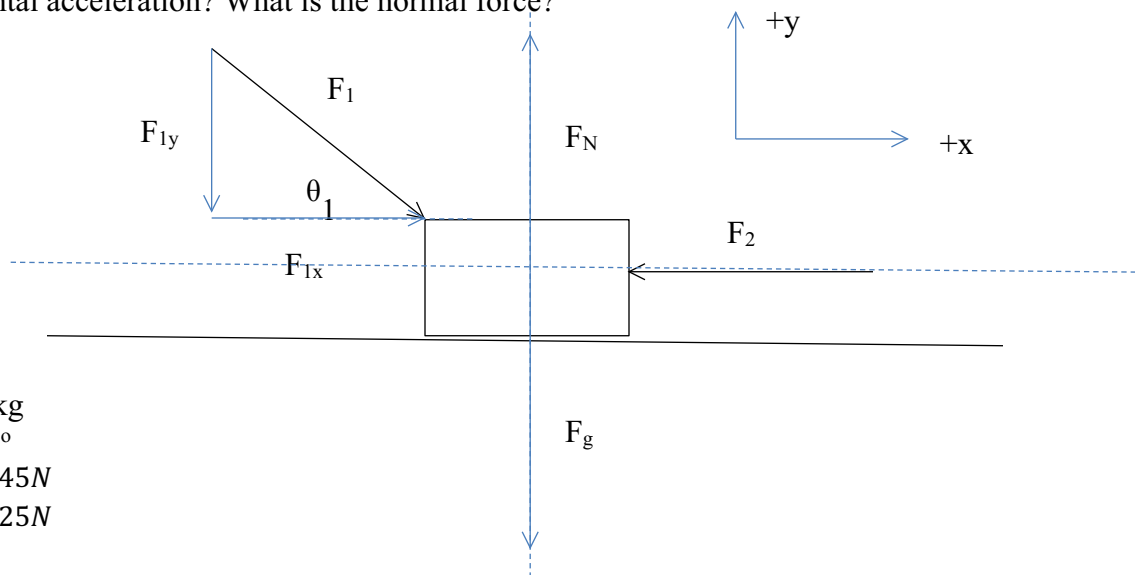Forces Review Answer Sheet

Review problems

1. Two forces, F_1 and F_2, act on a 5 kg block as shown. The plane is frictionless. The magnitude of F_1 is 45 N and the magnitude of $F_2 = 25$ N. What is the magnitude and direction of the horizontal acceleration? What is the normal force?

m = 5 kg
$\theta_1 = 65^\circ$
$|F_1| = 45N$
$|F_2| = 25N$

$|F_g| = mg$ $|F_{1x}| = |F_1|cos\theta_1$ $|F_{1y}| = |F_1|sin\theta_1$
$|F_g| = (5\ kg)(9.8\frac{N}{kg})$ $|F_{1x}| = 45N\ cos\ 65$ $|F_{1y}| = 45N\ sin\ 65$
$|F_g| = 49\ N$ $|F_{1x}| = 19.0\ N$ $|F_{1y}| = 40.8\ N$

a) $F_{Net,x} = ma_x$
$|F_{1x}| - |F_2| = ma_x$
19.0 N – 25 N = 5 kg a_x
-6 N = 5 kg a_x
A_x = -1.2 m/s^2 (so 1.2 m/s^2 to the left)

b) $F_{Net,\ y} = ma_y$
$|F_n| - |F_g| - |F_{1y}| = m\ a_y$ 0
$|F_n| - 49N - 40.8\ N = 0$
$|F_n| = 89.8\ N$

2. Two skaters, an 82 kg man and a 48 kg woman, are standing on ice. Neglect any friction between the skate blades and the ice. The woman pushes the man with a force of 45 N due east. Determine the direction and magnitude of the accelerations of both the man and the woman.
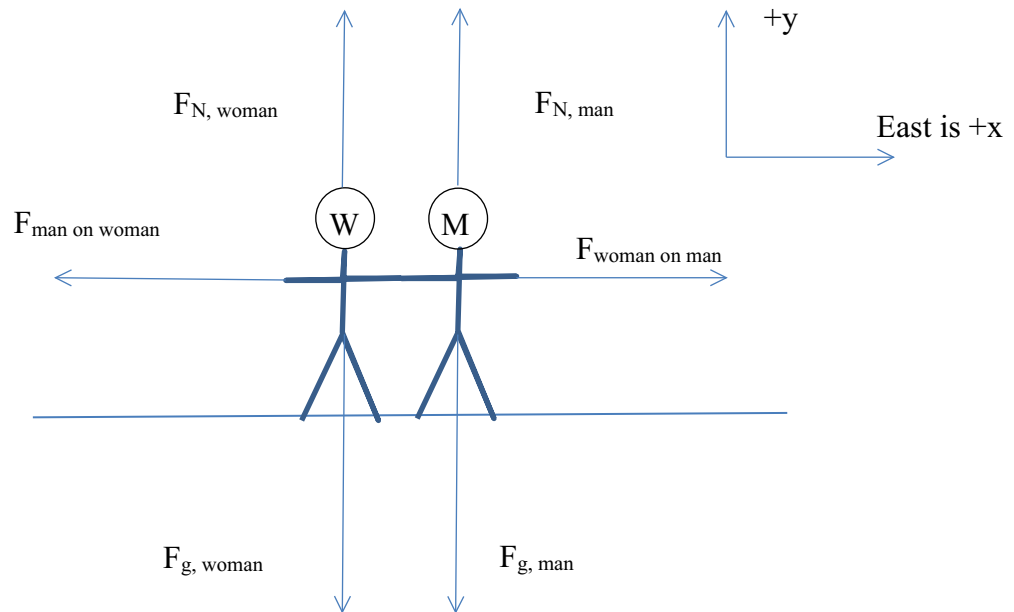
Because of Newton's Third Law, $F_{\text{woman on man}}$ as $F_{\text{man on woman}}$

