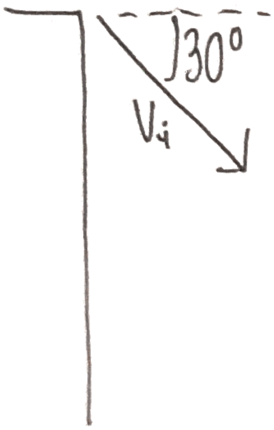
1.



$V_i = 16 m/s$

$\Delta t = 2.7 s$

$a_x = 0$

$a_y = -9.8 m/s$

$\Delta y = ?$

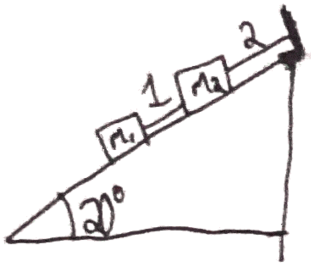
$\Delta y = V_{iy} t + \frac{1}{2} a_y t^2$ $\qquad V_{iy} = -V_i \sin\theta$

$\Delta y = (-V_i \sin\theta)(t) + \frac{1}{2}(-9.8) t^2$

$\Delta y = (-16 \sin 30)(2.7) + \frac{1}{2}(-9.8)(2.7)^2$

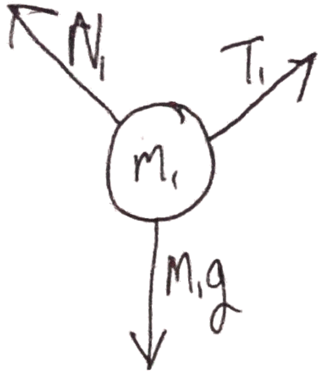
$\Delta y = 57 m$

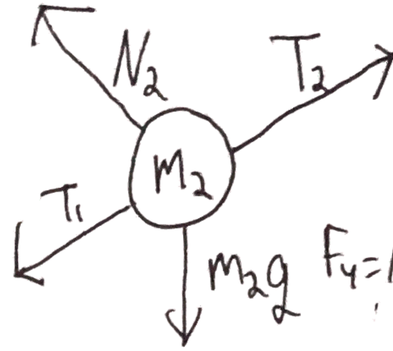
2.



$m_1 = 3kg$

$m_2 = 1kg$





$F_x: T_2 - T_1 - m_2 g \sin\theta =$

$F_y = N_2 - m_2 g \cos\theta = 0$

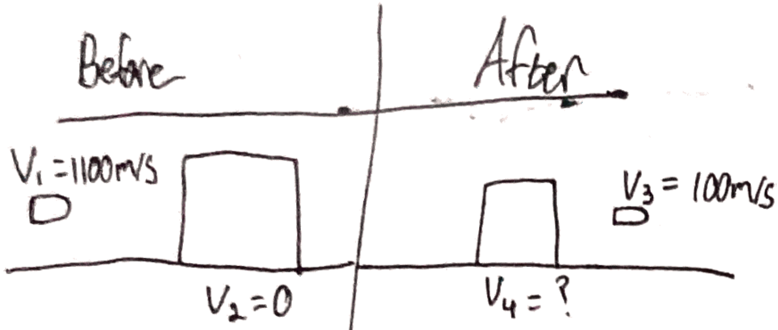
$F_x: T_1 - m_1 g \sin\theta = ma_x = 0 \quad F_y: N_1 - m_1 g \cos\theta = ma_y = 0$

$T_1 = m_1 g \sin\theta$

$T_1 = (3)(9.8)\sin(20)$

$T_1 = 10N$

3.



