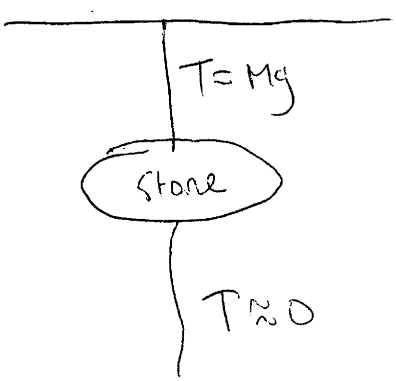
Homework #3

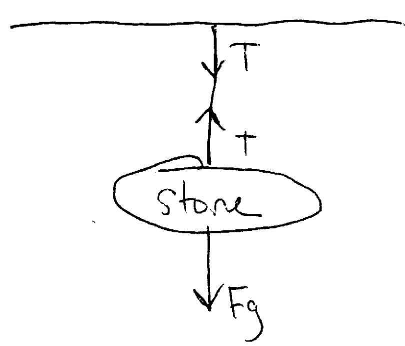
Ch #4

(Q#10) The string is likely to break where the tension in the string is the largest. With no one pulling on the bottom portion of the thread, the tension is larger in the upper portion and nearly zero in the lower portion ("dangling").

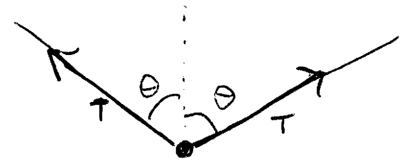
When you give a sharp tug, the force is initial applied to the bottom portion of the string. If the tug in sharp enough, the tension in the bottom portion of the string will exceed the maximum tolerance before force has time to "travel up" to the top part of the string (this has to do with the elasticity of the string and the speed of sound in the string). The string will break below the stone

If the pull is slow, then the force of the pull with be uniformly distributed on both sections of the string. In this case, the upper portion of the string will exceed the maximum tolerance first, and the string will break above the stone.





(Q#19) The tension along the entire rope is the same, equal to the force F



The upward component of the force on the backpack $2T\cos\theta$ is equal to the downward force of gravity.

Newton's First Law $\quad \Sigma F = 0 = 2T\cos\theta - mg$

The weight never changes so

$$T\cos\theta = \text{constant}$$

As θ increases (rope gets flatter), $\cos\theta$ gets smaller, so T must get bigger to compensate. Therefore, the force needs to be bigger the higher that backpack gets. The rope cannot be completely flat because there needs to be some vertical component of the force to balance the weight.

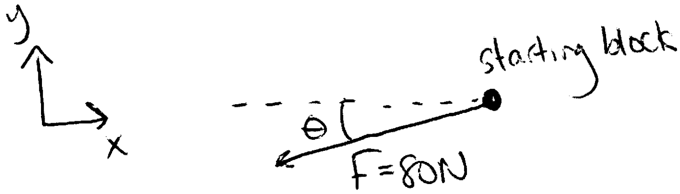
(P17) The thief should descend with an acceleration so that the force is $(57\,kg)(9.8\,m/s^2) = 558.6\,N$ on the rope

$$\Sigma F = ma = T_{rope} - mg$$

$$a \geq \frac{T_{rope}}{m} - g = \frac{558.6N}{65\,kg} - 9.8\,m/s^2$$

$$a \geq -1.2\,m/s^2$$

(P30)



a) $F_x = -F\cos\theta$

$F_{x\text{ on block}} = -F_{x\text{ on runner}}$ (Newton's 3rd Law)

$F_{x\text{ on runner}} = F\cos\theta = ma$

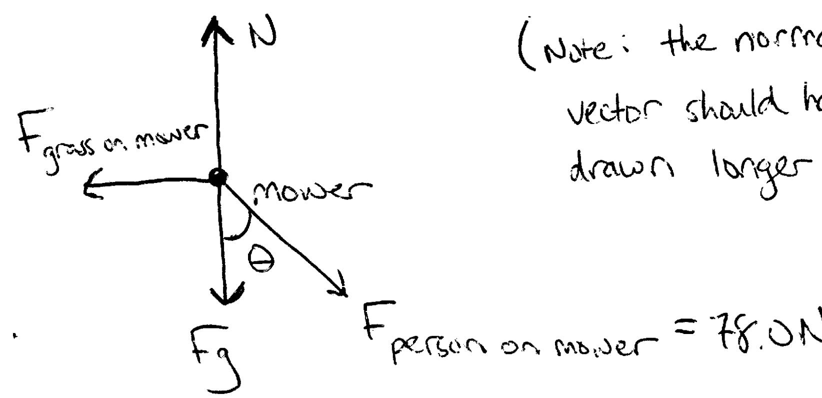
$a = \dfrac{F\cos\theta}{m} = \dfrac{(80N)\cos 22^\circ}{57\text{ kg}} = 1.3\ m/s^2$

