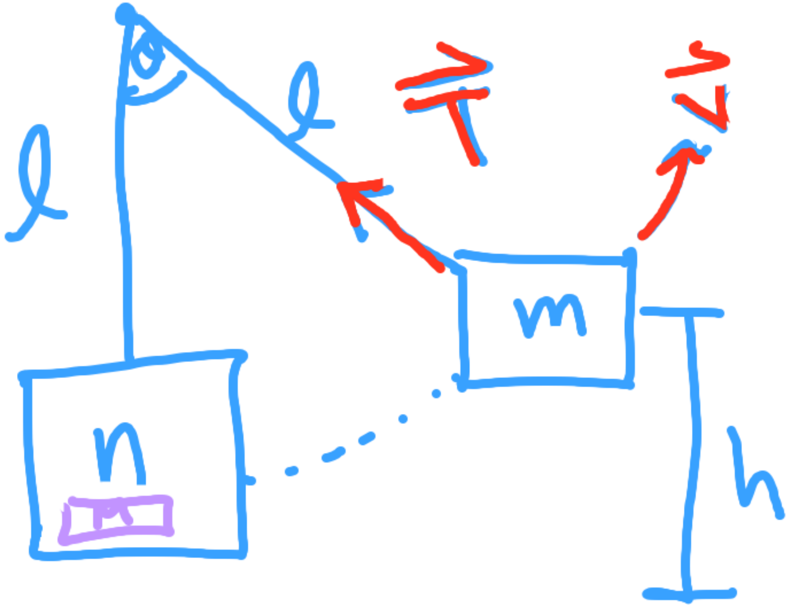
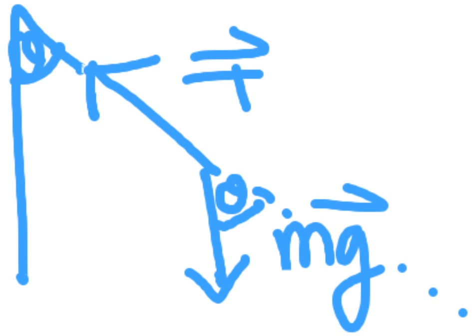
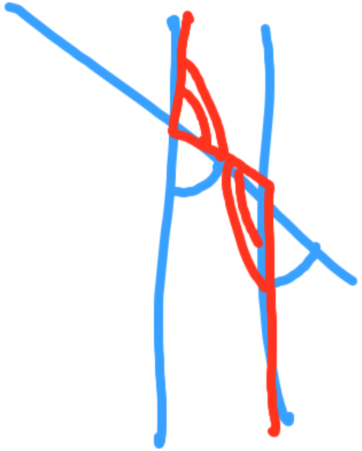
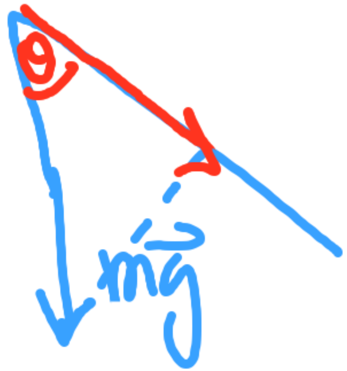
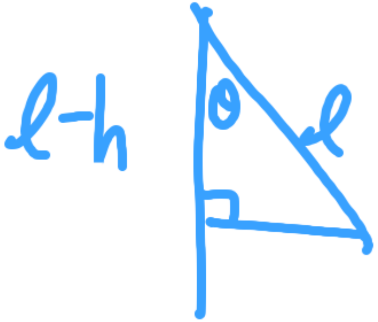
$$\boxed{m = M + n}$$











$$\cos\theta = \frac{\ell - h}{\ell}$$

$$mg\cos\theta = mg\left(\frac{\ell - h}{\ell}\right)$$

$$\vec{F}_{Net} = \vec{T} - \vec{mg}_r \Rightarrow F = T - mg\left(\frac{\ell - h}{\ell}\right)$$

