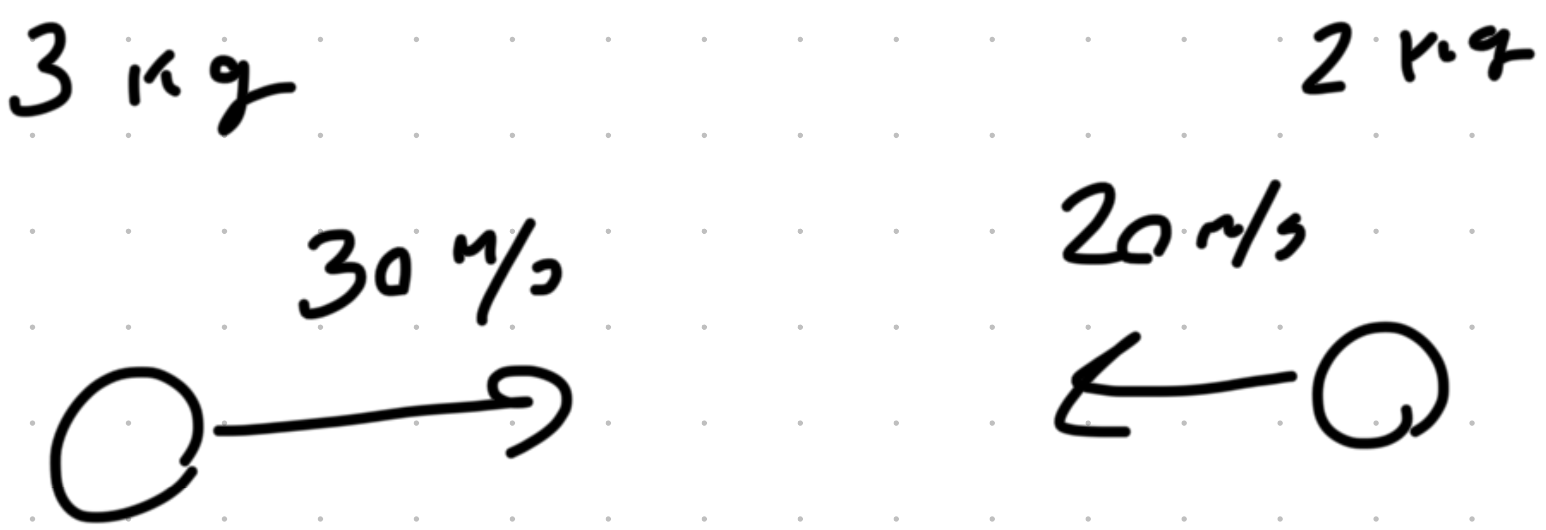
2018 A #2



$V_{cm} = ?$ after collision

$$V_{cm_0} = \frac{3\,kg \cdot 30\,m/s - 2\,kg \cdot 20\,m/s}{5\,kg} = 10\,m/s$$

Momentum is conserved

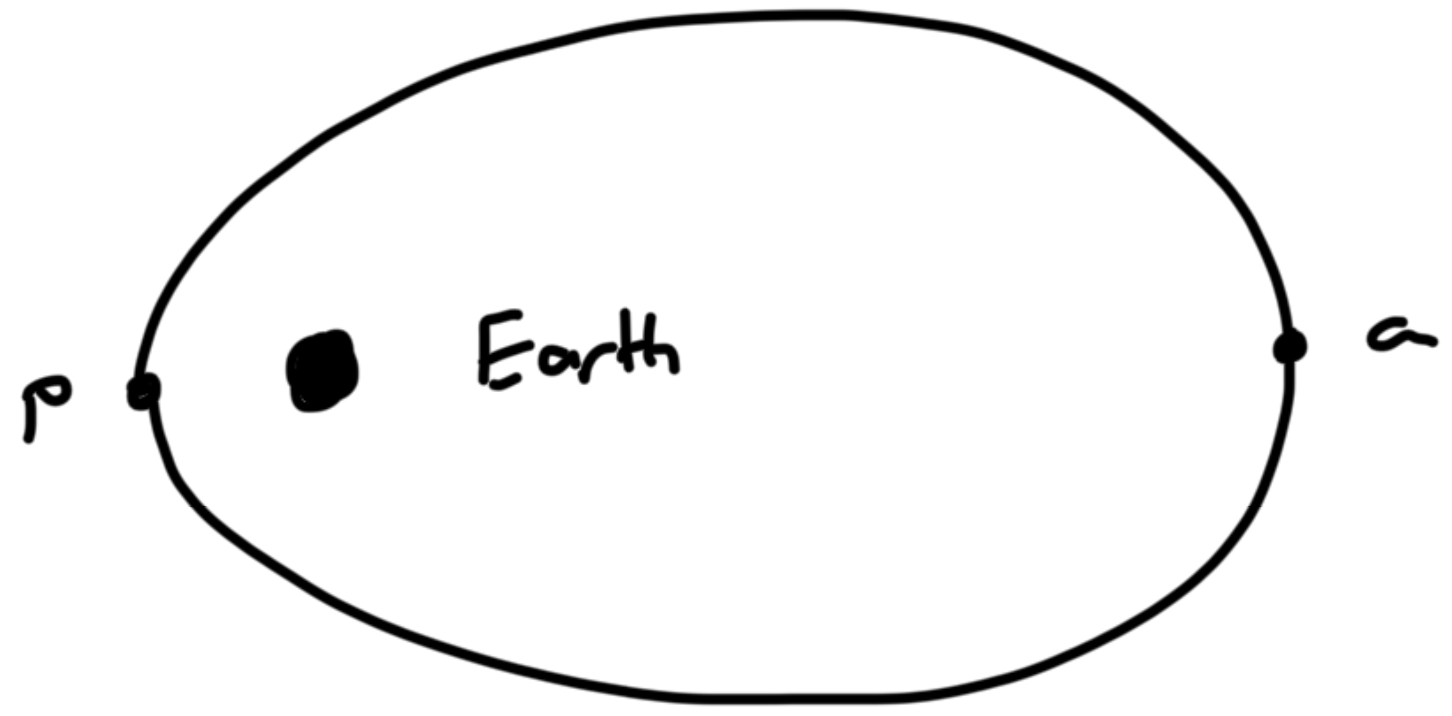
$P_1 = 90\,kg\,m/s$ to right

$P_2 = 40\,kg\,m/s$ to left

$P_{total} = 50\,kg\,m/s$ to right

$V_{cm} = 10\,m/s$

2018 #4



When & how to apply impulse to maximize satellite energy?

K2L: equal areas in equal time

V_0 is maximal at perigee.

to maximize work, apply impulse in the direction of motion.

