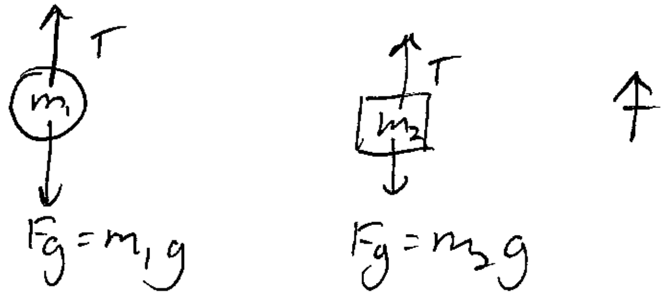
Physics 1A03
Assignment 3 solutions

1.



$m_1 = 3.15\,kg$
$m_2 = 5.30\,kg$
$g = 9.8\,m/s^2$

because $m_2 > m_1$, m_1 will go $\downarrow$ and m_1 will go $\uparrow$.
therefore:

$m_1: T > F_g$

$F_{net_1} = T - F_g$

① $m_1 a = T - m_1 g$

$m_2: F_g > T$

$F_{net} = F_g - T$

$m_2 a = m_2 g - T$

② $T = m_2 g - m_2 a$

we can substitute ② into ① to find a:

$$m_1 a = (m_2 g - m_2 a) - m_1 g$$
$$m_1 a + m_2 a = m_2 g - m_1 g$$
$$a = \frac{g(m_2 - m_1)}{(m_1 + m_2)}$$
$$= \frac{(9.8\,m/s^2)(5.30\,kg - 3.15\,kg)}{(3.15\,kg + 5.30\,kg)}$$
$$a = 2.49\,m/s^2$$

the magnitude of the acceleration is $2.49\,m/s^2$.

we can substitute the acceleration into either ① or ② above to find T.

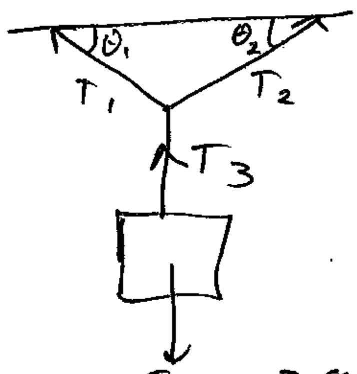
$$\text{①}\quad m_1 a = T - m_1 g$$
$$T = m_1 a + m_2 g$$
$$= m_1 (a + g)$$
$$= (3.15\,\text{kg})(2.49\,\text{m/s}^2 + 9.8\,\text{m/s}^2)$$
$$= 38.7\,\text{N}$$

we can now find the displacement from rest:

$v_i = 0\,\text{m/s}$ $\quad a = 2.49\,\text{m/s}^2$ $\quad \Delta t = 1.27\,\text{s}$ $\quad \Delta d = ?$

$$\Delta d = v_i \Delta t + \tfrac{1}{2} a \Delta t^2$$
$$= 0 + \tfrac{1}{2}(2.49\,\text{m/s}^2)(1.27\,\text{s})^2$$
$$= 2.01\,\text{m}$$

2.



$F_g = 295\,\text{N}$

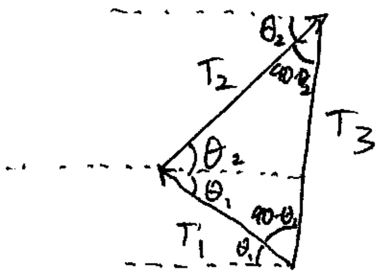
since the cement is in equilibrium:

$$F_{net} = 0$$
$$= T_3 - F_g$$
$$T_3 = F_g$$
$$= 295\,\text{N}$$

since we can see that:

$$T_1 + T_2 = T_3$$

let's redraw:



$\theta_1 = 59.4°$

$\theta_2 = 22.5°$

we can use the law of sines to solve for T_1 and T_2.

$$\frac{T_1}{\sin(90-\theta_2)} = \frac{T_2}{\sin(90-\theta_1)} = \frac{T_3}{\sin(\theta_1+\theta_2)}$$

$$\frac{T_3}{\sin(\theta_1+\theta_2)} = \frac{295}{\sin(59.4+22.5)}$$

$$= 297.97$$

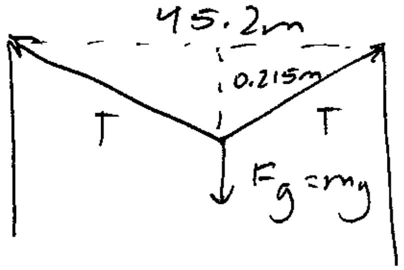
$$297.97 = \frac{T_1}{\sin(90-\theta_2)}$$

$$T_1 = 275.29 N$$

$$297.97 = \frac{T_2}{\sin(90-\theta_1)}$$

$$T_2 = 151 N$$

3.

