2019A#16

measure t
when splash

ignore speed of
sound for less than
5% error!

$$d = \frac{1}{2}gt^2$$

$$\Delta t = d/c$$

$t+\Delta t$ is the
real measurement

$$d+\Delta d = \frac{1}{2}\,g(t+\Delta t)^2$$

$$\Delta d = \frac{g(t+\Delta t)^2}{2} - \frac{gt^2}{2}$$

$$= g\left(t\Delta t + \cancelto{0}{\frac{1}{2}(\Delta t)^2}\right)$$

$$= gt\Delta t$$

$$\frac{\Delta d}{d} = 0.05$$

$$\frac{gt\Delta t}{\frac{1}{2}gt^2} = 0.05$$

$$= \frac{2\Delta t}{t} = \frac{2d/c}{\sqrt{2d/g}}$$

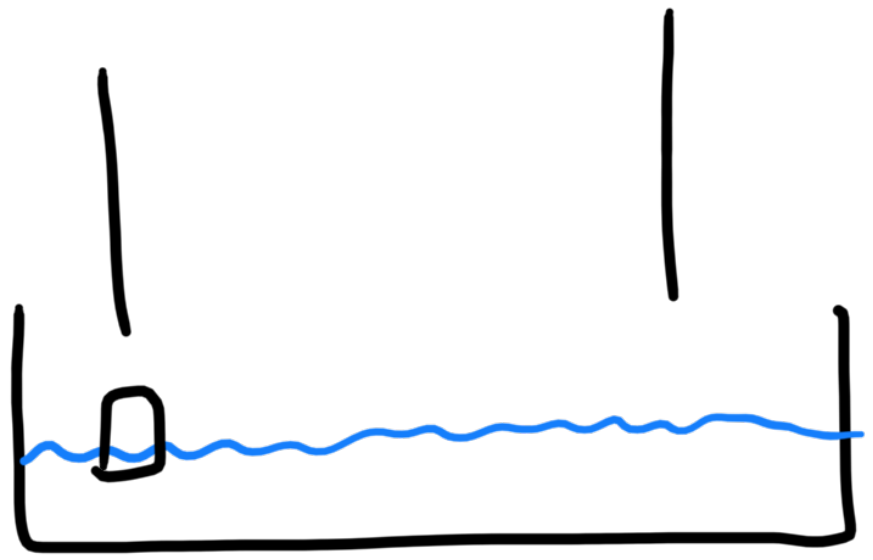
$$= \frac{\sqrt{2dg}}{c} = 0.05$$

$$d \leq \frac{(0.05)^2c^2}{2g}$$

$$\leq 13.6\text{ m}$$

"C"