b) $F_x = ma = m\dfrac{\Delta v}{\Delta t} \Rightarrow \Delta v = \dfrac{F_x \Delta t}{m}$

$\Delta v = \dfrac{F\cos\theta\ \Delta t}{m} = (1.3\,m/s^2)(0.34\,s) = 0.44\,m/s$

(P32)

a)



(Note: the normal force vector should have been drawn longer)

b) $F_{grass} = F_{person}\sin\theta$

$= (78.0N)\sin 45^\circ$

$= 55.2\ N$

c) $\Sigma F = ma = 0 = N - mg - F_{person}\cos\theta$

$N = mg + F_{person}\cos\theta$

$= (13.0\,kg)(9.8\,m/s^2) + (78.0\,N)(\cos 45°)$

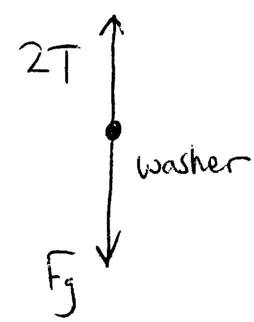
$N = 183\,N$

d) $\Sigma F = F_{person}\sin\theta - F_{grass} = ma$

$$F_{person} = \frac{ma + F_{grass}}{\sin\theta} = \frac{(13.0\,kg)\left(\frac{1.2\,m/s}{2.0\,s}\right) + 55.2\,N}{\sin 45°}$$

$F_{person} = 89\,N$

(P36)



a) $\Sigma F = 2T - F_g = 0$

$2T = mg = (58\,kg)(9.8\,m/s^2) = 570\,N$

$T = 280\,N$

b) $T' = 1.1\,T$

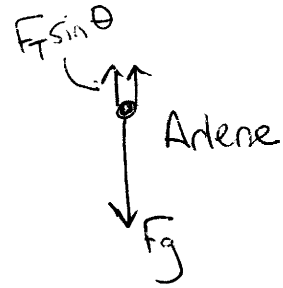
$2(1.1T) - mg = ma$

$$a = \frac{2.2T}{m} - g = \frac{2.2\,(280N)}{58\,kg} - 9.8\,m/s^2$$

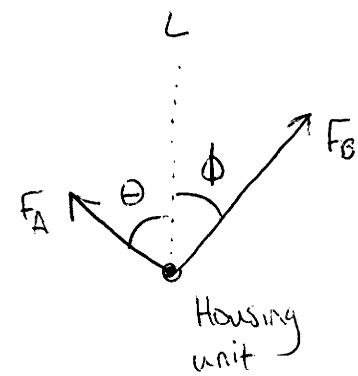
$a = 0.82\,m/s^2$

(P37) $\Sigma F = 2F_T \sin\theta - mg = ma = 0$

$$F_T = \frac{mg}{2\sin\theta} = \frac{(50.0\,kg)(9.8\,m/s^2)}{2\sin 10^\circ} = 1410\,N$$



(P39) Since the housing unit travels parallel to L, the horizontal components of the forces must cancel / balance.



$$F_A \sin\theta = F_B \sin\phi$$

$$F_B = \frac{F_A \sin\theta}{\sin\phi} = (4500\,N)\left(\frac{\sin 50^\circ}{\sin 30^\circ}\right)$$

$$F_B = 6900\,N$$

$\vec{F}_A + \vec{F}_B$ will lie along L, so only need to consider vertical components. (horizontal components are equal and opposite)

$$\vec{F}_A + \vec{F}_B = F_A\cos\theta + F_B\cos\phi = (4500N)\cos 50^\circ + 6900N\cos 30^\circ$$

