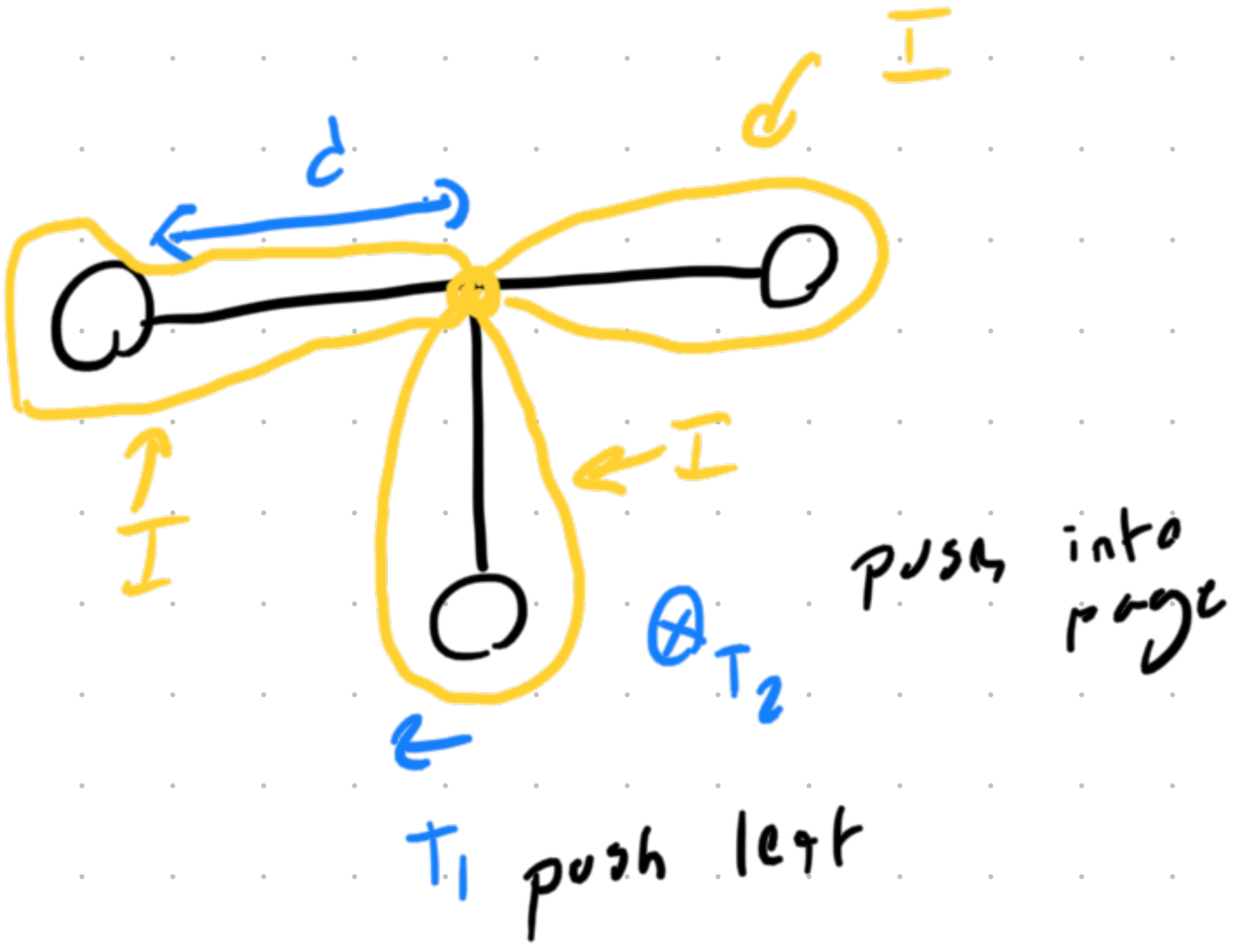
$k' = Nk$ when the spring is cut in Nths.