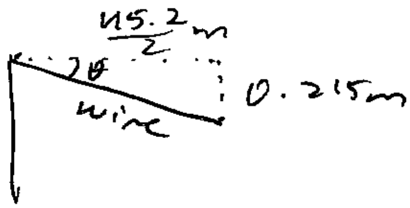


$m = 1.02\,kg$

$g = 9.8\,m/s^2$

tension is the same at all points in the wire.

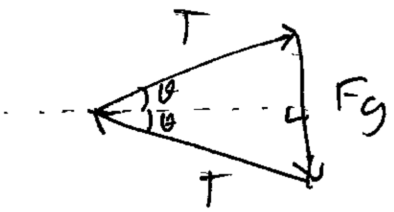
first, let's find the angle the wire makes with the horizontal:



$$\tan\theta = \frac{0.215\,m}{22.6\,m}$$

$$\theta = 0.545^\circ$$

we can now redraw the force vectors:



* this is an isoceles triangle!

$$\sin\theta = \frac{\frac{F_g}{2}}{T}$$

$$T = \frac{\frac{mg}{2}}{\sin\theta}$$

$$= \frac{(1.02\,kg)(9.8\,m/s^2)}{2(\sin(0.545^\circ))}$$

$$= 525.4\,N$$

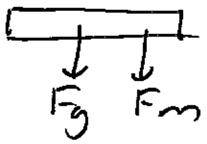
4.

a) force of lower magnet on upper is equal and opposite to force of upper on lower, which is 2.44x its weight.

$$F = 2.44 \times 2.72\,N$$
$$= 6.64\,N$$

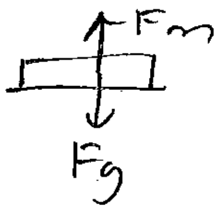
b) same as a)

c) normal force opposes downward forces exerted on upper magnet:



$$F_{net} = F_g + F_m$$
$$= (2.72N) + (2.44 \times 2.72N)$$
$$= 9.36\,N$$

d) normal force opposes net upwards force of lower magnet:



$$F_{net} = F_m - F_g$$
$$= (2.72 \times 2.44) - 2.72$$
$$= 3.92\,N$$

e) normal force opposes F_g of entire system (table + magnets)

$$F_g = W_{table} + W_{magnets}$$
$$= 18.4 + (2.72 \times 2)$$
$$= 23.8\,N$$

$$F_N = 23.8\,N$$

5. if speed is increasing, that means the train is accelerating and $F_{net} \neq 0$.

let's convert the mass to SI first:

$$14400 \cancel{\text{met. tons}} = \frac{1000\,kg}{1\,\cancel{ton}}$$

$$= 1.44 \times 10^7\,kg$$

$$F_{net} = ma$$

$$7.59 \times 10^5\,N = (1.44 \times 10^7\,kg)\,a$$

$$a = 0.0527\,m/s^2$$

let's convert 70.1 km/hr to m/s now:

$$\frac{70.1\,km}{1\,hr} \times \frac{1\,hr}{3600\,s} \times \frac{1000\,m}{1\,km} = 19.47\,m/s$$

$v_i = 0$ $\quad v_f = 19.47\,m/s$ $\quad a = 0.0527\,m/s^2$ $\quad \Delta t = ?$

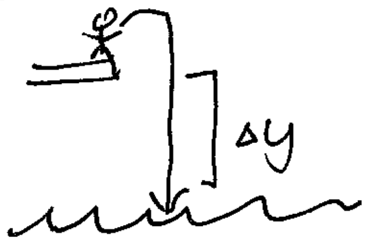
$$v_f = v_i + a\Delta t$$

$$19.47\,m/s = 0 + (0.0527\,m/s^2)\,\Delta t$$

$$\Delta t = 369.5\,s$$

6. if force was exerted on him in the water, then what was his acceleration?

to find that, we need to first find his speed entering the water.