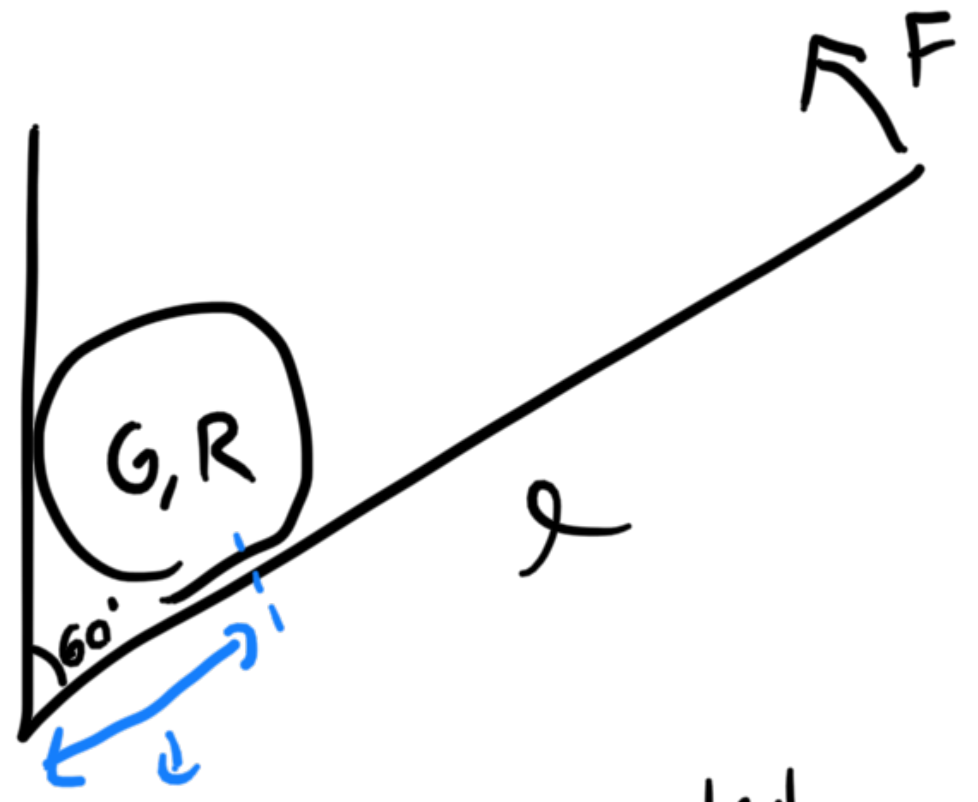
2019B#7



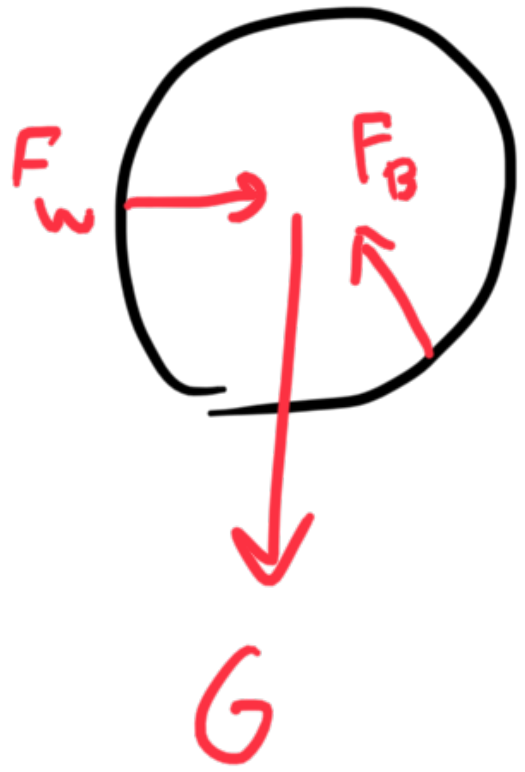
if we add a boat how does tension in the wires change?

pressure is constant in a static fluid so, tensions should increase the same amount

2019B #9



what F is needed to hold the ball in place?



y direction: $F_B \sin\theta = G$

$$F_B = G/\sin\theta$$

$$\tau_{board} = -F_B d + F\ell = 0$$

$$F = \frac{F_B d}{\ell}$$

$$d = R/\tan(\theta/2)$$

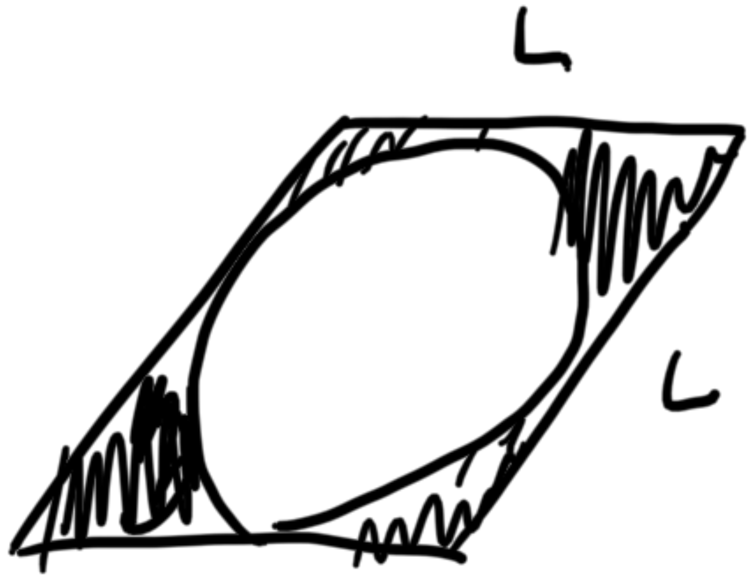
$$F = \frac{F_B R}{\ell \tan(\frac{\theta}{2})}$$