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

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

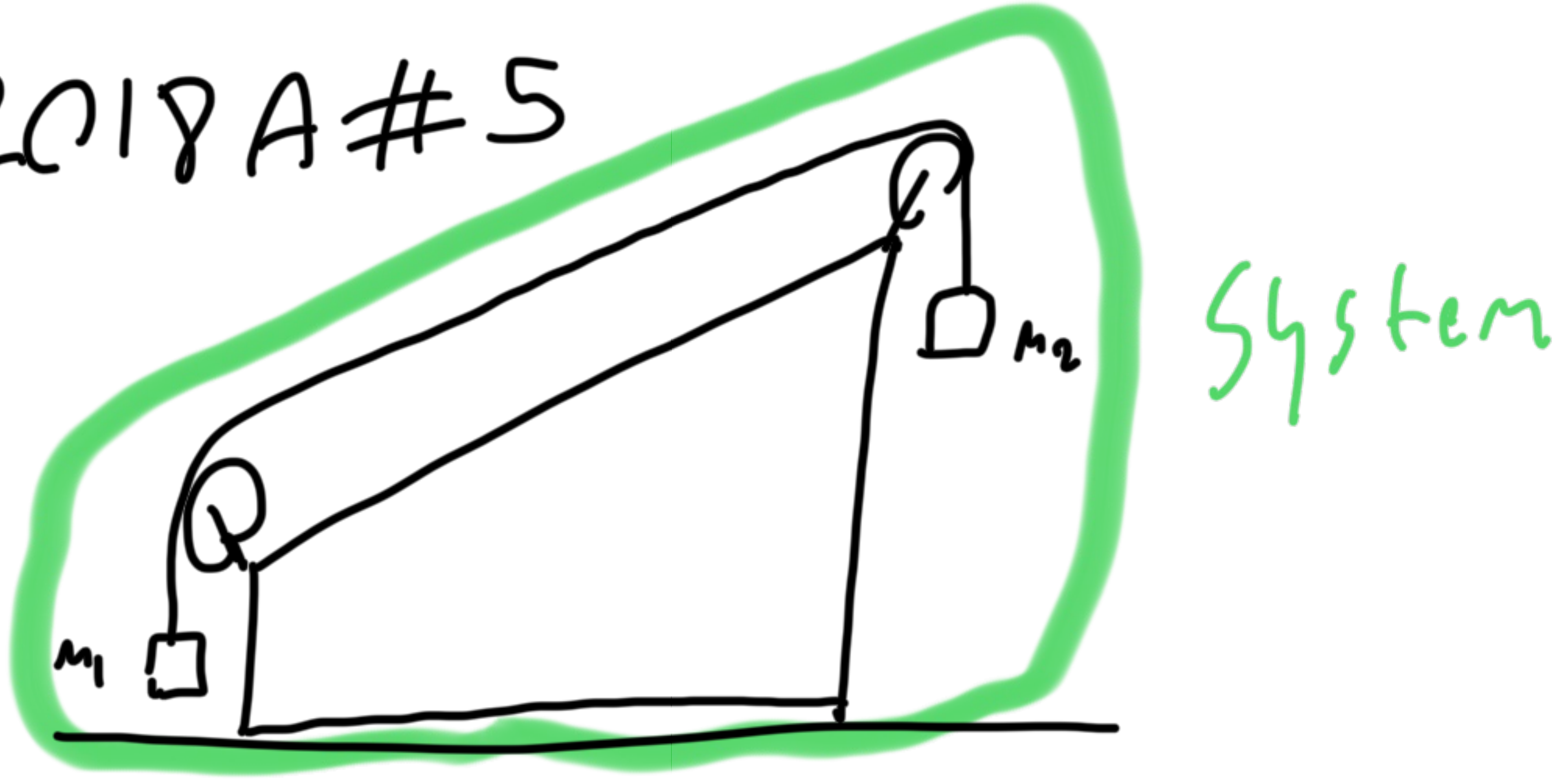
$$= \frac{1}{2}m\left[2v_0\Delta v + \underbrace{(\Delta v)^2}_{\text{cst.}}\right]$$