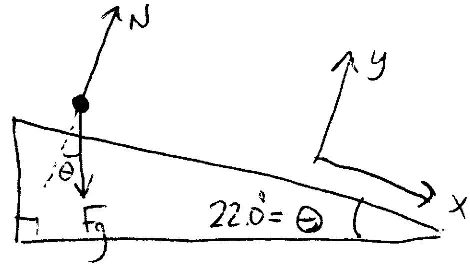
$$= 8900\,N$$

(P40) a) $\Sigma F_x = ma = F_g \sin\theta$

$\cancel{m}a = \cancel{m}g \sin\theta$

$a = (9.8\,m/s^2) \sin 22.0°$

$a = 3.67\,m/s^2$



b) $\sin\theta = \frac{h}{d} \Rightarrow d = \frac{h}{\sin\theta}$

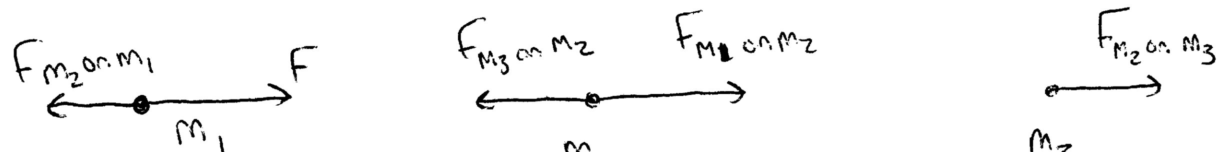
$v_f^2 = \cancel{v_i^2}^{\,0} + 2ad \Rightarrow v_f = \sqrt{2ad}$

$v_f = \sqrt{\frac{2ah}{\sin\theta}} = \sqrt{\frac{2(3.67\,m/s^2)(12.0\,m)}{\sin 22°}}$

$v_f = 15.3\,m/s$

(P46)

a)



(Note: scaling different for each diagram)

b) $F = ma \Rightarrow a = \frac{F}{m_1 + m_2 + m_3} = \frac{96.0\,N}{3(12.0\,kg)} = 2.7\,m/s^2$

c)

$(F_{net})_{m_1} = m_1 a = (12.0\,kg)(2.7\,m/s^2) = 32\,N$

$(F_{net})_{m_1} = (F_{net})_{m_2} = (F_{net})_{m_3}$

d) $(\Sigma F)_{m_1} = F - F_{m_2 \text{ on } m_1}$

$F_{m_2 \text{ on } m_1} = F - (F_{net})_{m_1} = 64N$; $|F_{m_2 \text{ on } m_1}| = |F_{m_1 \text{ on } m_2}|$

$(\Sigma F)_{m_2} = F_{m_1 \text{ on } m_2} - F_{m_3 \text{ on } m_2}$

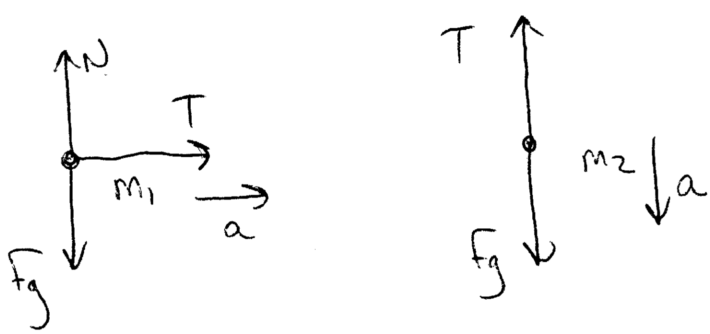
$F_{m_3 \text{ on } m_2} = F_{m_1 \text{ on } m_2} - (F_{net})_{m_2} = 32\ N$

$|F_{m_2 \text{ on } m_3}| = |F_{m_3 \text{ on } m_2}|$

$(\Sigma F)_{m_3} = F_{m_2 \text{ on } m_3} = 32\ N \rightarrow$ Good, we're consistant See part c

e) Numerical answers already given

(P47) a)



b) The acceleration will be the same for both boxes

$-m_2 a = T - m_2 g$ $\longrightarrow T = m_1 a$

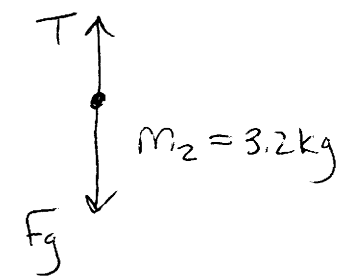
$m_1 a = T$ $\quad T = \left(\frac{m_1 m_2}{m_1 + m_2}\right) g$