$M_1 = 20g = .02kg$

$M_2 = 1kg$

Impulse $= J = F\Delta t = m\Delta V$

$= m(V_4 - V_2)$

$= (1)(20-0)$

$= 20 \, kg\,m/s$

$M_1V_1 + M_2V_2 = M_1V_3 + M_2V_4$

$M_1V_1 + M_2V_2 - M_1V_3 = M_2V_4$

$\frac{M_1V_1 + M_2V_2 - M_1V_3}{M_2} = V_4$

$\frac{(.02)(1100) + (1)(0) - (.02)(100)}{(1)} = V_4$

$V_4 = 20 m/s$

4. $T = 687 \text{ days} = 59356800 s$

$M_s = 1.99 \times 10^{30} kg$

$M_m = 6.39 \times 10^{23} kg$

$G = 6.67 \times 10^{-11}$

Circular Motion: $F_c = \frac{mv^2}{r}$

Gravity: $F_g = G \frac{m_1 m_2}{r^2}$

$$G \frac{M_s M_m}{r^2} = \frac{M_m V^2}{r}$$

$$T = \frac{2\pi r}{V} \rightarrow \frac{2\pi r}{T} = V$$

$$G \frac{M_s M_m}{r^2} = \frac{m_m \left(\frac{2\pi r}{T}\right)^2}{r}$$

$$G \frac{M_s}{r^2} = \left(\frac{2\pi r}{T}\right)^2 \frac{1}{r}$$

$$\frac{G M_s}{r^2} = \frac{4\pi^2 r}{T^2}$$

$$\frac{G M_s T^2}{4\pi^2} = r^3$$

$$r = \sqrt[3]{\frac{G M_s T^2}{4\pi^2}}$$

$$r = 2.28 \times 10^{11} m$$

OR: use Kepler's Third Law:

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

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

$$\sqrt[3]{\frac{T^2 GM}{4\pi^2}} = r$$

$$r = 2.28 \times 10^{11} m$$

5. $m = .21kg$

$d = .24m \rightarrow r = .12m$

$\tau = .059Nm$

$\omega_i = 0$ rpm

$\omega_f = 1800rpm = 188.4$ rad/s

$$\tau = I\alpha \rightarrow \frac{\tau}{I} = \alpha$$

I (for disk): $I = \frac{1}{2}MR^2$

$$\omega_f = \omega_i + \alpha t$$

$$\omega_f = \omega_i + \left(\frac{\tau}{I}\right)t$$

$$\omega_f = \omega_i + \left(\frac{\tau}{\frac{1}{2}MR^2}\right)t$$

$$\omega_f = \omega_i + \left(\frac{2\tau}{MR^2}\right)t$$

$$(\omega_f - \omega_i) = \left(\frac{2\tau}{MR^2}\right)t$$

$$\frac{(\omega_f - \omega_i)(MR^2)}{2\tau} = t$$

$$t = 4.8s$$

6. E, τ, I $(\omega_0 = 0)$

$E = \frac{1}{2} I \omega^2$ $\omega = \omega_0 + \alpha t$ $\tau = I\alpha \rightarrow \alpha = \frac{\tau}{I}$

$E = \frac{1}{2} I \left(\frac{\tau}{I} t\right)^2$ $\omega = \left(\frac{\tau}{I}\right) t$

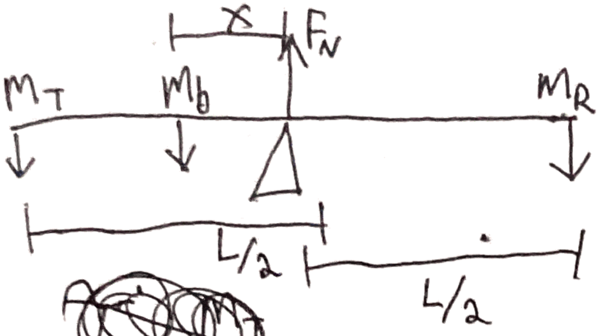
$E = \frac{1}{2} I \frac{\tau^2}{I^2} t^2$

$E = \frac{1}{2} \frac{\tau^2 t^2}{I}$

$\frac{2EI}{t^2} = \tau^2$

$\tau = \sqrt{\frac{2EI}{t^2}}$

7.



