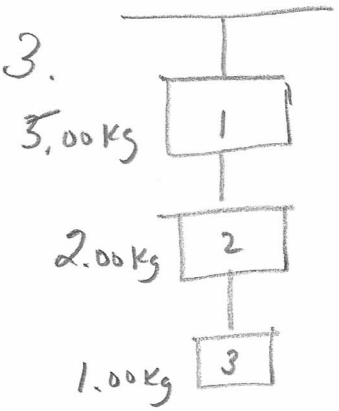
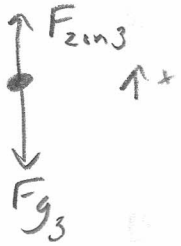
Section 2.3 Dynamics Section Questions #3-11

3.



a)



$\Sigma F = 0$

$\Sigma F = F_{2on3} - F_g$

$F_{2on3} - F_{g_3} = 0$

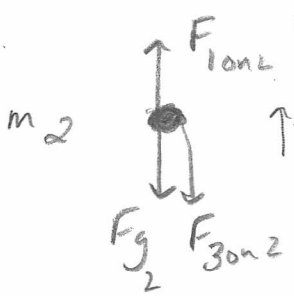
$\therefore F_{2on3} = F_g$

$= mg$

$= (1.00\,kg)(9.80\,\frac{N}{kg})$

$= 9.80N$

b)



$\Sigma F = 0$

$\Sigma F = F_{1on2} - F_g - F_{3on2}$

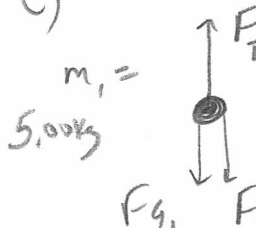
$F_{1on2} = F_g + F_{3on2}$

$= (m_2 g) + F_{3on2}$

$= (2.00kg)(9.80\,\frac{N}{kg}) + 9.80N$

$= 29.4\,N$

c)



$\Sigma F = 0$

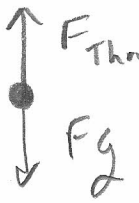
$\Sigma F = F_{T1} - F_{g_1} - F_{2on1}$

$F_{T_1} = m_1 g + F_{2on1}$

$= (5.00kg)(9.80\,\frac{N}{kg}) + 29.4N$

$= 78.4\,N$

4]



$a = 0.50g$ [↑]

$m = 2.0 \times 10^5 kg$

$\begin{cases} \Sigma F = ma \\ \Sigma F = F_{Thrust} - F_g \end{cases}$

$F_{Thrust} - mg = ma$

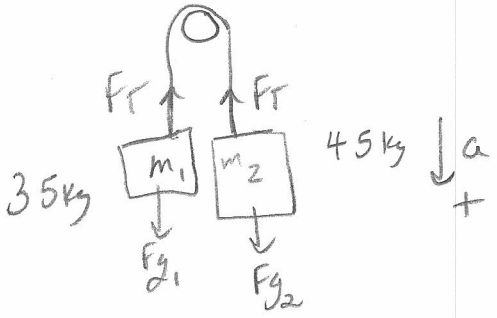
$F_{Thrust} = ma + mg$

$= 2.0 \times 10^5 kg \left((0.50)(9.80 \frac{m}{s^2}) + 9.80 \frac{m}{s^2} \right)$

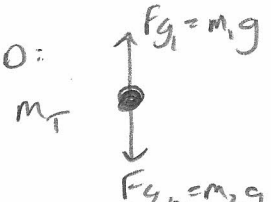
$= 2.94 \times 10^7 N$

∴ the upward thrust force is 2.94×10^7 N. This force is caused by the expanding gases in the shuttle's rocket launcher.