$k' = 2k$

but there are two of them! so $k' = 4k$

$\omega = \sqrt{k/m}$ $\omega' = \sqrt{k'/m} = \sqrt{4k/m} = 2\omega$ D

2018A #14



$$\frac{T_1}{T_2} = ?$$

Topic 3

$F = -kx$

$\omega = \sqrt{k/m}$

$I_1 = 3md^2$ *

$I_2 = 1md^2$ *

Angular N2L:

$\tau = I\alpha = -mgd\sin\theta \simeq -mgd\theta$

Hooke's Law:

$F = -kx$

$\tau = -k\theta \Rightarrow k = -mgd$

Oscillations:

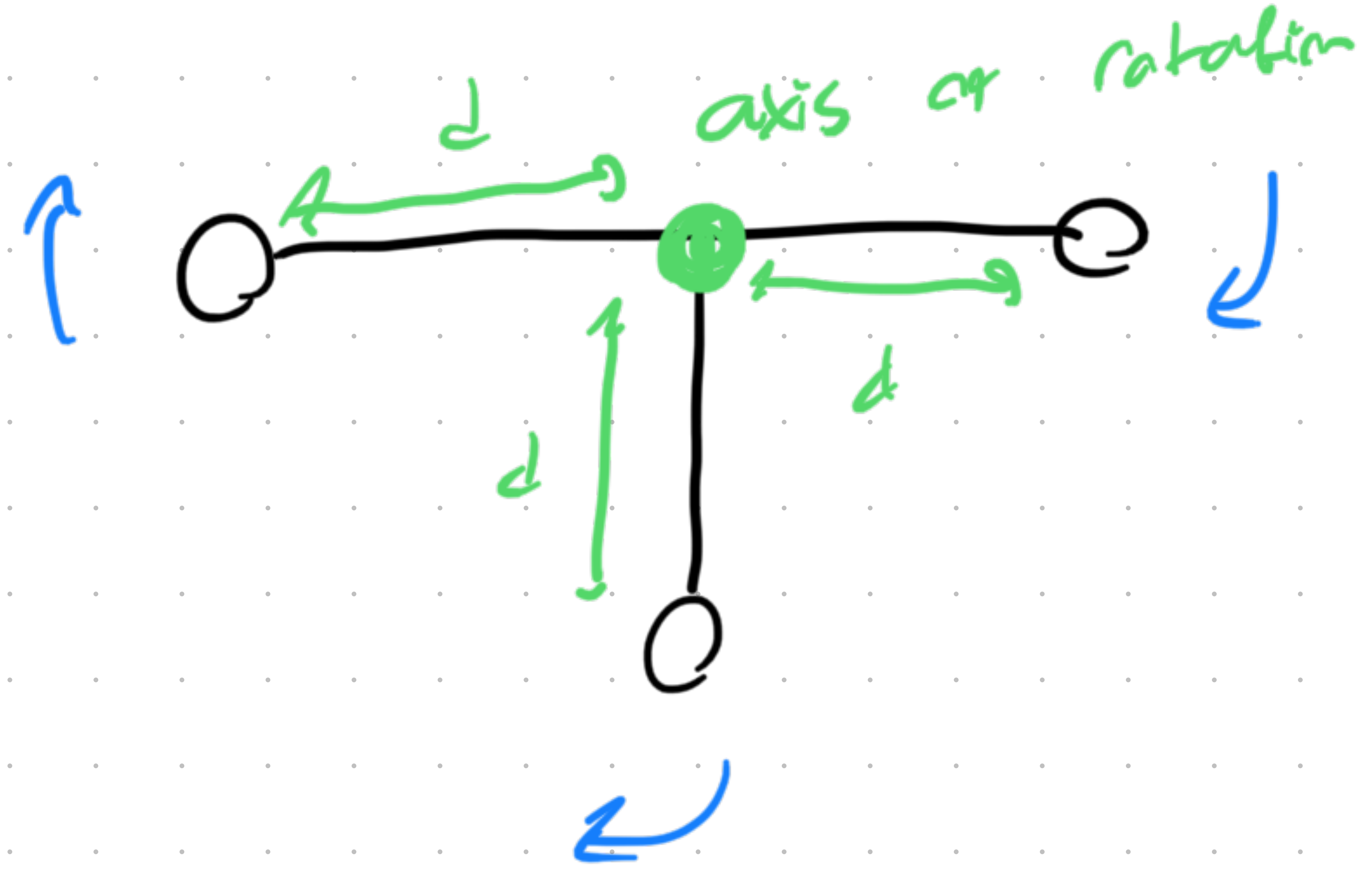
$\omega = \sqrt{k/m} = \sqrt{mgd/I} \propto 1/\sqrt{I}$

$T \propto \sqrt{I} \Rightarrow \frac{T_1}{T_2} \propto \sqrt{\frac{I_1}{I_2}} = \sqrt{3}$

C

cont.