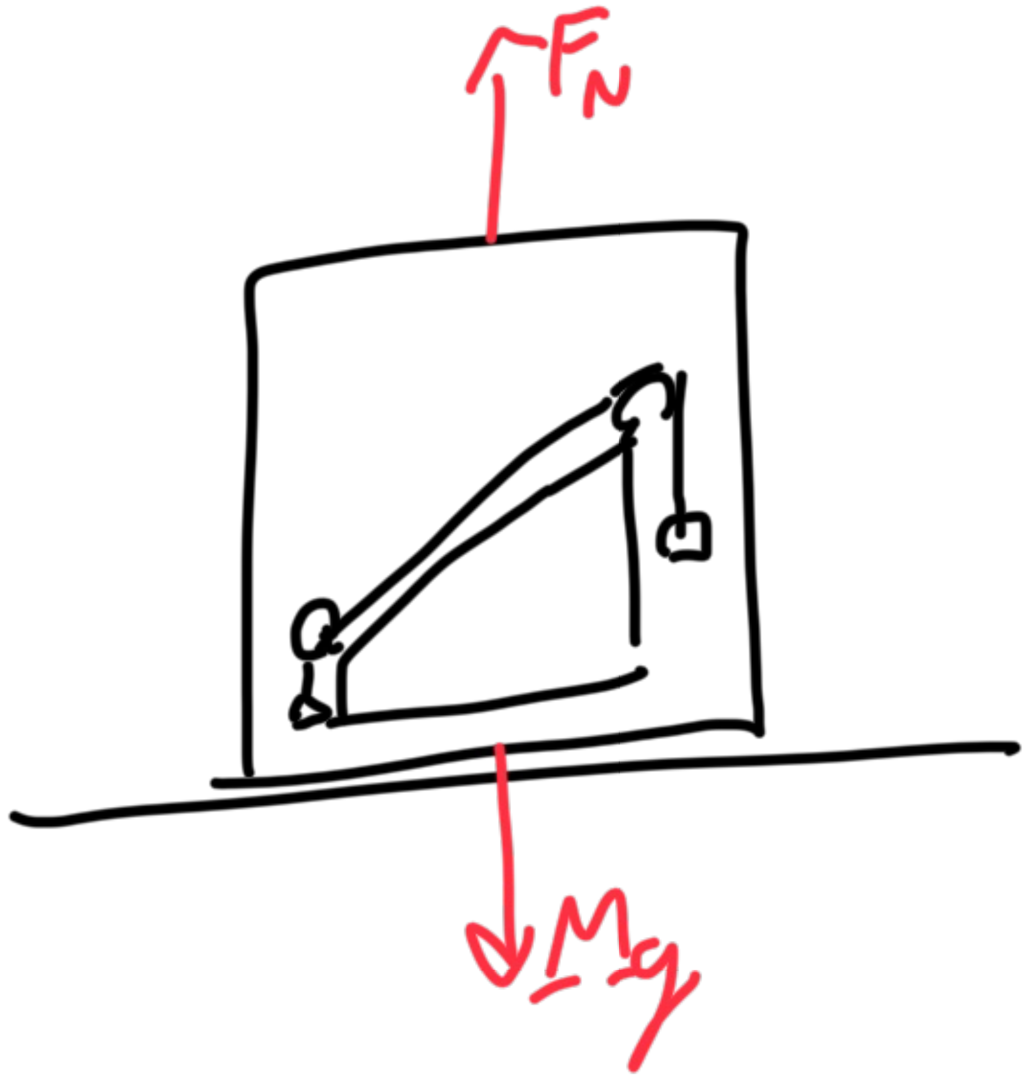
want to fire at max. speed

when is that? perigee!