5)



a) $a = ?$ Consider the system FBD:



$\begin{cases} \Sigma F = m_T a \\ \Sigma F = F_{g_2} - F_{g_1} \end{cases}$

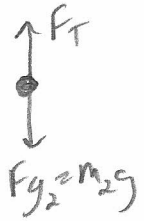
$m_T a = m_2 g - m_1 g$

$a = \dfrac{g(m_2 - m_1)}{(m_1 + m_2)}$

$a = \dfrac{(9.80 m/s^2)(45 kg - 35 kg)}{(45 kg + 35 kg)}$

$a = 1.225 \ m/s^2$

b) $F_T = ?$ Consider m_2:



$\begin{cases} \Sigma F = m_2 a \\ \Sigma F = m_2 g - F_T \end{cases}$

$m_2 g - F_T = m_2 a$

$F_T = m_2 g - m_2 a$

$= (45 kg)(9.80 m/s^2 - 1.225 m/s^2)$

$= 385.875 N$

$F_T \approx 390 N$

c) $\Delta t = 0.50 s$

$\Delta d = ?$

$\vec{v}_1 = 0.0 m/s$

$\vec{a} = 1.225 m/s^2$

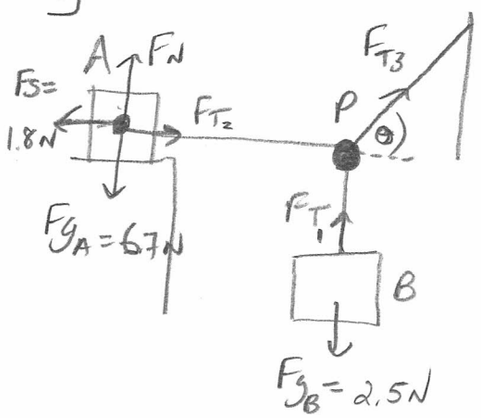
$\Delta d = \cancel{v_1 \Delta t}^{0} + \frac{1}{2} a \Delta t^2$

$\Delta d = \frac{1}{2}(1.225 \frac{m}{s^2})(0.50 s)^2$

$= 0.153 m$

OR 15 cm

6)



a) Block B:

$\Sigma F = 0$

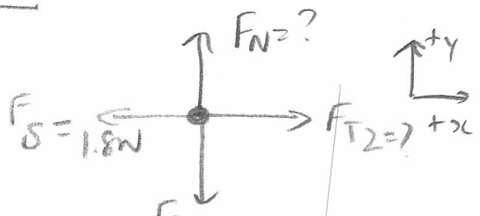
$\Sigma F = F_{T_1} - F_{g_B}$

$F_{T_1} - F_{g_B} = 0$

$F_{T_1} = F_{g_B}$

$F_{T_1} = 2.5N$

b) Block A:



x dir:

$\Sigma F_x = 0$

$\Sigma F_x = F_{T_2} - F_S$

$F_{T_2} = F_S$

$F_{T_2} = 1.8N$

y dir:

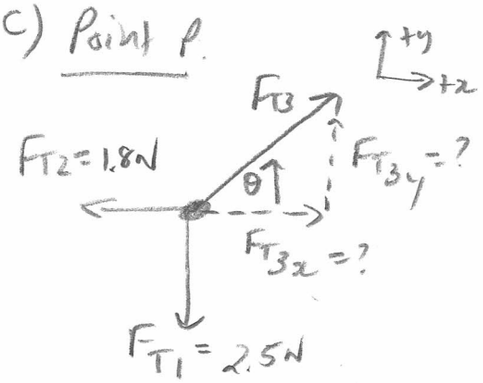
$\Sigma F_y = 0$

$\Sigma F_y = F_N - F_{g_A}$

$F_N = F_{g_A}$

$F_N = 6.7N$

c) Point P



x dir

$\Sigma F_x = 0$

$\Sigma F_x = F_{T_{3x}} - F_{T_2}$

$F_{T_{3x}} = F_{T_2}$

$= 1.8N$

y dir

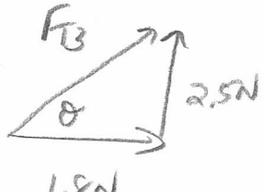
$\Sigma F_y = 0$

$\Sigma F_y = F_{T_{3y}} - F_{T_1}$

$F_{T_{3y}} = F_{T_1}$

$= 2.5N$

Combining components for F_{T_3}:



$F_{T_3} = \sqrt{1.8^2 + 2.5^2}$

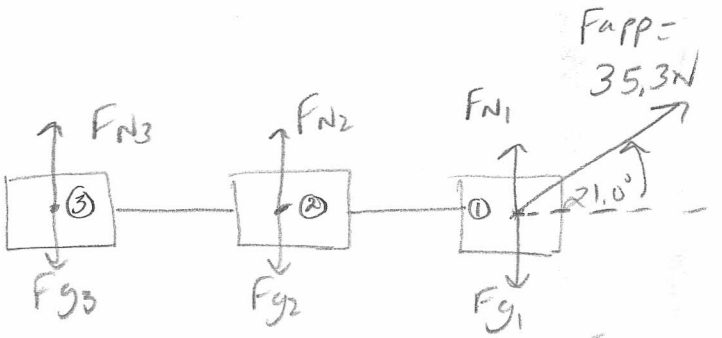
$= 3.08\ N$

$\theta = \tan^{-1}\left(\frac{2.5N}{1.8N}\right)$

$= 54.2°$

$\therefore$ $F_{T_3} = 3.1N$ [54° above horizontal]

7)



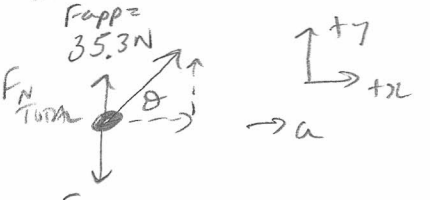
$m_3 = 16.1\ kg$ $\quad m_2 = 13.2 kg$ $\quad m_1 = 15.0 kg$

$a = ?$

$F_{12} = ?$

$F_{23} = ?$

a) Consider the system to find. acceleration.



$m_T = 16.1kg + 13.2kg + 15.0kg$

$= 44.3kg$

$\begin{cases} \Sigma F_x = m_T a \\ \Sigma F_x = F_{app}\cos\theta \end{cases}$

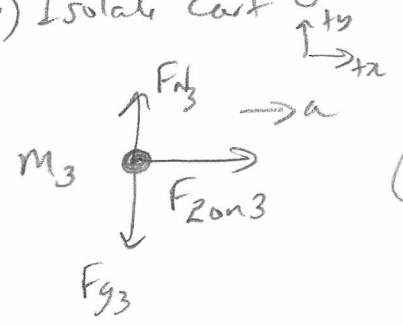
$m_T a = F_{app}\cos\theta$

$a = \dfrac{(35.3N)(\cos 21.0°)}{(44.3kg)}$

$a = 0.7439\ m/s^2$

$\boxed{a \simeq 0.744 m/s^2}$

b) Isolate cart 3



$\begin{cases} \Sigma F_x = m_3 a \\ \Sigma F_x = F_{2on3} \end{cases}$

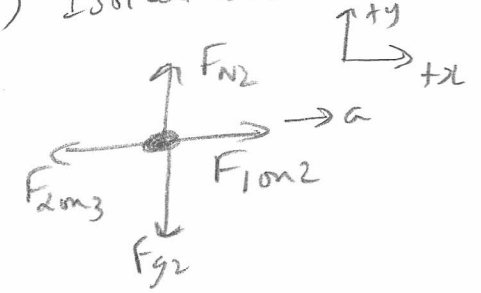
$F_{2on3} = m_3 a$

$= (16.1kg)(0.7439 m/s^2)$

$= 11.977\ N$

$\boxed{F_{2on3} \simeq 12.0 N}$

c) Isolate cart 2



$\begin{cases} \Sigma F_x = m_2 a \\ \Sigma F_x = F_{1on2} - F_{2on3} \end{cases}$