$\Delta y = -8.84\,m$
$a = -9.8\,m/s^2$
$v_i = 0$
$v_f = ?$

$$v_f^2 = v_i^2 + 2a\Delta y$$
$$= 0 + 2(-9.8\,m/s^2)(-8.84\,m)$$
$$= 173.3$$
$$v_f = 13.2\,m/s \quad \text{downwards}$$

now what about in the water?

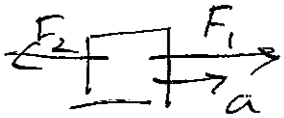
$v_i = -13.2\,m/s \quad v_f = 0 \quad \Delta t = 2.00\,s \quad a = ?$

$$v_f = v_i + a\Delta t$$
$$0 = (-13.2\,m/s) + a(2.00\,s)$$
$$a = 6.6\,m/s^2$$

now we can find the force exerted on him:

$$F_{net} = ma$$
$$= (72.1\,kg)(6.6\,m/s^2)$$
$$= 475.86\,N$$

7.



$F_1 = 27.84 N$

$m = 0.64 kg$

a) if $a = 9.7 m/s^2$:

$F_{net} = ma$

$F_1 - F_2 = ma$

$27.84N - F_2 = (0.64 kg)(9.7 m/s^2)$

$F_2 = 21.632 N$

b) if $a = 0$ $\quad F_{net} = 0$

$F_1 = F_2$

$= 27.84 N$

c) if $a = -9.28 m/s^2$

$F_{net} = ma$

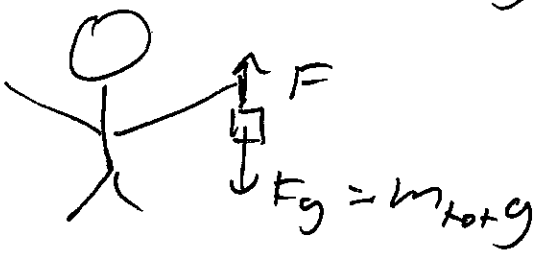
$F_1 - F_2 = ma$

$27.84N - F_2 = (0.61 kg)(-9.28 m/s^2)$

$F_2 = 33.5 N$

8. Let's consider the system as a whole:

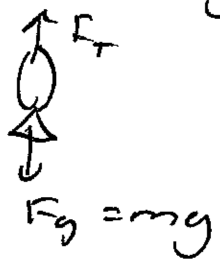
$$m_{tot} = 3.40\,kg + 2.42\,kg$$
$$= 5.82\,kg$$



Note: The question does not state that there is no acceleration!! (that makes this question a bit more tricky)

$$F_{net} = ma$$
$$F - mg = ma$$
$$a = \frac{F - mg}{m}$$
$$= \frac{(83.8N) - (5.82\,kg)(9.8\,m/s^2)}{5.82\,kg}$$
$$= 4.60\,m/s^2$$

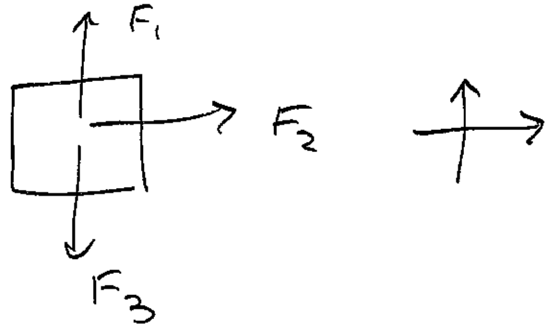
and now we can consider the steel hat separately:



$m = 3.40\,kg$

$$F_{net} = ma$$
$$F_T - F_g = ma$$
$$F_T = ma + F_g$$
$$= ma + mg$$
$$= m(a+g)$$
$$= (3.40\,kg)((4.60\,m/s^2) + (9.8\,m/s^2))$$
$$= 48.96\,N$$

9.