$\rightarrow -m_2 a = m_1 a - m_2 g$

$a(m_2 + m_1) = +m_2 g$

$a = \left(\frac{m_2}{m_1 + m_2}\right) g$

(P50) $\sum F_{m_2} = T - m_2 g = -m_2 a$



While m_2 is falling, the acceleration of the blocks are the same.

$$\sum F_{m_1} = T - m_1 g = +m_1 a$$

$$T = m_1 a + m_1 g = m_1 (a+g)$$

$$-m_2 a = m_1(a+g) - m_2 g$$

$$-m_2 a = m_1 a + m_1 g - m_2 g$$

$$-(m_1 + m_2) a = (m_1 - m_2) g$$

$$a = \left(\frac{m_2 - m_1}{m_1 + m_2}\right) g = \frac{(3.2\,kg - 2.2\,kg)}{(3.2\,kg + 2.2\,kg)} (9.8\,m/s^2) = 1.8\,m/s^2$$

$$v_f^2 = 2a\Delta y$$

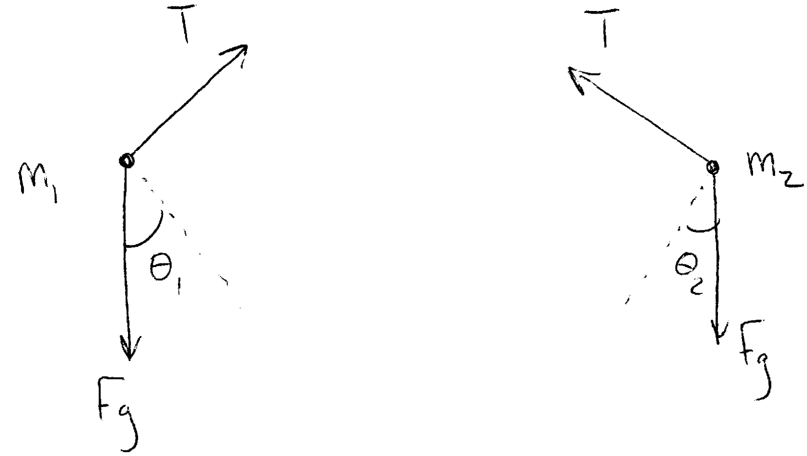
$$v_f = \sqrt{2(1.8\,m/s^2)(1.80\,m)} = 2.5\,m/s$$

$$\cancel{v_f^2}^{\,0} = v_i^2 - 2gh$$

$$\frac{v_i^2}{2g} = h = \frac{(2.5\,m/s)^2}{2(9.8\,m/s^2)} = 0.32\,m$$

final height $= 2(1.80\,m) + 0.32\,m =$ 3.92 m

(P68)



Let's call m_1 sliding downward a positive acceleration

$$m_1 a = m_1 g \sin\theta_1 - T \qquad\qquad m_2 a = T - m_2 \sin\theta_2 \, g$$

$$T = m_1 g \sin\theta_1 - m_1 a$$

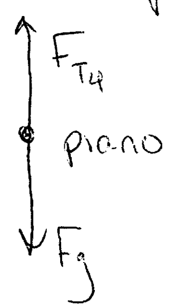
$$m_2 a = m_1 g \sin\theta_1 - m_1 a - m_2 g \sin\theta_2$$

$$(m_1 + m_2) a = (m_1 \sin\theta_1 - m_2 \sin\theta_2) g$$

$$a = \left(\frac{m_1 \sin\theta_1 - m_2 \sin\theta_2}{m_1 + m_2} \right) g$$

(#75) The force diagrams for the pulleys look like:

a) The tension in rope 4 is equal to the weight of the piano in equilibrium. So:



$$F_{T_4} = F_{T_1} + F_{T_2} = Mg$$

$$F_{T_1} = F_{T_2} = \frac{Mg}{2}$$

Since the tension along the whole rope is the same, then if a force $F > \frac{Mg}{2}$ will cause the piano to accelerate

b) Assuming $(a=0)$, we already know $F_{T_4} = Mg$,

$F_{T_1} = F_{T_2} = \frac{Mg}{2}$, $F = \frac{Mg}{2}$

So $F_{T_3} = F_{T_2} + F_{T_1} + F = \frac{3Mg}{2}$