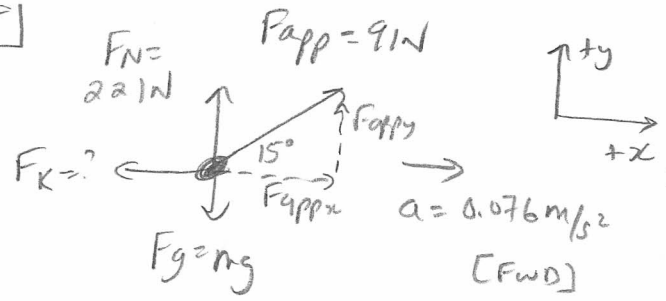
$F_{1on2} = m_2 a + F_{2on3}$

$= (13.2kg)(0.7439 m/s^2) + 11.977\ N$

$= 21.797\ N$

$\boxed{F_{1on2} \simeq 22.0 N}$

8]



F_K = ?
m = ?

x dir:

$$\begin{cases} \Sigma F_x = m a_x \\ \Sigma F_x = F_{appx} - F_K \end{cases}$$

$$F_{appx} - F_K = m a_x$$

Step 1

Solve for m using y direction forces:

y dir:

$$\begin{cases} \Sigma F_y = 0 \\ \Sigma F_y = F_N - F_g + F_{appy} \end{cases}$$

$$F_N - F_g + F_{appy} = 0$$

$$\therefore F_g = F_N + F_{appy}$$

$$mg = 221N + 91\sin 15$$

$$m = \frac{221N + 23.553N}{g}$$

$$m = \frac{244.56N}{(9.80\ m/s^2)}$$

$$\boxed{m = 24.954\ kg}$$

$$\boxed{m \approx 25\ kg}$$

Step 2: Solve for F_K using x direction conditions:

$$F_{appx} - F_K = m a_x$$

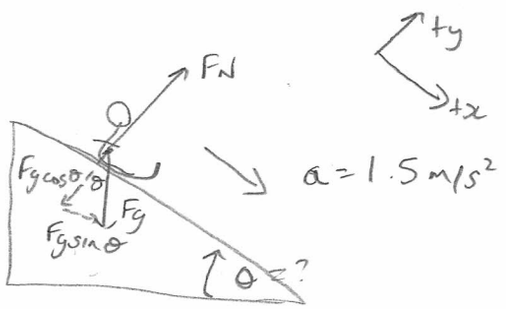
$$F_K = F_{appx} - m a_x$$

$$F_K = 91N\cos 15 - (24.954\ kg)(0.076 m/s^2)$$

$$\boxed{F_K = 86\ N}$$

∴ the chair mass is 25 kg. The force of friction on the chair is 86 N in magnitude.

9)



x dir:

$$\begin{cases} \Sigma F_x = ma \\ \Sigma F_x = F_g \sin\theta \end{cases}$$

$$mg\sin\theta = ma$$

$$\theta = \sin^{-1}\left(\frac{a}{g}\right)$$

$$\theta = \sin^{-1}\left(\frac{1.5\ m/s^2}{9.80\ m/s^2}\right)$$

$$\boxed{\theta = 8.8^\circ}$$

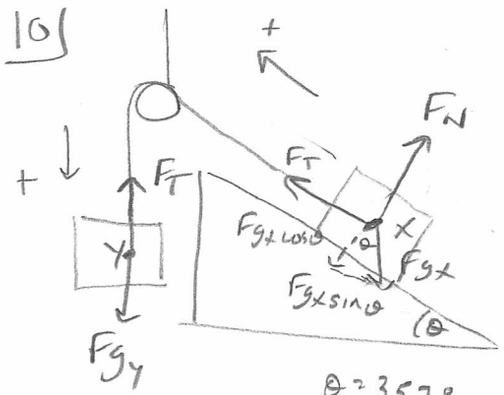
y dir:

$$\begin{cases} \Sigma F_y = 0 \\ \Sigma F_y = F_N - F_g\cos\theta \end{cases}$$

$$F_N = F_g\cos\theta$$

∴ the angle between the hill and the horizontal is 8.8°.