A

2018 A #5





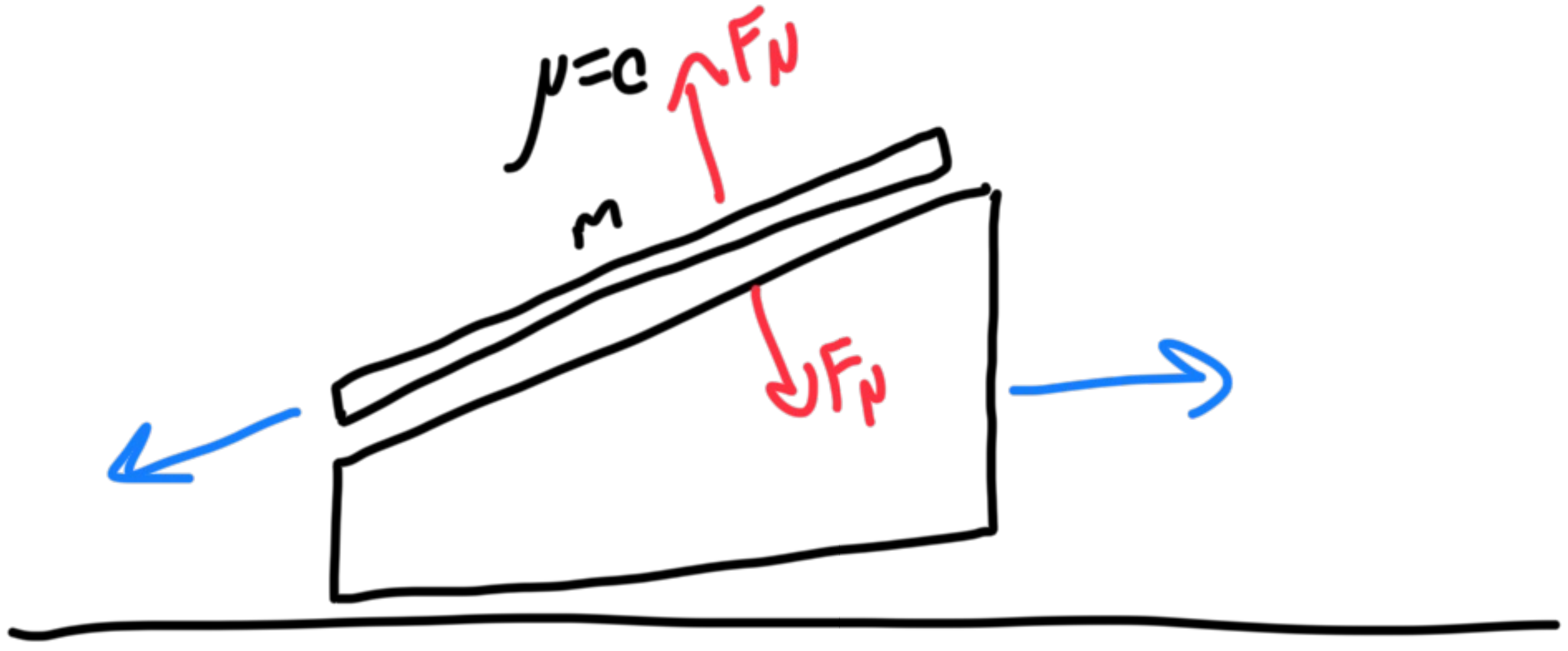
which way does the inclined plane accelerate?

No net external forces

No net acceleration!

E

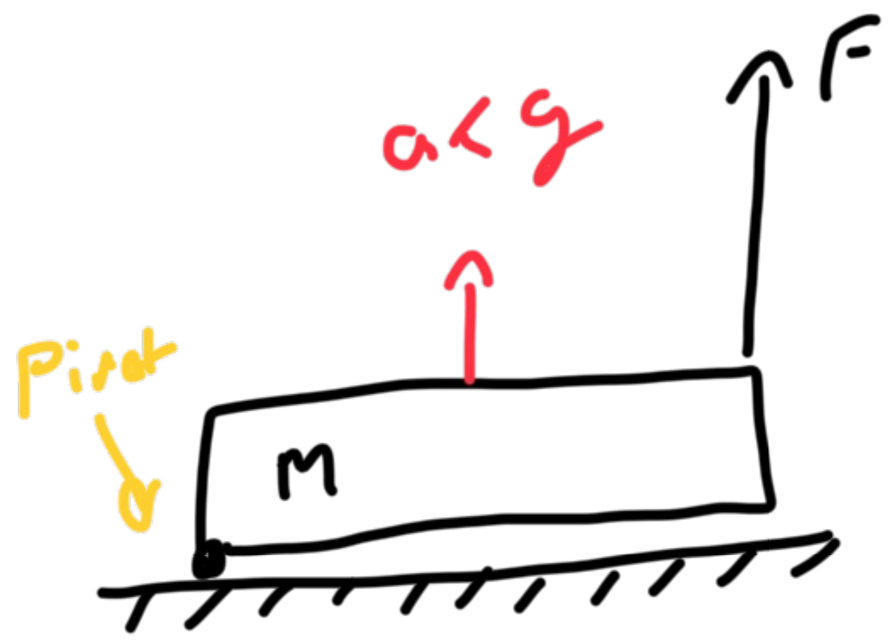
what if, instead, it looked like this?



What will be the motion of the plane?

to the right!