1

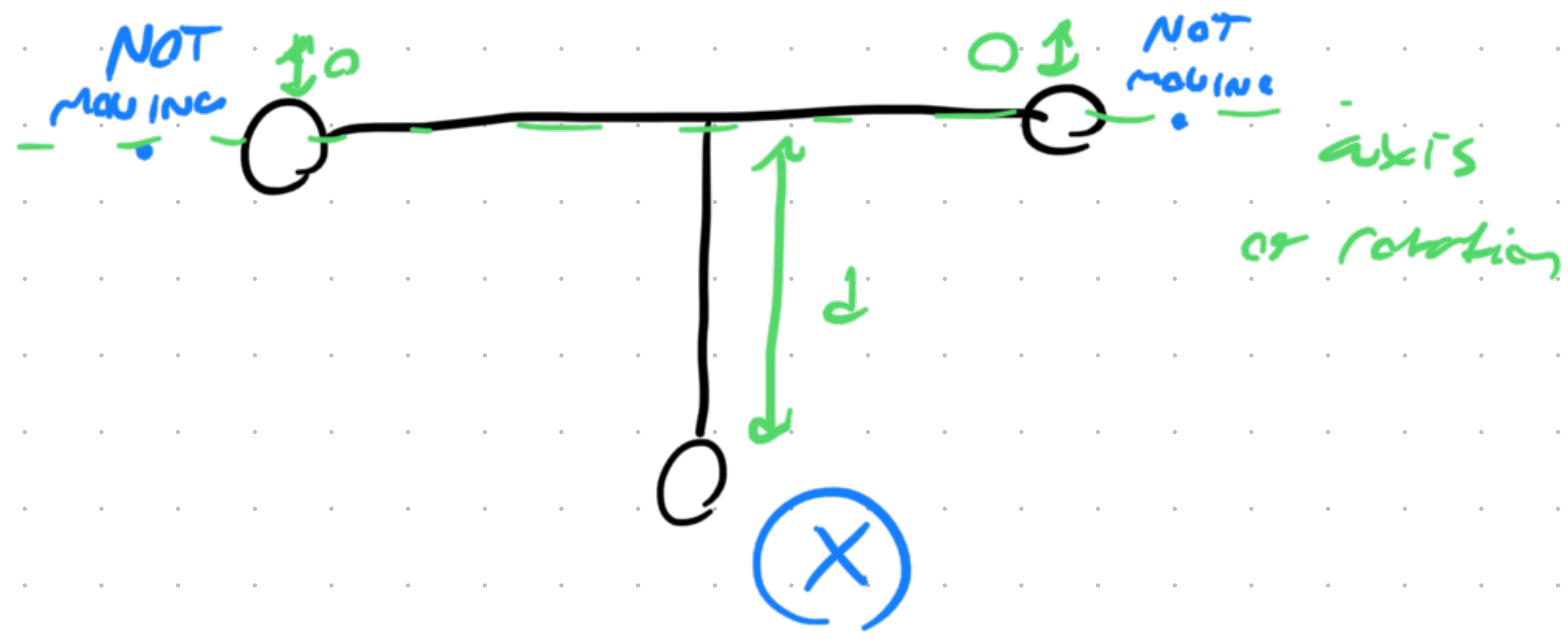


all are moving

$$I_1 = 3md^2$$

(three masses moving, all d from axis of rotation)