$\tau = rF\sin\theta$

$\tau: \left(\frac{L}{2}\right)m_T + (x)m_b - \left(\frac{L}{2}\right)m_r + (0)F_N = 0$

$\left(\frac{L}{2}\right)m_T + (x)m_b - \left(\frac{L}{2}\right)m_r = 0$

$\left(\frac{L}{2}\right)m_T + (x)m_b = \left(\frac{L}{2}\right)m_r$

$m_T = \frac{2}{3}m_r$

$m_b = \frac{1}{2}m_r$

$\left(\frac{L}{2}\right)\left(\frac{2}{3}\right)m_r + (x)(1/2)m_r = \left(\frac{L}{2}\right)m_r$

$\left(\frac{L}{2}\right)\left(\frac{2}{3}\right) + (x)\left(\frac{1}{2}\right) = (L/2)$

$\frac{L}{3} + \frac{x}{2} = L/2$

$\frac{x}{2} = L/6$

$x = L/3$

8. Conservation of angular momentum: $L = I\omega$

$$L_1 = L_2$$

$$I_1\omega_1 = I_2\omega_2 \rightarrow I_2 = \frac{I_1\omega_1}{\omega_2}$$

$I_1 = .77$

$\omega_1 = 3.6$

$\omega_2 = 2.9$

$$I_2 = \frac{(.77)(3.6)}{2.9}$$

$$I_2 = .96$$

9. $F = 1.3N$

$\Delta x = 8.6cm = .086m$

$f = .83Hz$

$$w = \sqrt{\frac{k}{m}}$$

$$w^2 = \frac{k}{m}$$

$$mw^2 = k$$

$$m = \frac{k}{w^2}$$

$$|F| = k\Delta x$$

$$\frac{|F|}{\Delta x} = k$$

$$m = \frac{|F|}{\Delta x w^2}$$

$$w = 2\pi f$$

$$w = 2\pi(.83)$$

$$w = 5.21 \text{ rad/s}$$

$$m = \frac{1.3}{(.086)(5.21)^2}$$

$$m = .56 \text{ kg}$$

10. Pendulum: $\omega = \sqrt{\frac{g}{l}}$ $\qquad \omega = \frac{2\pi}{T}$

$$\frac{2\pi}{T} = \sqrt{\frac{g}{l}}$$

$\downarrow$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T_1 = 2\pi\sqrt{\frac{l_1}{g}} \qquad T_2 = 2\pi\sqrt{\frac{l_2}{g}}$$

$$l_2 = l_1$$

$$T_2 = 2\pi\sqrt{\frac{l_1}{g}}$$

$$T_2 = T_1$$

11. Doppler effect:

$$f = f_0 \frac{V \pm V_O}{V \pm V_S} \qquad V_O = 0$$

$$V_S = \pm V_p$$

$$f_1 = f_0 \frac{V}{V - V_S} \qquad f_2 = f_0 \frac{V}{V + V_S}$$

$$f_1\left(\frac{V - V_S}{V}\right) = f_0 \qquad f_2\left(\frac{V + V_S}{V}\right) = f_0$$