2018A #9



$N = ?$

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

$$I = ml^2/3$$

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

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

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

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

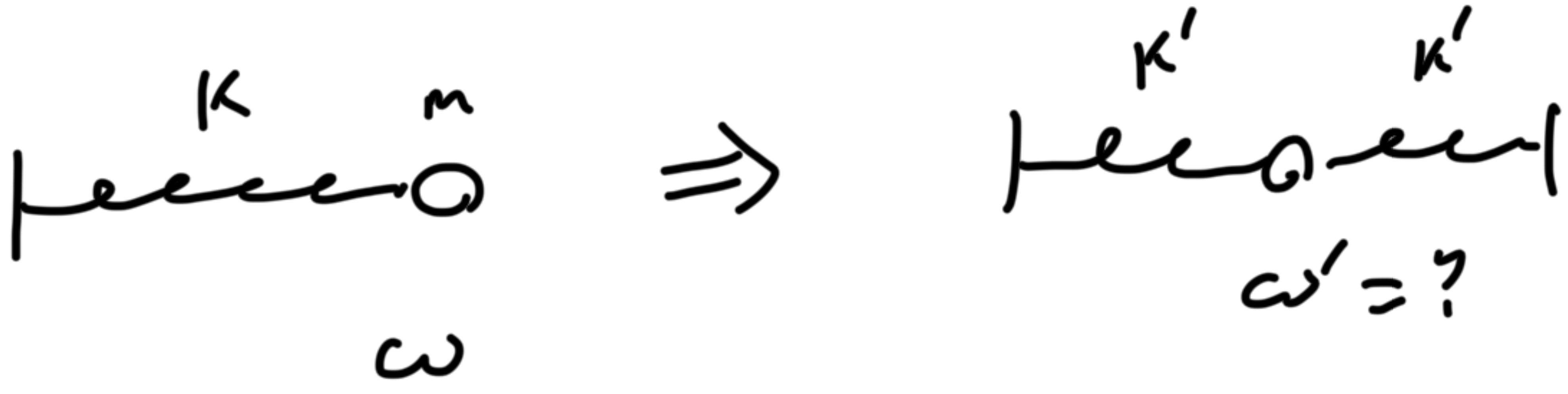
$$-2a + 3a = a = -\left(\frac{3}{m}F - \frac{3}{2}g\right) + 3\left(\frac{F}{m} - g + \frac{N}{m}\right)$$