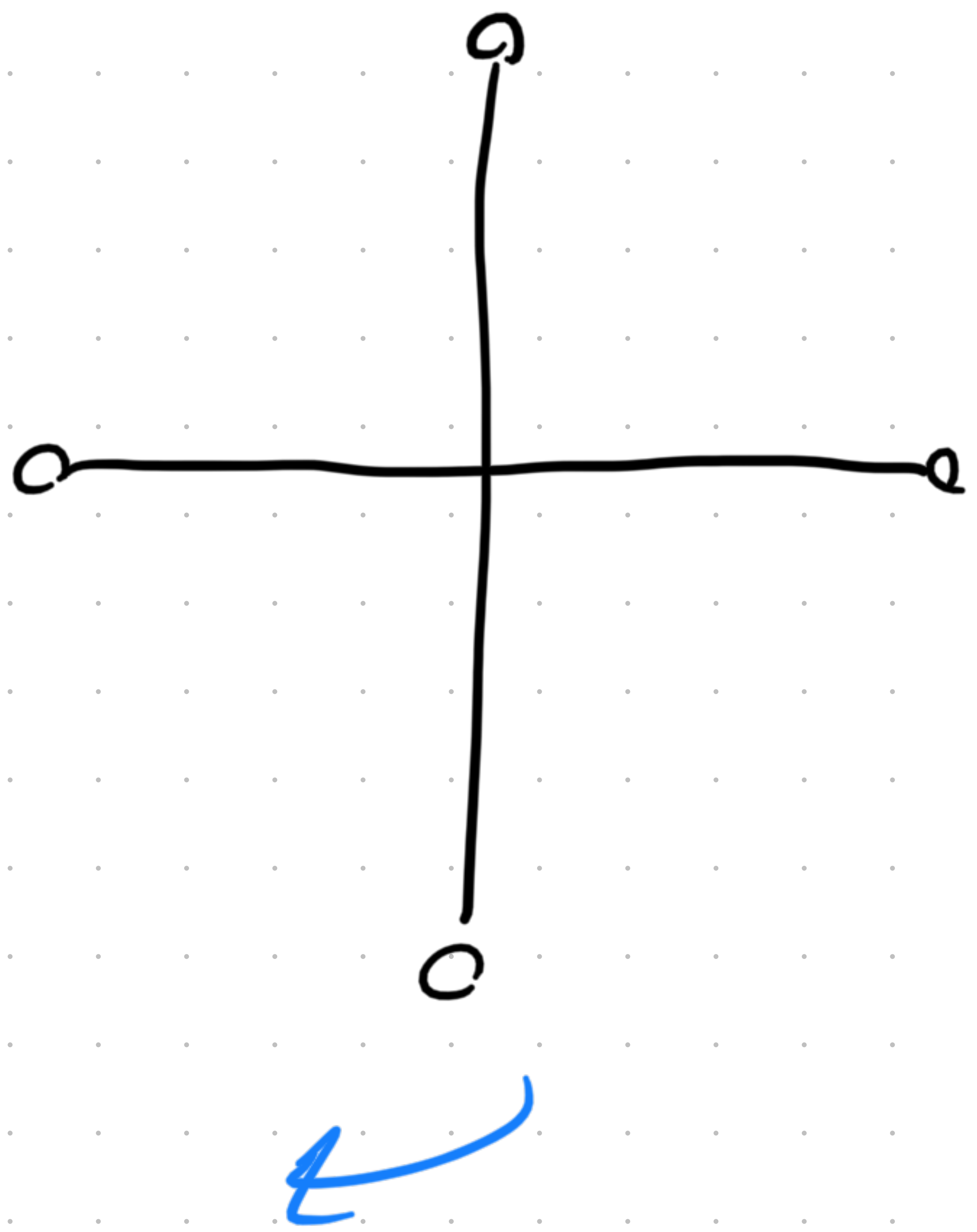
2



one is moving

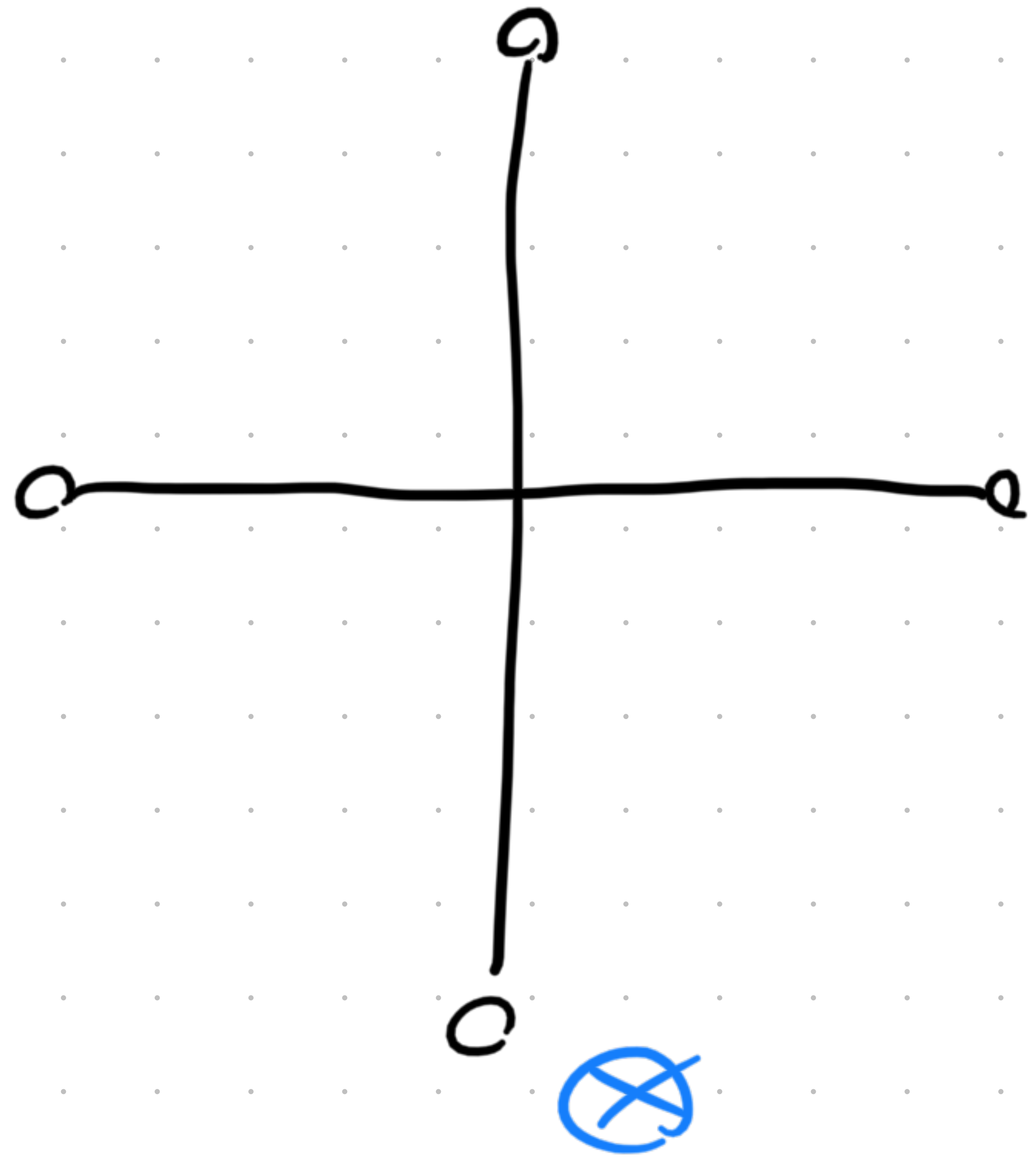
$$I_2 = 1md^2$$

(one mass moving, the other two have $d=0$ from axis of rotation) cont.



T_1

T_2



$I_1 = 4md^2$

$\frac{T_1}{T_2} = ?$

$I_2 = 2md^2$

$$\frac{T_1}{T_2} \propto \sqrt{\frac{I_1}{I_2}} = \sqrt{\frac{4md^2}{2md^2}} = \sqrt{2}$$

2018A #19

Raindrops with number density n (m^{-3}) and radius r_0 hit ground with speed v_0. Resulting pressure is P_0

$n' \to 2n \quad r \to r_0/2 \quad v \to v_0/2 \qquad P = ?$

ρ = density
N = volumetric flow
v = velocity
Δt = splat time

$$J_{surface} = PA\,\Delta t = \rho N v \,\Delta t$$

$$P = \frac{\rho N v}{A} = \frac{4\pi}{3}\rho n v^2 r^3$$

$$N = \frac{4\pi}{3} n A v r^3$$