$$= \frac{GR}{\ell \sin(\theta) \tan(\frac{\theta}{2})}$$

$$= 2GR/\ell$$

$$\boxed{B}$$

2019B#11



$I_{shaded} = ?$

Perpendicular axis theorem.

$I_z = I_x + I_y$

HW: read about it!

$I_{sq} = \frac{1}{6} M L^2$

$I_c = \frac{1}{2} M_c \left(\frac{L}{2}\right)^2 = \frac{1}{8} M_c L^2$

$M_c = \frac{A_c}{A_{sq}} M = \frac{\pi (L/2)^2}{L^2} M$

$= \frac{\pi}{4} M$

$I_c = \frac{\pi}{32} M L^2$

$I_{obj} = I_{sq} - I_c$

$= \frac{1}{6} M L^2 - \frac{\pi}{32} M L^2$

$= \left(\frac{1}{6} - \frac{\pi}{32}\right) M L^2$

Ⓐ

2019 B #18

v_0 , constant a

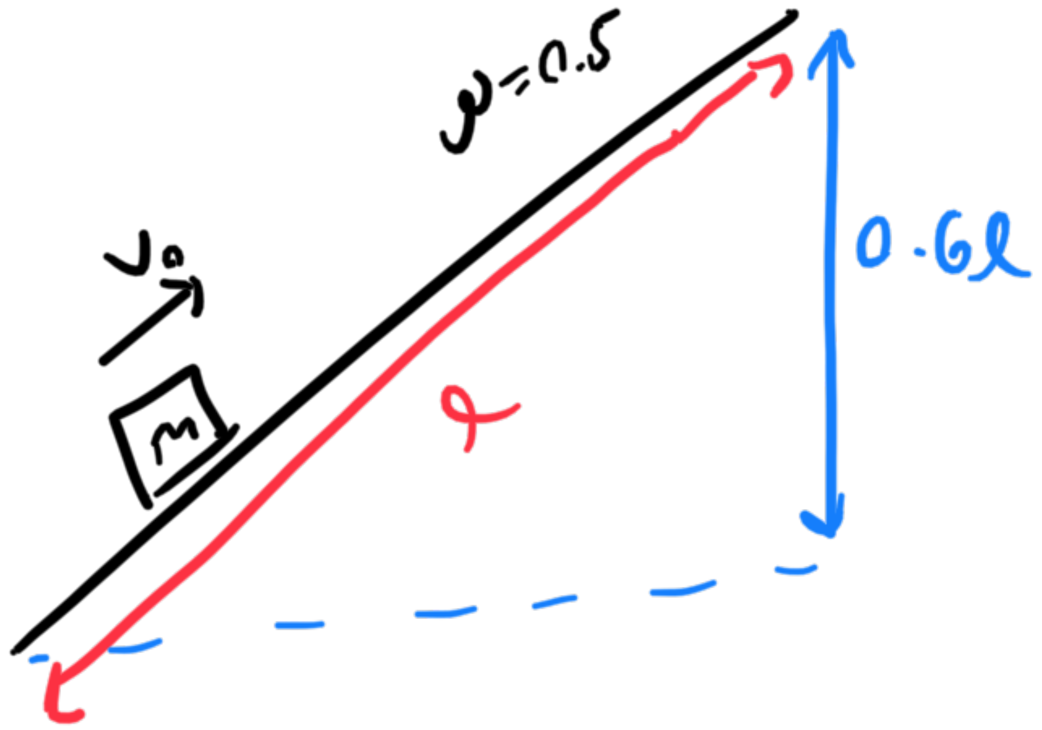
both 10% uncertain

$$x = v_0 t + \frac{1}{2} a t^2$$

$$= \underset{\substack{\uparrow \\ \text{dominates} \\ \text{for short} \\ \text{races}}}{(v_0 + \Delta v)}\, t + \frac{1}{2} \underset{\substack{\uparrow \\ \text{dominates} \\ \text{for long} \\ \text{races}}}{(a_0 + \Delta a)}\, t^2$$

Ⓐ

2019B#20



how does t_{down} relate to t_{up}?

if $\mu = 0$ $t_d = t_0$

$a_g = g\sin\theta$ $a_f = \mu g\cos\theta$

$a_{up} = -a_g - a_f$

$a_{down} = a_g - a_f$

$$\frac{a_{down}}{a_{up}} = \frac{\sin\theta - \mu\cos\theta}{\sin\theta + \mu\cos\theta}$$

$\sin\theta = \frac{3}{5}$ $\cos\theta = \frac{2}{5}$

$$\frac{a_{down}}{a_{up}} = \frac{\frac{3}{5} - \frac{2}{5}}{\frac{3}{5} + \frac{2}{5}} = \frac{1}{5}$$