$$F = ma = m\frac{v^2}{r} = \frac{mv^2}{\ell} = T - mg\left(\frac{\ell - h}{\ell}\right)$$

$$v^2 = \frac{\ell}{m}\left(T - mg\left(\frac{\ell - h}{\ell}\right)\right)$$

$$V = \sqrt{\frac{\ell}{m}T - g(\ell - h)}$$

$$mgh + \frac{1}{2}mv^2 = \frac{1}{2}mv_i^2$$

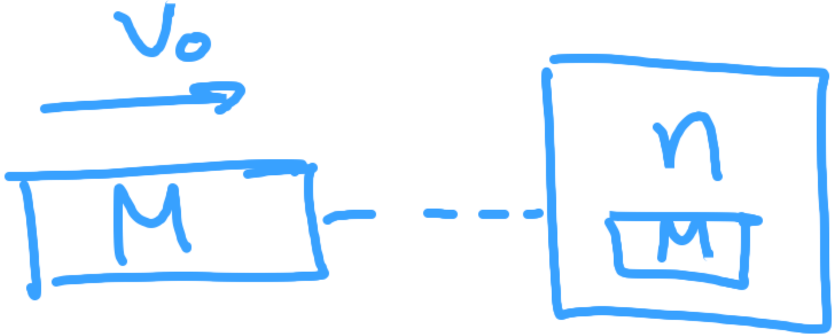
$$2gh + v^2 = v_i^2$$

$$2gh + v^2 = v_i^2$$

$$\vec{P}_i = \vec{P}_f$$

$$M v_0 = m v_i$$

$$v_0 = \frac{m}{M} v_i$$



$$v_0 = \frac{m}{M}\sqrt{2gh + \frac{\ell}{m}\left(T - mg\left(\frac{\ell-h}{\ell}\right)\right)}$$

$m = n + M$

$\ell - h = 1.52m - 0.775m$

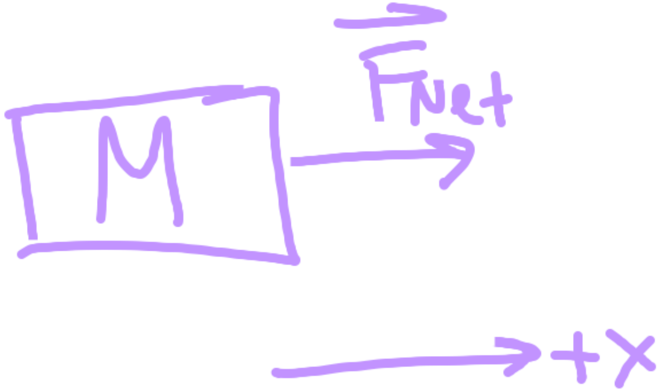
$$v_0 = \frac{\overbrace{0.725kg + 0.0136kg}^{0.7386kg}}{0.0136kg}\sqrt{2 \cdot 9.81\frac{m}{s^2}\, 0.775m + \frac{1.52m}{0.7386kg}\left[4.98N - \underbrace{0.7386kg\, 9.81\frac{m}{s^2}}_{N}\left(\frac{0.745\cancel{m}}{1.52\cancel{m}}\right)\right]}$$

$$\vec{P}_i = \vec{P}_f$$

$$\frac{M}{4}v_0 = \left(M+\frac{M}{4}\right)v_f \Rightarrow v_f^2 = \left(\frac{\cancel{M}v_0}{\cancel{4}\underbrace{\left(M+\frac{M}{4}\right)}_{\frac{5\cancel{M}}{\cancel{4}}}}\right)^2$$

$$\frac{1}{2}\cancel{\left(M+\frac{M}{4}\right)}v_f^2 = \cancel{\left(M+\frac{M}{4}\right)}gh$$