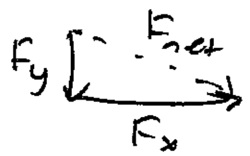
$F_1 = 10.7N$
$F_2 = 20.2N$
$F_3 = -14.9N$

let's add up the x and y components:

x-axis:
$F_{1x} = 0$
$F_{2x} = 20.2N$
$F_{3x} = 0$
$F_x = 20.2N$

y-axis:
$F_{1y} = 10.7N$
$F_{2y} = 0N$
$F_{3y} = -14.9N$
$F_y = -4.2N$

now we can add them together to find F_{net}:

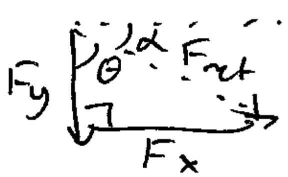


$$F_{net} = \sqrt{F_x^2 + F_y^2}$$
$$= \sqrt{(20.2)^2 + (-4.2)^2}$$
$$= 20.63N$$

now that we have the net force, we can find acceleration.

$F_{net} = ma$
$20.63N = (3.87kg)a$
$a = 5.33\ m/s^2$

to find the angle:



$$\tan\theta = \frac{F_x}{F_y} = \frac{20.2}{4.2} = 78.3$$

$\alpha = 90° - \theta$
$= 11.7°$ below the horizontal.

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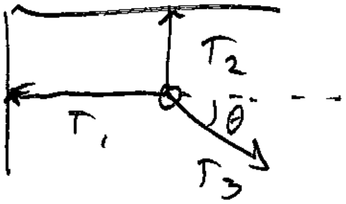
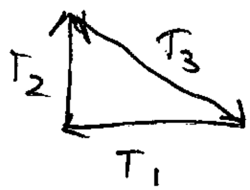


$F_{net} = 0$
$T_1 = 50.3N$
$T_2 = 88.4N$
$T_3 = ?$

the rope lengths are irrelevant information since we're merely dealing with forces.

let's redraw the vectors:



$$F_{net} = 0 = T_1 + T_2 + T_3$$

so:

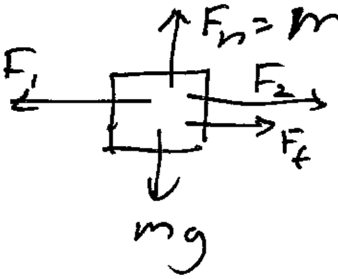
$$T_3 = T_1 + T_2$$

since T_1 and T_2 are at right angles, we don't need to split them into components.

$$T_3 = \sqrt{T_1^2 + T_2^2}$$
$$= \sqrt{50.3^2 + 88.4^2}$$
$$= 101.71N$$

11. since $m_1 > m_3$, the blocks will move to the left.

a) to find the acceleration, let's consider the forces acting on m_2



$$F_{net} = F_1 - F_2 - F_f$$

F_1 and F_2 are the forces exerted by gravity on m_1 and m_2 respectively.

$$F_{net} = m_1 g - m_2 g \cdot \mu k - m_3 g$$

$$\cancel{= (4.12kg)(9.8m/s^2) - (1.16kg)(9.8m/s^2)(0.34) - (g}$$

$$= (4.12kg)(9.8m/s^2) - (1.16kg)(9.8m/s^2)(0.34) - (2.02kg)(9.8m/s^2)$$

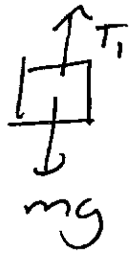
$$= 16.714N$$

$$m_{tot} a = 16.714N$$

$$a = \frac{16.714}{(4.12 + 1.16 + 2.02)}$$

$$= 2.29 \, m/s^2$$

b) since we know the acceleration:

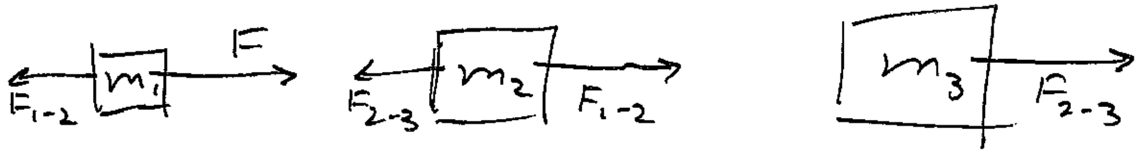


$$F_{net} = m_1 a$$
$$F_g - F_T = m a$$
$$F_T = F_g - m_1 a$$
$$= m_1 g - m_1 a$$
$$= m_1 (g - a)$$
$$= (4.12 kg)(9.8 m/s^2 - 2.29 m/s^2)$$
$$= 30.94 N$$

b) same thing:

$$F_{net} = m_2 a$$
$$F_T - F_g = m_2 a$$
$$F_T = m_2 a + m_2 g$$
$$= m_2 (a + g)$$
$$= (2.02 kg)(2.29 m/s^2 + 9.8 m/s^2)$$
$$= 24.42 N$$