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

$$N = \frac{1}{3}ma + \frac{1}{2}mg \in \left[\tfrac{1}{2}mg,\ mg\right]$$

B

2018A #11



since we cut the spring in half, $k' = 2k$

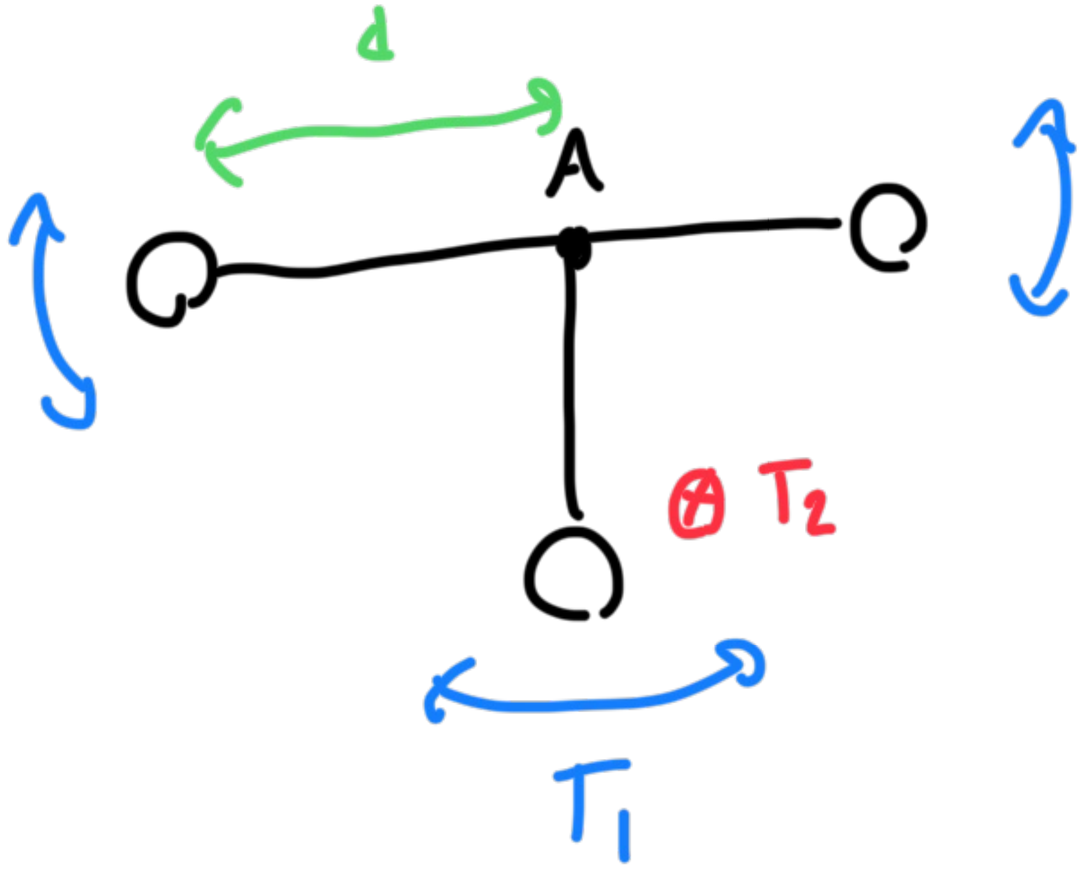
See F=ma Physics Topic 4.

$$\omega = \sqrt{\frac{k_{eff}}{m}} = \sqrt{\frac{2(2k)}{m}} = 2\sqrt{\frac{k}{m}}$$