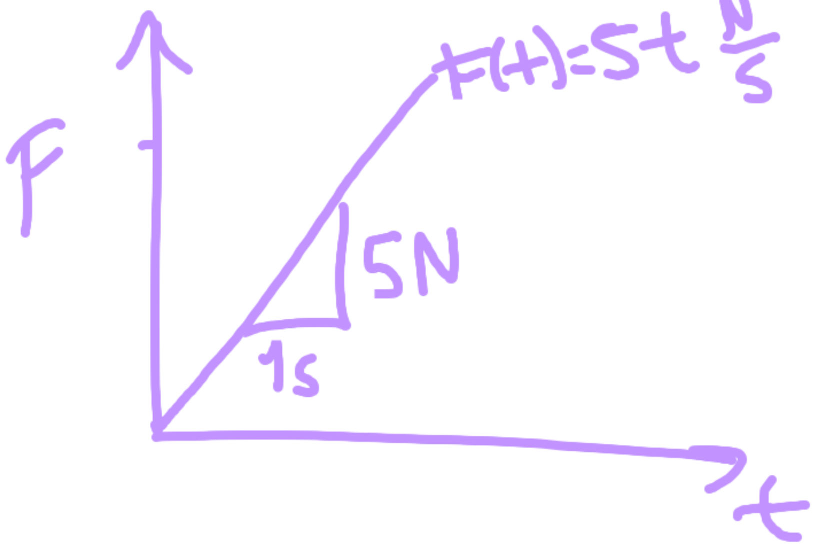
$$h = \frac{v_f^2}{2g} = \left(\frac{v_0}{5}\right)^2\frac{1}{2g} = \frac{v_0^2}{50g}$$



$$\int_0^t F\,dt = \Delta P$$

$$\int_0^t F(t')\,dt' = P_f - P_i$$

$$\int_0^t 5t'\,dt' = Mv - \emptyset$$

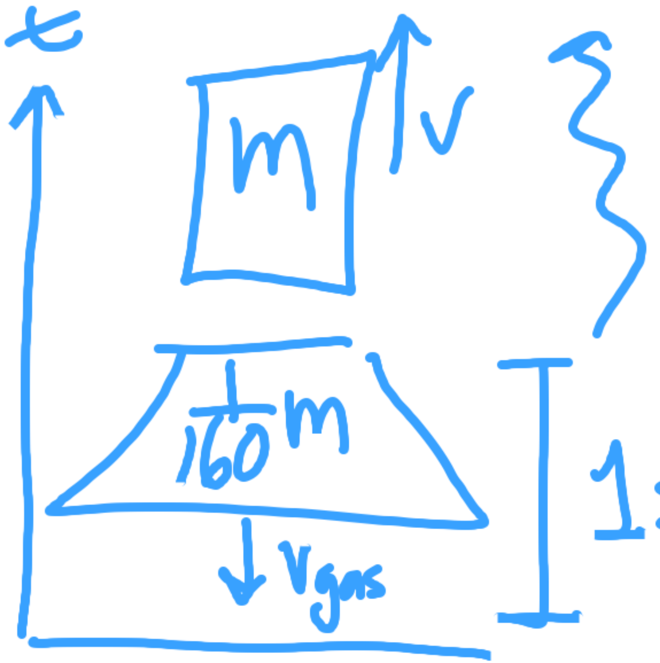


$$5\frac{t^2}{2} = Mv$$

$$t = \sqrt{\frac{2}{5}Mv}$$

$$F = 5\sqrt{\frac{2}{5}Mv} = \sqrt{10Mv}$$

$$= \sqrt{10\cdot 5\cdot 9}$$



$1s = \Delta t$

$V = a\Delta t$

$14.7\frac{m}{s^2} = a \approx 0.0147\frac{m}{s^2}$

$F = ma$

$F\Delta t = \Delta P$

$ma\Delta t = P_f - P_i$

$P_f = m\frac{159}{160}\overset{a\Delta t}{\cancel{v}} - \frac{m}{160}V_{gas}, \quad P_i = 0.$

