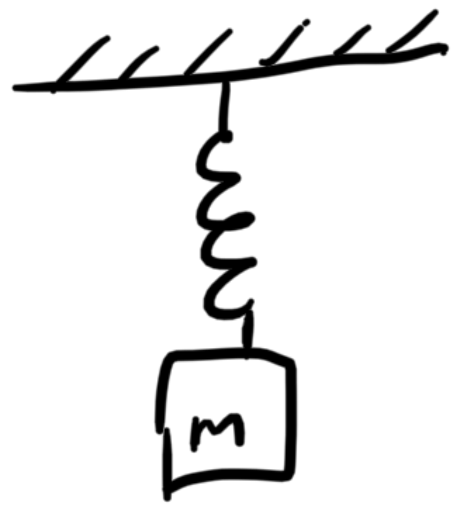
2019 A #4



$$T = 2\pi\sqrt{\frac{m}{k}}$$

$y_{max} = 5\text{ cm}$

Conservation of energy

$$E_0 = mgy_{max}$$

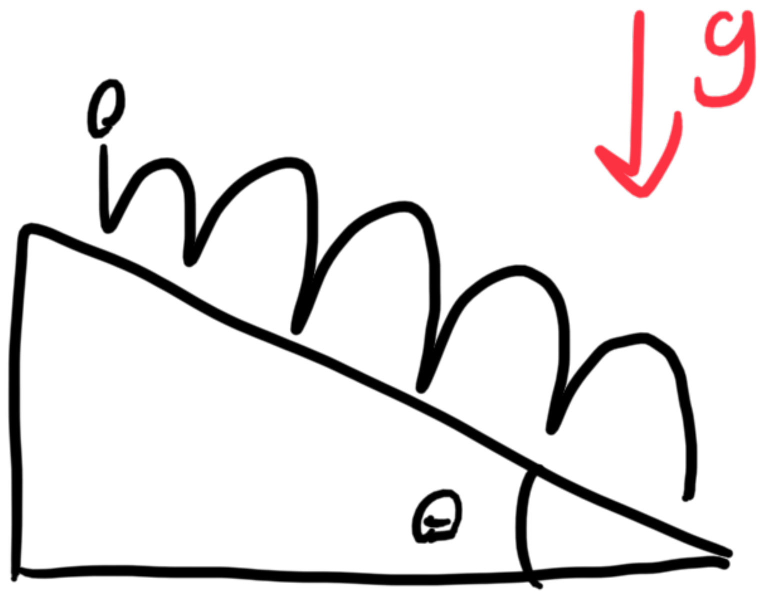
$$E_f = \frac{1}{2}ky_{max}^2$$

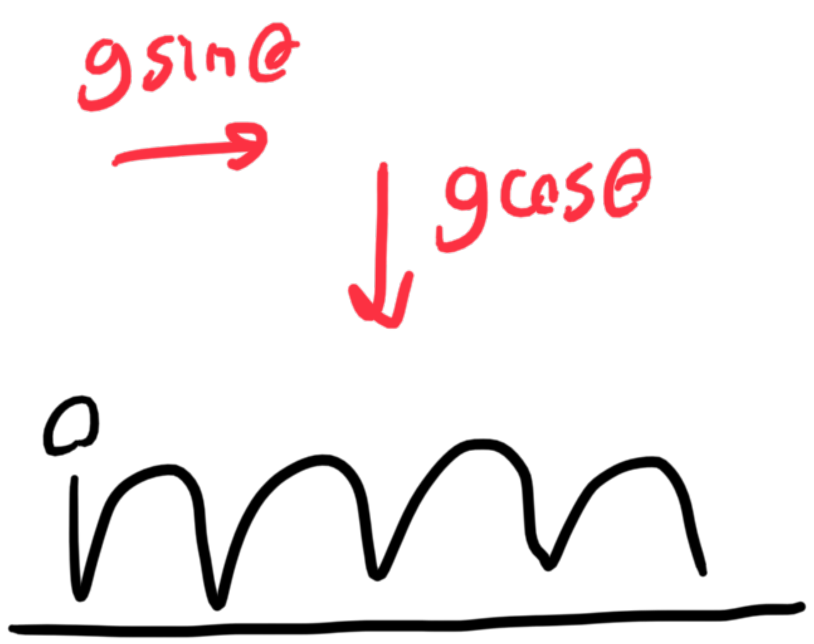
$$E_0 = E_f \Rightarrow \frac{1}{2}ky_{max}^2 = mgy_{max}$$

$$\frac{m}{k} = \frac{y_{max}}{2g}$$

$$T = 2\pi\sqrt{\frac{y_{max}}{2g}} = 0.31\text{ s}$$

2019A #6





how does the time and distance between each collision change?

$\perp$, $\parallel$ coordinate system.

height at bounces remains constant $\Rightarrow$ t const.