12.



a) $F = m_{net}a$

$$a = \frac{F}{m_{net}}$$

$$= \frac{20.2N}{(2.03kg + 3.40kg + 3.86kg)}$$

$$= 2.17\ m/s^2$$

b) $F_{net} = m_1 a$

$$= 2.03\ kg \cdot 2.17 m/s^2$$

$$= 4.41N$$

c) $F_{net} = m_2 a$

$$= 3.40\ kg \cdot 2.17 m/s^2$$

$$= 7.39N$$

d) $F_{net} = m_3 a$

$$= 3.86\ kg \cdot 2.17 m/s^2$$

$$= 8.38N$$

e) $F_{net} = F - F_{1-2}$

$$4.41N = 20.2N - F_{1-2}$$

$$F_{1-2} = 20.2 - 4.41$$

$$= 15.79N$$

f) $F_{\cancel{net}} = F_{1-2} - F_{2-3}$

$$7.39N = 15.79 - F_{2-3}$$

$$F_{2-3} = 8.4\ N$$

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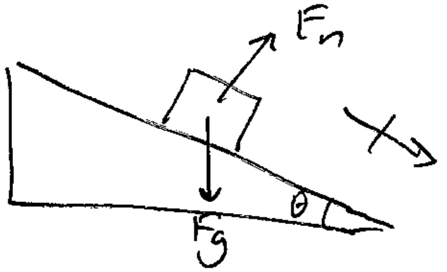
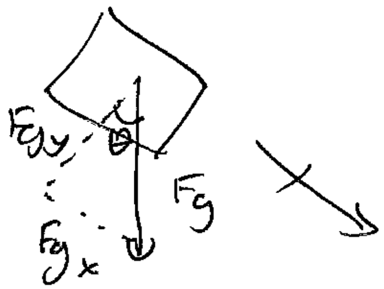


$\theta = 15.9°$

a) $F_{net} = ma$

the only force acting on the block in the horizontal axis is the horizontal component of gravity. let's take a closer look:



$F_{net} = F_{gx}$

$= mg \sin\theta$

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

$a = g\sin\theta$

$= (9.8 m/s^2)\sin(15.9°)$

$= 2.68 m/s^2$

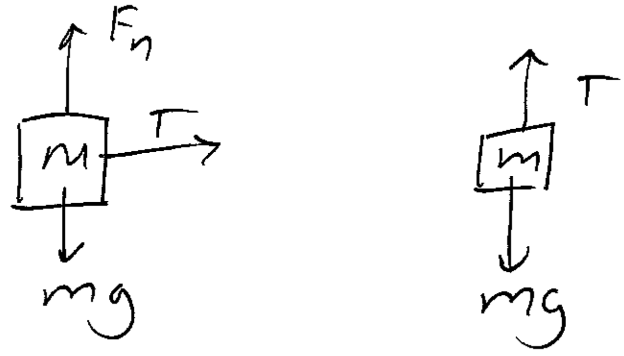
b) $v_i = 0$ $v_f = ?$ $a = 2.68 m/s^2$ $\Delta d = 1.91 m$

$v_f^2 = v_i^2 + 2a\Delta d$

$= 0 + 2(2.68 m/s^2)(1.91 m)$

$v_f = 3.20 m/s$

14.



a) m:

$$F_{net} = ma - T$$
$$ma = mg - T$$
$$T = mg - ma \qquad (1)$$

M:

$$F_{net} = T$$
$$Ma = T \qquad (2)$$

so:

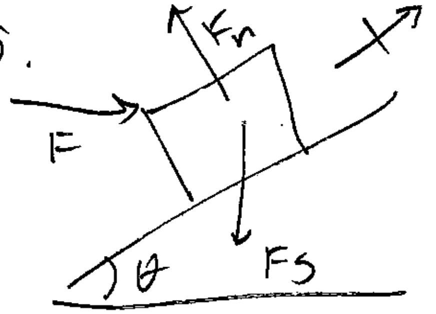
$$(1) = (2)$$
$$mg - ma = Ma$$
$$mg = Ma + ma$$
$$= a(M + m)$$
$$a = \frac{mg}{M+m}$$
$$= \frac{(1.06\,kg)(9.8\,m/s^2)}{(6.43\,kg + 1.06\,kg)}$$
$$= 1.39\,m/s^2$$

b) they're connected, so a is the same.