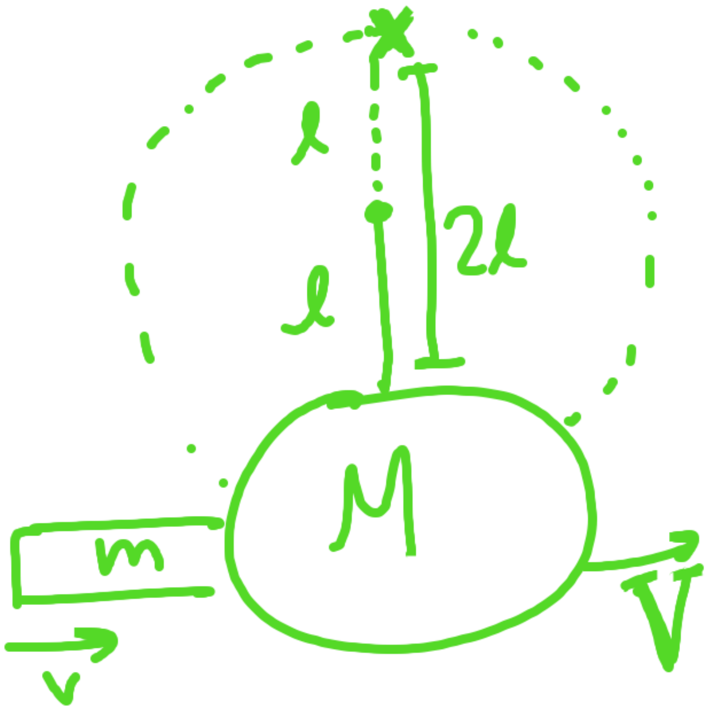
$V_{gas} = \frac{\left(\cancel{m}a\Delta t_{\times 160} - \cancel{m}a\Delta t\left(\frac{159}{\cancel{160}}\right)\right)\left(-1\cancel{60}\right)}{\cancel{m}}$

