6.

$x \propto F$,

$x \propto I^{-1} \propto m^4$

$x \propto E^?$

$x \propto L^?$

$F: N$

$I: m^4$

$E: N/m^2$

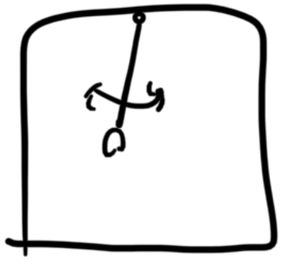
$L: m$

$x = F \cdot I^{-1} \cdot E^{-1} \cdot L^{\gamma}$

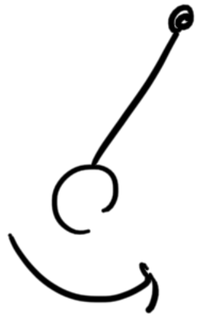
$m = \underbrace{N \cdot m^{-4} \cdot \frac{m^2}{N}}_{m^{-2}} \cdot m^{\gamma}$

m^3

7

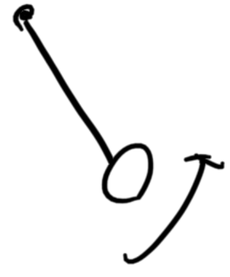


w



g↑

increased speed



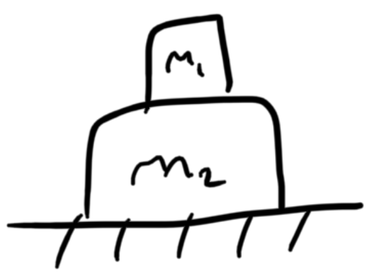
g↓

increased height

$$w_{grav} \approx 2\sqrt{g/L}$$

so that the relative gravity oscillates twice per cycle.

13



$\mu_{s\,(m_1-m_2)} = 0.2$

$N_{(m_2\text{-table})} = 0$

$F < 3\mu_s m_1 g = 12N$

maximum F_s total

$$a = \frac{F}{m_1+m_2}$$ total acceleration

$$F_s = m_2 a = \frac{m_1}{m_1+m_2} F = \frac{F}{3}$$

force from m_1 on m_2

16.

$F_L \propto v^2 \Theta$

$F_D \propto v^2$

$v \to v - w$

$v \downarrow \quad \Theta \uparrow$

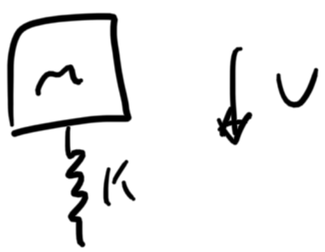
to keep F_L const.

Engine power

$P \propto F \cdot v \propto v^3$

(generally useful)

17.

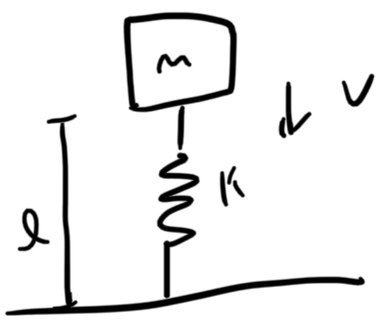


modified spring length

$$E_{init} = \frac{1}{2}mv^2 + \frac{1}{2}k\left(\frac{mg}{k}\right)^2$$

$$= K_{max} = \frac{1}{2}m(v^2 + mg^2/k)$$

$$= \frac{1}{2}mv_{max}^2 \Rightarrow v_{max} = \sqrt{v^2 + mg^2/k}$$



$L_0 = l$

$L_{real} = l - mg/k$

equilibrium compressed due to block on top

19.

$s = 75.0 \pm 2.0$ cm

$t = 2.15 \pm 0.10$ ms

$\frac{\Delta s}{s}$, $\frac{\Delta t}{t}$

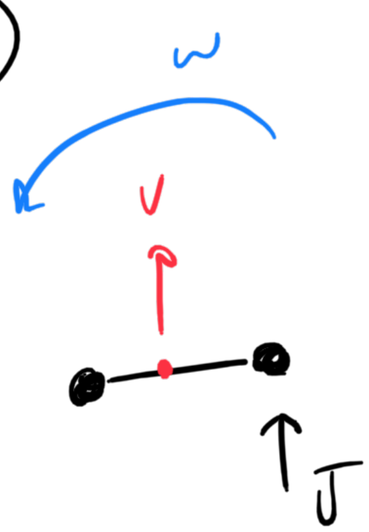
HW: derive

$$\frac{\Delta v}{v} = \frac{\Delta\left(\frac{s}{t}\right)}{\left(\frac{s}{t}\right)} = \sqrt{\left(\frac{\Delta s}{s}\right)^2 + \left(\frac{\Delta t}{t}\right)^2} \approx 5.4\%$$

$v \simeq \frac{s}{t} \approx 34\,g$

$\frac{\Delta v}{v} = (5.4\%) \cdot v \simeq 1.9\,m/s$

23.



$$\Rightarrow V = V_c + r_1 w = \frac{m_1 V}{m_1+m_2} + \frac{m_2}{m_1+m_2} L w$$

$$\Rightarrow w = V/L$$

$$\vec{V_c} + \boxed{(\vec{w} \times \vec{r_2})} = 0 \quad \text{at } t=0$$

$$\Rightarrow |\vec{V_c}| = |\vec{w} \times \vec{r_2}|$$

$$P = (m_1+m_2) V_c \leftarrow J$$

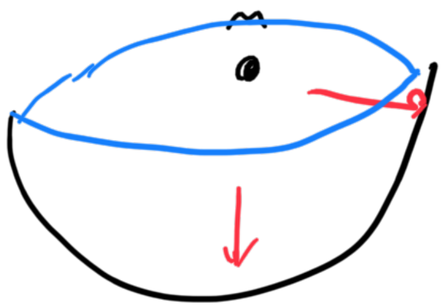
$$\boxed{V_c} = \frac{m_1 V}{m_1+m_2}$$

$$r_1 = \frac{m_2}{m_1+m_2} L$$

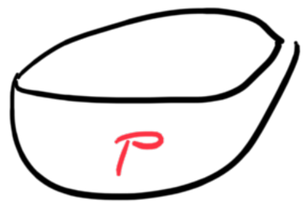
$$r_2 = \frac{m_1}{m_1+m_2} L$$

$$t = \frac{2\pi}{w} = 2\pi L/V.$$

24. (approach 1: clever)



$\sigma = [kg/m^2]$



$$F = PA = \frac{GM\sigma}{R^2}\pi R^2 = \pi GM\sigma$$

$$\frac{F}{A} = GM\sigma/R^2 = P$$

24. (approach 2: calculus)

$$dm = \sigma R^2 \sin\theta \, d\theta \, d\phi$$

$$F = \iint_S \frac{Gm}{R^2} \cos\theta \, dm$$

$$= \int_0^{2\pi} \int_0^{\pi/2} G m \sigma \sin\theta \cos\theta \, d\theta d\phi$$

$$= 2\pi G m \sigma \underbrace{\int_0^{\pi/2} \sin\theta \cos\theta \, d\theta}_{1/2}$$

$$= \pi G m \sigma$$