$$P' = P_0 \cdot 2 \cdot \left(\tfrac{1}{2}\right)^2 \cdot \left(\tfrac{1}{2}\right)^3 = P_0/16 \qquad \text{E}$$

2018A #21

$\mu = \mu_s = \mu_k$

$t = ?$

$$F = -\mu m g$$

$$a = -\mu g$$

$$I = \frac{2}{3} m r^2$$

$$\tau = I\alpha$$

$$\alpha = \frac{\tau}{I} = \frac{\mu m g r}{\frac{2}{3} m r^2} = \frac{3}{2}\mu g / r$$

$$v(t) = v_0 - \mu g t$$

$$\omega(t) = \frac{3}{2}\mu g t / r$$

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

$$v_0 - \mu g t = \frac{3}{2}\mu g t$$

$$t = \frac{2}{5}\frac{v_0}{\mu g}$$

A

2018A #25

$a \pm \Delta a = 1.013 \pm 0.008$ s

$b \pm \Delta b = 0.997 \pm 0.016$ s

1 $\Delta a = 0.008$ s

2 $\Delta(a+b) = \frac{1}{2}\sqrt{(\Delta a)^2 + (\Delta b)^2} = 0.0089$ s

3 $\Delta(4a+b) = \frac{1}{5}\sqrt{4(\Delta a)^2 + (\Delta b)^2} = 0.0072$ s

B