10)

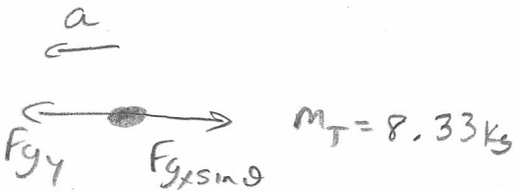


$m_X = 5.12\ kg$

$m_Y = 3.22\ kg$

a) System FBD

a = ?



$$\begin{cases} \Sigma F = m_T a \\ \Sigma F = F_{g_Y} - F_{g_X}\sin\theta \end{cases}$$

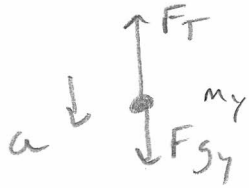
$$m_T a = m_Y g - m_X g\sin\theta$$

$$a = \frac{(3.22\ kg)(9.80\ N/kg) - (5.12\ kg)(9.80\ N/kg)(\sin 35.7^\circ)}{8.33\ kg}$$

$$\boxed{a = 0.273\ m/s^2}$$

∴ the blocks accelerate at $0.273\ m/s^2$ so that Y moves down and X moves up the ramp.

10 b) Isolate Block Y to find tension:



$\left\{ \begin{array}{l} \Sigma F = m_y a \\ \Sigma F = F_{g_y} - F_T \end{array} \right.$

$m_y g - F_T = m_y a$

$F_T = m_y g - m_y a$

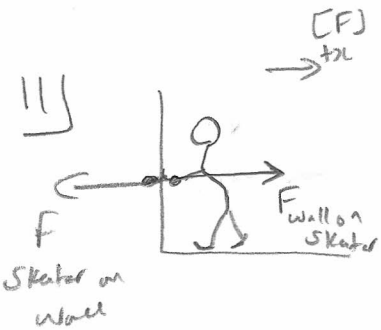
$F_T = (3.22\,kg)(9.80\,m/s^2 - 0.273\,m/s^2)$

$F_T = 30.676\,N$

$\boxed{F_T \simeq 30.7\,N}$

∴ the tension in the line is 30.7 N.

11)



$m = 56\,kg$

$\Delta t = 0.75\,s$

$\vec{v}_1 = 0.0\,m/s$

$\vec{v}_2 = 75\,cm/s\ [F] = 0.75\,m/s\ [F]$

a) $a = ?$ $\quad \vec{a} = \dfrac{\vec{v}_2 - \vec{v}_1}{\Delta t}$

$= \dfrac{0.75\,m/s - 0}{(0.75\,s)}$

$= 1.00\,m/s^2\ [F]$

b) $\vec{F}_{wall\ on\ skater} = ?$ $\quad \vec{F} = m\vec{a}$

$= (56\,kg)(1.00\,m/s^2\ [F])$

$\boxed{= 56\,N\ [F]}$

c) $\vec{F}_{skater\ on\ wall} = ?$

$\vec{F}_{skater\ on\ wall} = -\vec{F}_{wall\ on\ skater}$

$= -56\,N\ [F]$

$\boxed{= 56\,N\ [Backward]}$

d) $\Delta\vec{d}_T = ?$

acceleration phase → $\Delta\vec{d}_1 = ?$

constant velocity phase → $\Delta\vec{d}_2 = ?$

$\Delta\vec{d}_1 = \vec{v}_1 \Delta t + \frac{1}{2}\vec{a}\Delta t^2$

$= (0.0)^0(0.75\,s) + \frac{1}{2}(1.00\,m/s^2)(0.75\,s)^2$ [F]

$= 0.281\,m\ [F]$

$\Delta\vec{d}_2 = \vec{v}\Delta t$

$= (0.75\,m/s)(0.75\,s) = 0.562\,m\ [F]$

$\Delta\vec{d}_T = ?$

$= \Delta\vec{d}_1 + \Delta\vec{d}_2$

$= 0.2812\,m + 0.562\,m$

$= 0.844\,m\ [F]$

$\simeq 0.84\,m\ [F]$