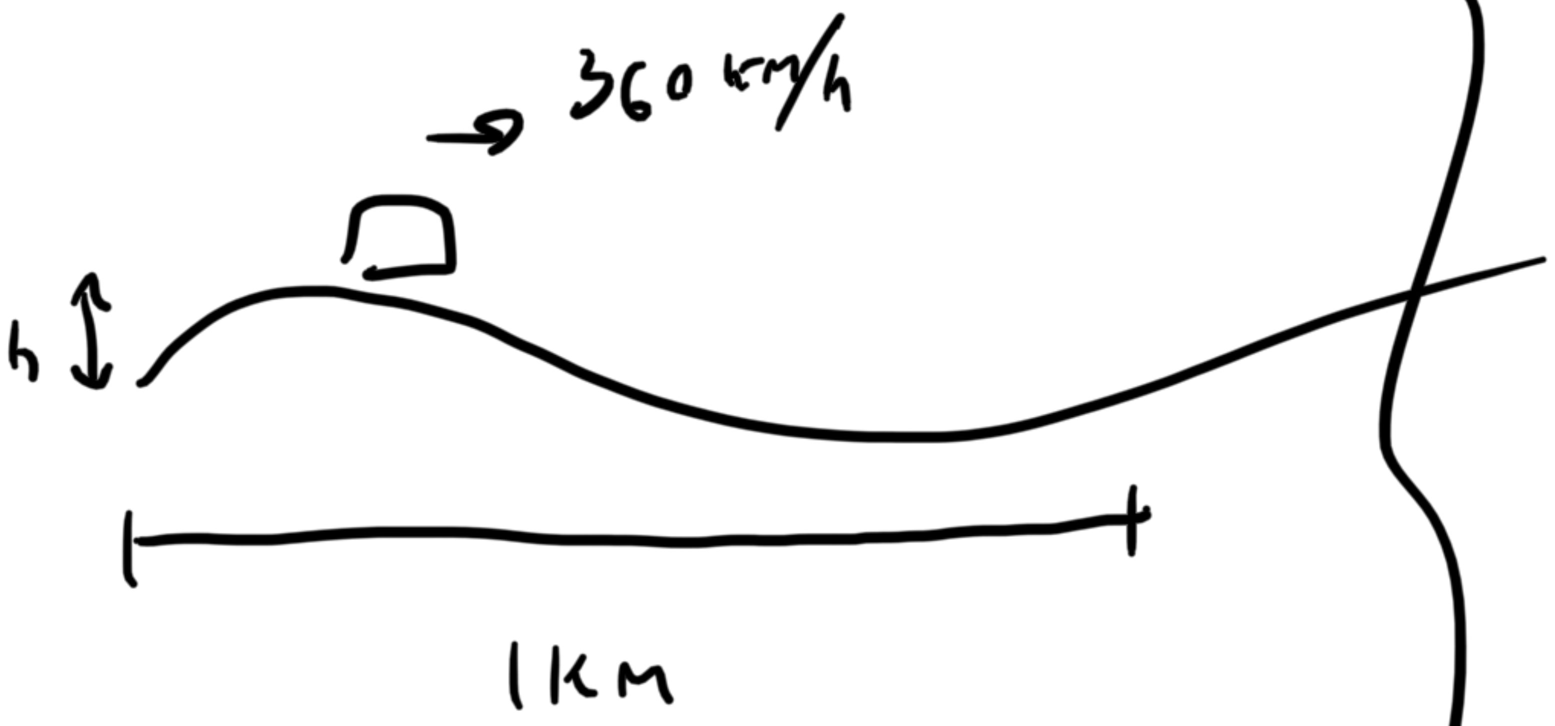
$d = \frac{1}{2}at^2$

$t \propto 1/\sqrt{a}$

$t_d = \sqrt{5}\, t_0$

$\boxed{C}$

2019 B #23



$a_{max} = 0.1\, m/s^2$

what is h?

$A = h$

$T = \frac{1\,km}{360\,km/h} = 10\,s$

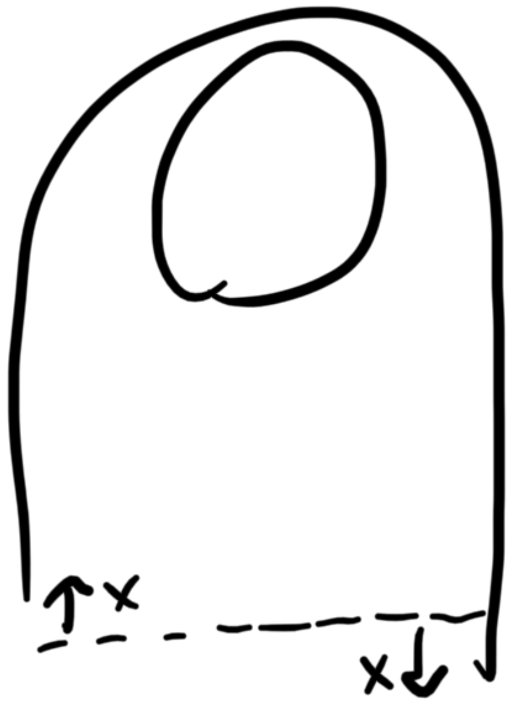
$T = 2\pi\sqrt{m/k} \Rightarrow k = \frac{4\pi^2 m}{T}$

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

$h = \frac{T^2 a_{max}}{4\pi^2} = \frac{(10\,s)^2\,(0.1\,m/s^2)}{4\pi^2} = 0.25\,m$

Ⓑ

2019B#24



$a = ?$

Atwoods machine.

$\Delta L = 2x$

$\Delta m g = 2xMg/L$

$a = \frac{\Delta m g}{m} = \frac{2xMg}{ML} = 2xg/L$

Ⓔ

2019B #25

measuring g, how to minimize

$\Delta g / g$?

$$g = \frac{2h}{t^2}$$

$$\frac{\Delta(x^p)}{x^p} = |p| \frac{\Delta x}{x}$$

$$\frac{\Delta(xy)}{xy} = \sqrt{\left(\frac{\Delta x}{x}\right)^2 + \left(\frac{\Delta y}{y}\right)^2}$$

Ⓐ

A: 10%

B: 20%

C: $\sqrt{(5\%)^2+(10\%)^2} \simeq 11.2\%$

$1.1^2 \simeq 1.2$

$0.9^2 \simeq 0.8$

$(1 \pm x)^2 \simeq 1 \pm 2x$ for small $|x|$

$A < C < B$

Ⓐ