$$= 2\omega$$

D

2018 A #14



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

$$\omega = \sqrt{\frac{mgd}{I}}$$

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

$$\tau = -k\theta \Rightarrow \omega = \sqrt{k/m}$$

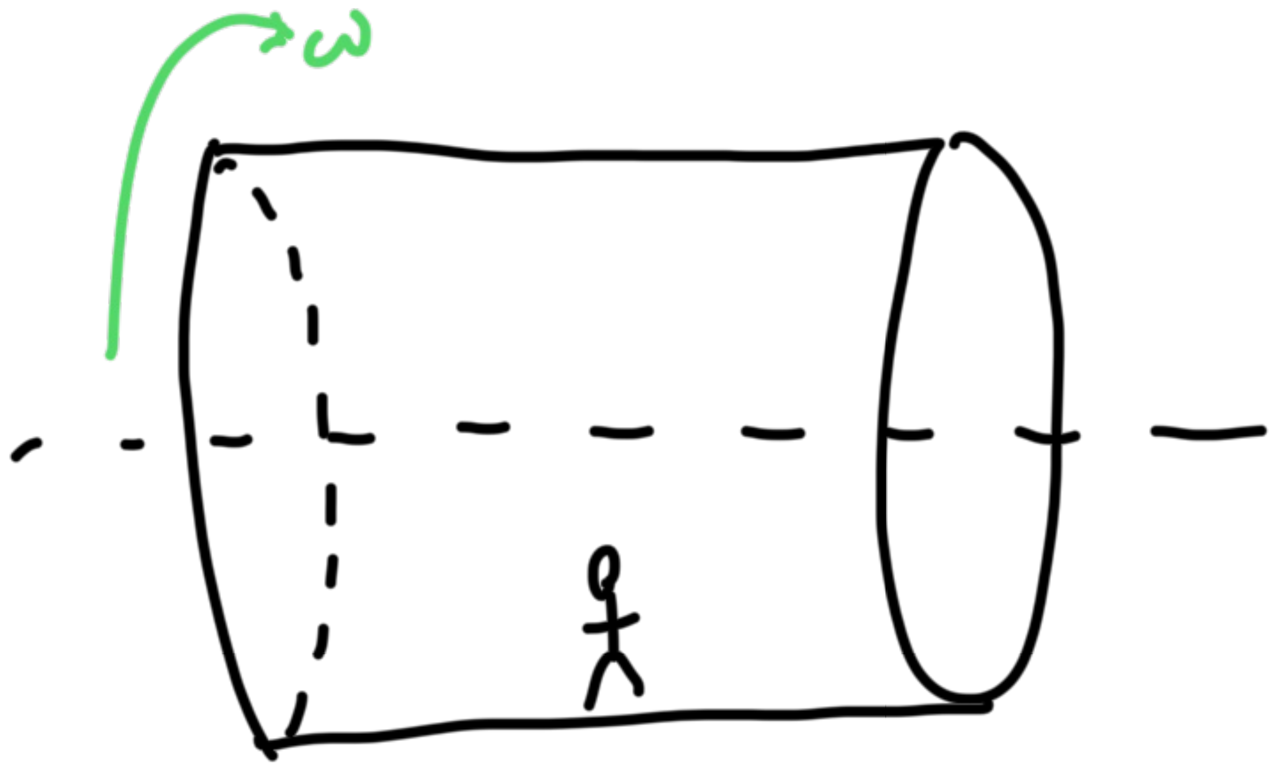
$$\omega = \sqrt{\frac{mgd}{I}} \propto 1/\sqrt{I}$$