$= -160\,a\cdot\Delta t + a\Delta t(159) = a\Delta t(159-160)$

$= -a\Delta t$

$V_{gas} = ?$

$J = \int_0^t F(t')dt' = Ft$



$$mv = (M+m)V$$

$$V = \frac{mv}{M+m}$$

$$\frac{1}{2}(M\cancel{+m})V^2 = (M\cancel{+m})g\,2l$$

$$V^2 = 4gl$$

$$\left(\frac{mv}{M+m}\right)^2 = 4gl$$

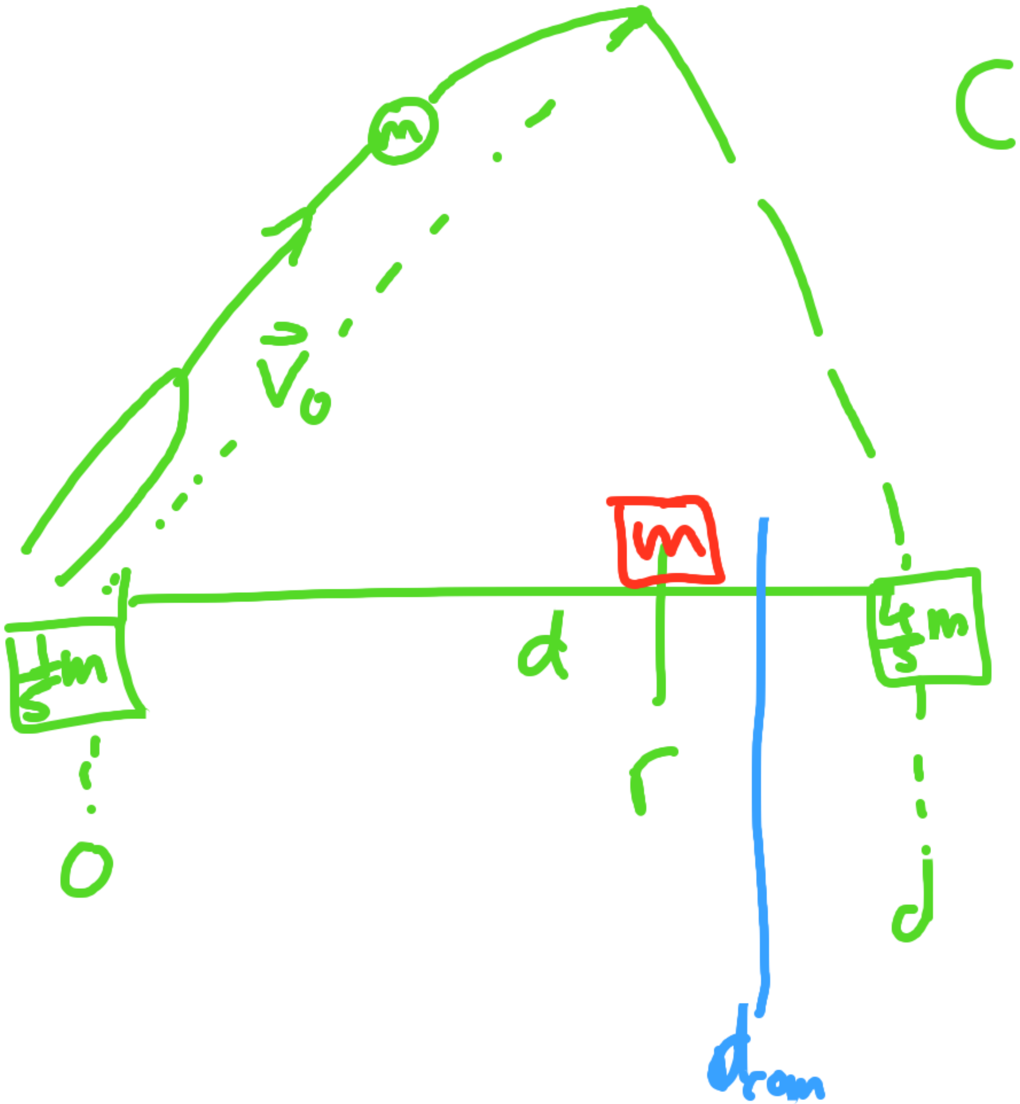
$$\cancel{m^2}v^2 = \frac{4gl(M+m)^2}{m^2}$$

$$v = \sqrt{\frac{4gl(M+m)^2}{m^2}} = \frac{2(M+m)}{m}\sqrt{gl}$$

$$v = 2\,\frac{(M+m)}{m}\sqrt{gl}$$

$$= 2\,\frac{(24.00\,\text{kg} + 5.00\,\text{kg})}{5.00\,\text{kg}}\sqrt{9.81\,\frac{\text{m}}{\text{s}^2}\,2\,\text{m}}$$