A or E

constant accel in the $\parallel$ direction

$v_{\parallel}(t) = v_0 \sin\theta + g t \sin\theta$

A

2019A #12

intuitively ~~D~~ ~~E~~

$$v_n = \alpha^n v_i$$

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

$$\tau_0 = 2v_i/g$$

have τ vs. n but

want τ vs time.

total time

$$t_n = \sum_{j=0}^{n} \tau_j = \tau_0 (\alpha + \alpha^2 + \dots + \alpha^n)$$

$$= \tau_0 \frac{\alpha(1-\alpha^{n-1})}{1-\alpha}$$

$$= \frac{\tau_1 - \tau_n}{1-\alpha}$$

linearly decreasing! B

2019A #13

individual ball needs NT

in the air.

$NT = 2v/g$

$v \propto N$

$P \propto E \propto v^2 \propto N^2$

C

2019A #14

Coriolis force

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

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

$$\vec{v} = 200 \text{ m/s } \hat{N}$$

$$a = -2\omega v \sin(\theta)$$

$$d = \frac{1}{2}at^2 = \frac{1}{2}(-2\omega v \sin\theta)\left(\frac{L}{v}\right)^2$$

$$= L^2 \omega \sin\theta / v$$

$$= 1.8 \text{ mm}$$

east

D

2019A #21

$$m\omega^2 r = G\frac{mM_{enc}}{r^2}$$

$$\frac{T^2}{r^3} = \frac{4\pi^2}{GM_{enc}}$$

$$T^2 = \frac{4\pi^2 r^3}{GM_{enc}}$$

$$M_{enc} = \frac{4}{3}\pi r^3$$

$$T^2 \propto 1/\rho$$

$$\rho = cst.$$

$$T_A = T_B$$

$$T_A = T_B$$

$$\omega_A = \omega_B$$

$$V \propto r^1$$

$$V_A > V_B$$

E

2019A #24

1. x and y are independent
2. $m\ddot{x} = -kx \Rightarrow \omega = ?$
3. Lissajous curves

$U(z) = \frac{1}{2}kz^2$

$m\ddot{z} = -kz$

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

$T_z = 2\pi\sqrt{m/k}$

$k_x = 18k \quad k_y = 32k$

$T_x = 2\pi\sqrt{m/18k}$

$T_y = 2\pi\sqrt{m/32k} = \boxed{\frac{3}{4}T_x}$

minimum period

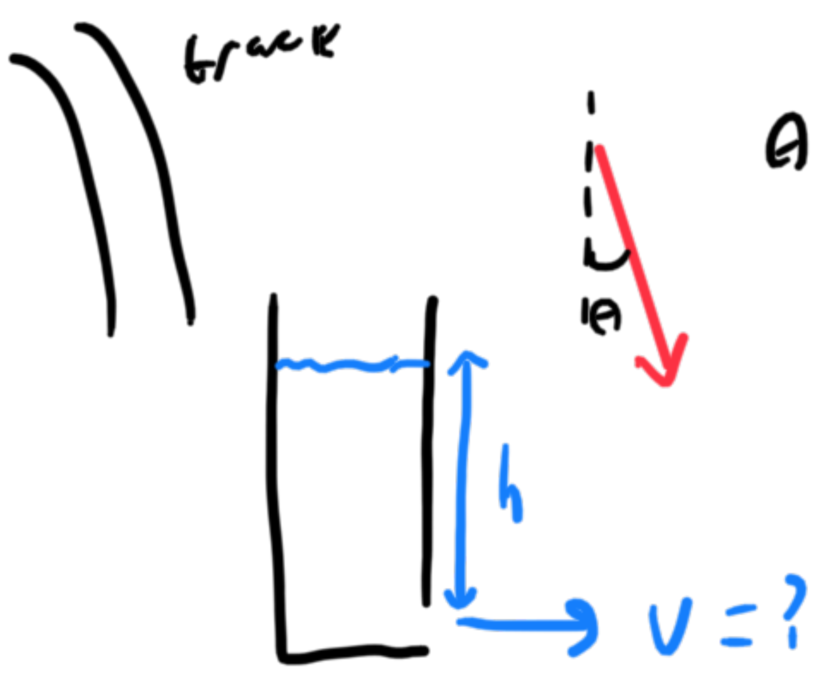
maximum period is LCM

$\boxed{T_{max} = 3T_x}$

Ratio = 4

D

2019 A #25



$\theta = \tan^{-1}\left(\frac{v^2}{gr}\right)$

$P = \rho g h$

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

$v = \sqrt{2gh}$

$\vec{g}_{eff} = -g\hat{y} + \vec{a}_c = \frac{v^2}{r}\hat{x} - g\hat{y} \Rightarrow g_{eff} = \frac{g}{\cos\theta}$

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

$v = \sqrt{2 g_{eff} h_{eff}} = \sqrt{2\frac{g}{\cos\theta} h\cos\theta} = \sqrt{2gh}$ A