$$T \propto \sqrt{I}$$

$$\frac{I_1}{I_2} = \frac{3md^2}{md^2} = 3 \Rightarrow \frac{T_1}{T_2} = \sqrt{3}$$

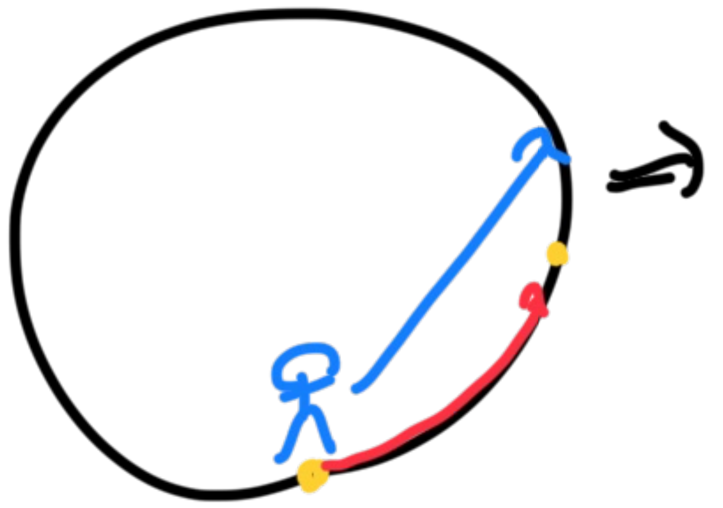
C

2018 #16



When the astronaut jumps, how do they move?

Side view:



$\Rightarrow$ "getting ahead"

Centrifugal force:

back towards the floor

~~D~~ ~~E~~

Coriolis force:

$$F_c \propto -\vec{\omega} \times \vec{v} \Rightarrow \text{out of the page}$$

"getting ahead"

B

2018 #19

$n,\ r_0,\ v_0,\ P_0$

$n \to 2n$

$r_0 \to r_0/2$

$v_0 \to v_0/2$

$P_0 \to\ ?$

$J_{surface} = F\Delta t = PA\Delta t$

$= \rho N v \Delta t$

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

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

$\times 2 \quad \times\frac{1}{2} \quad \times\frac{1}{2}$

$P_0 \to \frac{1}{16} P_0$

E

2018A#25

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

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

What are the uncertainties for:

Δa

$\Delta(a+b)$

$\Delta(4a+b)$

$\Delta a = 0.008$ s

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

$= 0.0089$ s

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

$= 0.0072$ s

B

Topic 10

F=ma Physics