$$= 51.38\,\frac{\text{m}}{\text{s}}$$



C.O.M. $= r_{com}$

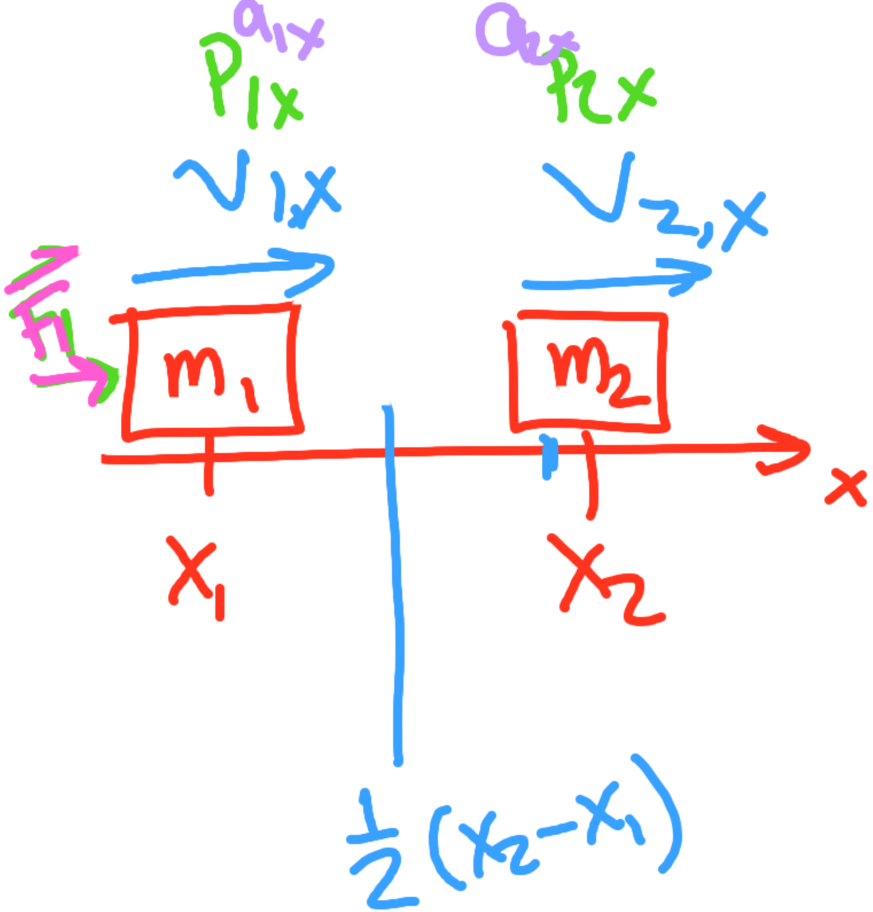
$$d_{com} = \frac{\sum_i m_i x_i}{\sum_i m_i}$$

$$= \frac{\frac{1}{5}\cancel{m}(0) + \frac{4}{5}\cancel{m}d}{\cancel{m}}$$

$$= \frac{4d}{5}$$

$$r_{com} = \frac{\cancel{m}r}{\cancel{m}} = r$$

$$d = \frac{5r}{4}$$



$$x_{cm} = \frac{m_1x_1+m_2x_2}{m_1+m_2}$$

$\boxed{\text{Part B}}$ $m_2 \gg m_1$

$$x_{cm} \approx x_2$$

$$\frac{dx_{cm}}{dt} = v_{cm} = \frac{d}{dt}\left(\frac{m_1x_1+m_2x_2}{m_1+m_2}\right)$$

$$= \frac{1}{m_1+m_2}\left(\underbrace{m_1v_1}_{p_1} + \underbrace{m_2v_2}_{p_2}\right)$$

$$\boxed{v_{cm} = \frac{m_1v - m_2v}{m_1+m_2} = \frac{v(m_1-m_2)}{m_1+m_2}}$$

Part I

$$\vec{F} = m\vec{a}$$

$$F = m a_{cm,x}$$

$$F = (m_1 + m_2) a_{cm,x}$$

$$\frac{F}{m_1 + m_2} = a_{cm,x}$$

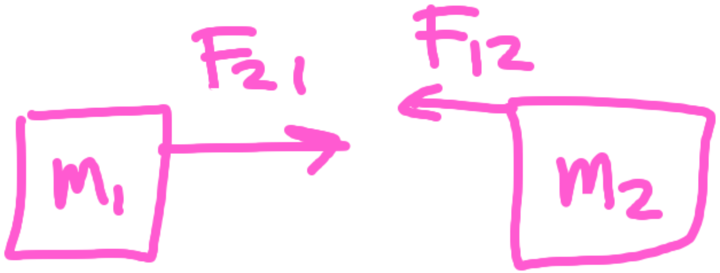
Part J

$$\frac{F_1 - F_2}{m_1 + m_2} = a_{cm,x}$$

Part K

$$F_1 = -F_2$$

Part L



Part K