$$f_1\left(\frac{V - V_S}{V}\right) = f_2\left(\frac{V + V_S}{V}\right)$$

$$f_1(V - V_S) = f_2(V + V_S)$$

$$f_1 V - f_1 V_S = f_2 V + f_2 V_S$$

$$f_1 V - f_2 V = f_1 V_S + f_2 V_S$$

$$(f_1 - f_2) V = (f_1 + f_2) V_S$$

$$\frac{(f_1 - f_2) V}{(f_1 + f_2)} = V_S$$

$$V_S = \left(\frac{800 - 650}{800 + 650}\right)(350)$$

$f_1 = 800\,Hz$

$f_2 = 650\,Hz$

$V = 350\,m/s$

$$\boxed{V_S = 36.2\,m/s}$$

12. Closed-end pipe: $f_n = \frac{v}{\lambda_n}$ $\lambda_n = \frac{4L}{n}$

$$f_n = \frac{v}{4L/n} = \frac{vn}{4L}$$

$$L = \frac{vn}{4f_n}$$

First resonant frequency: $n=1$

$v = 330\,m/s$

$f_1 = 53\,Hz$

$$L = \frac{(330)(1)}{4(53)}$$

$$L = 1.56\,m$$

13. $P = IA$

Efficiency $= \frac{\text{Output}}{\text{Input}} \rightarrow$ Input $=$

$I = .84\,kW/m^2$

$A = 14.3\,m^2$

$\frac{.10\$}{kWh}$

$P = (.84\,kW/m^2)(14.3\,m^2) = 12.012\,kW$

$P\Delta t = E$

$\frac{6\text{ hours}}{\text{day}}$

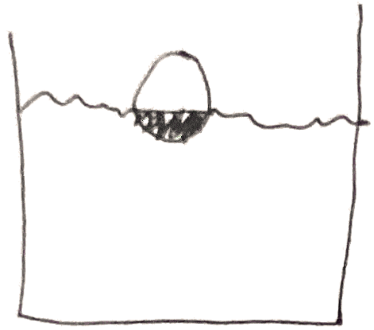
$(12.012\,kW)\left(6\frac{\text{hours}}{\text{day}}\right) = (72.072\,kWh/\text{day})$

$\left(72.072\frac{kWh}{\text{day}}\right)15\% = 10.8108\frac{kWh}{\text{day}}$

$10.8108\frac{kWh}{\text{day}} \times \frac{.1\$}{kWH} = \frac{1.08\$}{\text{day}}$

$\frac{\$8000}{\$1.08/\text{day}} = 7407\text{ days} = 20\text{ years}$

14.



Buoyant force: $F_B = \rho_{fluid} V_{fluid}\, g$

$$F_{net} = F_B - mg = ma = 0$$

$$\rho_{fluid} V_{fluid}\, g - mg = 0$$

$$\rho_{fluid} V_{fluid}\, g - \rho_{ball} V_{ball}\, g = 0$$

$$V_{fluid} = \tfrac{1}{4} V_{ball}$$

$$\rho_{fluid} \left(\tfrac{1}{4} V_{ball}\right) g - \rho_b V_{ball}\, g = 0$$

$$\tfrac{1}{4} \rho_{fluid} V_{ball}\, g = \rho_{ball} V_{ball}\, g$$

$$\frac{1}{4} \rho_{fluid} = \rho_{ball}$$

$$\rho_{fluid} = 13.5\,g/mL$$

$$\frac{1}{4}(13.5) = \rho_{ball}$$

$$\rho_{ball} = 3.375\,g/mL$$

15.

$d_2 = \frac{d_1}{2}$

$h_1 = h_2$

$\Delta P = 8\times10^4 Pa$

Bernoulli's equation: $P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

Flow Rate: $Q = vA$

Continuity Equation: $Q_1 = Q_2$

$$V_1 A_1 = V_2 A_2$$

$$V_1\left(\cancel{\pi}\left(\frac{d_1}{2}\right)^2\right) = V_2\left(\pi\left(\frac{d_2}{2}\right)^2\right)$$

$$V_1 \pi^2 \frac{d_1^2}{4} = V_2 \pi^2 \frac{d_2^2}{4}$$

$$V_1 d_1^2 = V_2 d_2^2$$

$$V_1 d_1^2 = V_2\left(\frac{d_1}{2}\right)^2$$

$$V_1 d_1^2 = V_2 \frac{d_1^2}{4}$$

$$V_1 = \frac{V_2}{4}$$

$$4V_1 = V_2$$

$$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho(4V_1)^2$$

$$P_1 - P_2 = \frac{15}{2}\rho V_1^2$$

$$\Delta P = \frac{15}{2}\rho V_1^2$$

$$\sqrt{\frac{2\Delta P}{15\rho}} = V_1$$

$$V_1 = \sqrt{\frac{2(8\times10^4)}{15(1000)}}$$

$$V_1 = 3.3 m/s$$