c) we can sub a back in to (2):

$$Ma = T$$
$$(6.43\,kg)(1.39\,m/s^2) = T$$
$$T = 8.94\,N$$

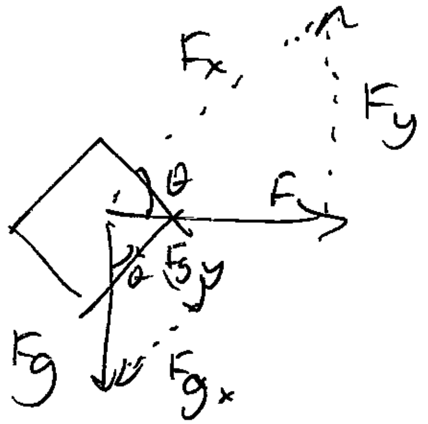
15.



$\theta = 21°$

$F_{net} = 0$

a) the forces acting in the x-axis are the x-components of F_g and F.



$$F_g \sin\theta = F\cos\theta$$

$$mg\sin 21 = F\cos 21$$

$$F = \frac{mg\sin 21}{\cos 21}$$

$$= \frac{(71.6\,kg)(9.8\,m/s^2)\sin 21}{\cos 21}$$

$$= 269.3\,N$$

b) normal force acts opposite all downwards forces acting on the block.

so:

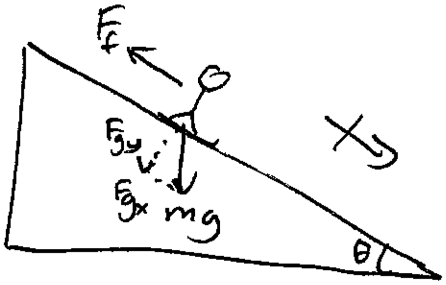
$$F_N = F_{gy} + F_y$$

$$= mg\cos\theta + F\sin\theta$$

$$= (71.6\,kg)(9.8\,m/s^2)\cos 21 + (269.3\,N)\sin 21$$

$$= 751.58\,N$$

16.



$\theta = 4.52°$
$\mu_k = 0.171$

a) to find the stopping distance, we need to find the acceleration.

$$F_{net} = F_{gx} - F_f$$

vertical component of F_g

$$= mg\sin\theta - F_n \cdot \mu_k$$
$$\cancel{m}a = \cancel{m}g\sin\theta - \cancel{m}g\cos\theta \cdot \mu_k$$
$$a = g(\sin\theta - \cos\theta \cdot \mu k)$$
$$\cancel{= 0.898 m/s^2}$$
$$= (9.8 m/s^2)(\sin 4.52 - \cos 4.52 \cdot (0.171))$$
$$= -0.8983 m/s^2$$

now we can find the stopping distance:

$a = -8.98 m/s^2$ $v_i = 16.2 m/s$ $v_f = 0 m/s$ $\Delta d = ?$

$$v_f^2 = v_i^2 + 2a\Delta d$$
$$0 = (16.2 m/s)^2 + 2(-0.8983 m/s^2)\Delta d$$
$$\Delta d = 146.1 m$$

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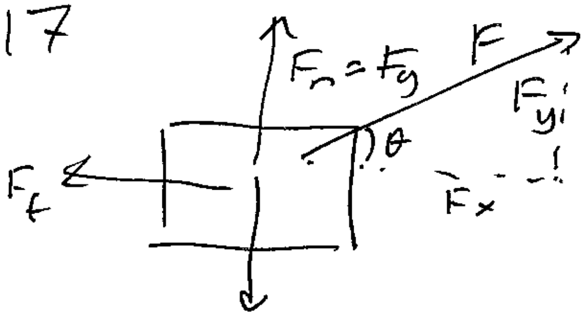

$F_g = mg$

constant speed, so $F_{net} = 0$

$F_{net} = F_x - F_f$

$F_x = F_f$

$= 21.5 N$

$F\cos\theta = 21.5$

$\cos\theta = \frac{21.5}{F}$

$= \frac{21.5}{3\cancel{5}.3 N}$

$\theta = 52.5°$