$m_{\text{man}} = 82$ kg
$m_{\text{woman}} = 48$ kg
$\left| F_{woman\ on\ man} \right| = \left| F_{man\ on\ woman} \right| = 45N$

Therefore

$F_{Net,x,\ woman} = m_{woman} a_{x,\ woman}$
$0 - \left| F_{man\ on\ woman} \right| = m_{woman} a_{x,woman}$
- 45N = 48 kg a_{woman}
-0.94 m/s² = a_{woman}

$F_{Net,x,\ man} = m_{man} a_{x,\ man}$
$+ \left| F_{woman\ on\ man} \right| - 0 = m_{man} a_{x,\ man}$
45 N = 82 kg a_{man}
+0.55 m/s² = a_{man}

Notice that same force but two totally different results.

3. A water skier of mass 49 kg is being pulled due south by a horizontal towrope. The rope exerts a force of 228 N due south. The water and air combined exert a combined resistive force of 165 N that is directed due north. What is the direction and magnitude of the acceleration of the skier?
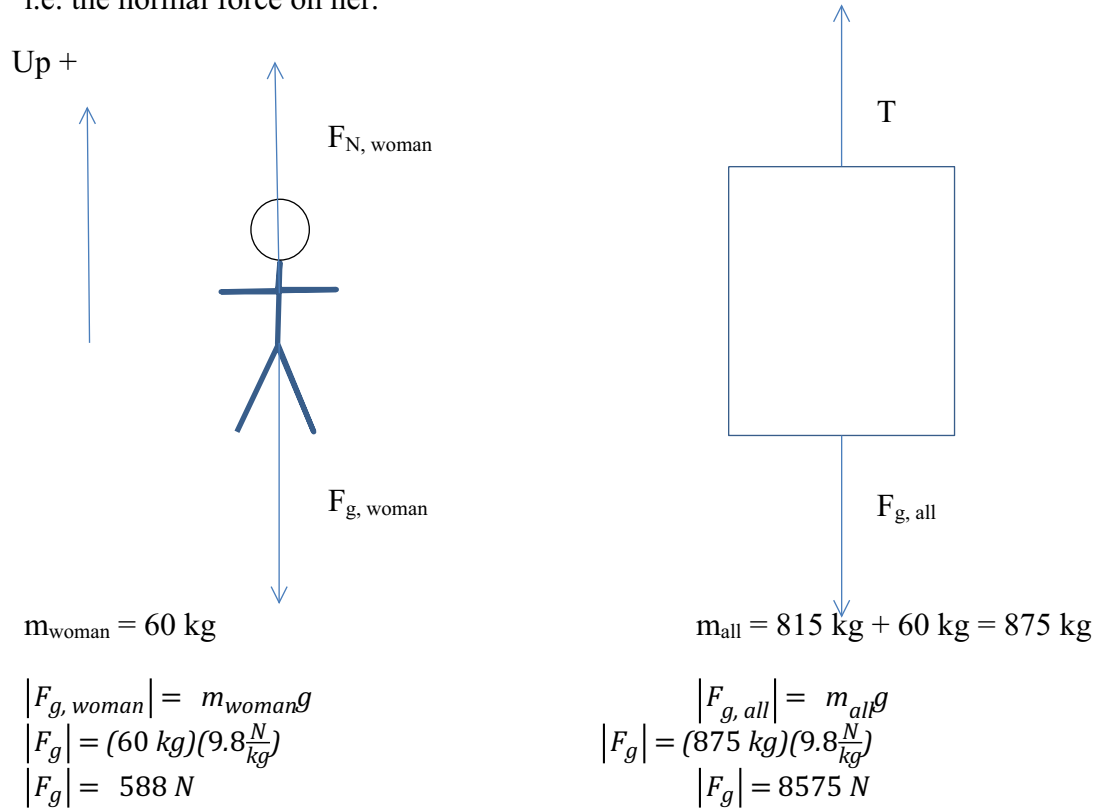
$+y$

F_N

South is $+x$

F_R

T

m = 49 kg
$|T| = 228\ N$
$|F_R| = 165\ N$

F_g
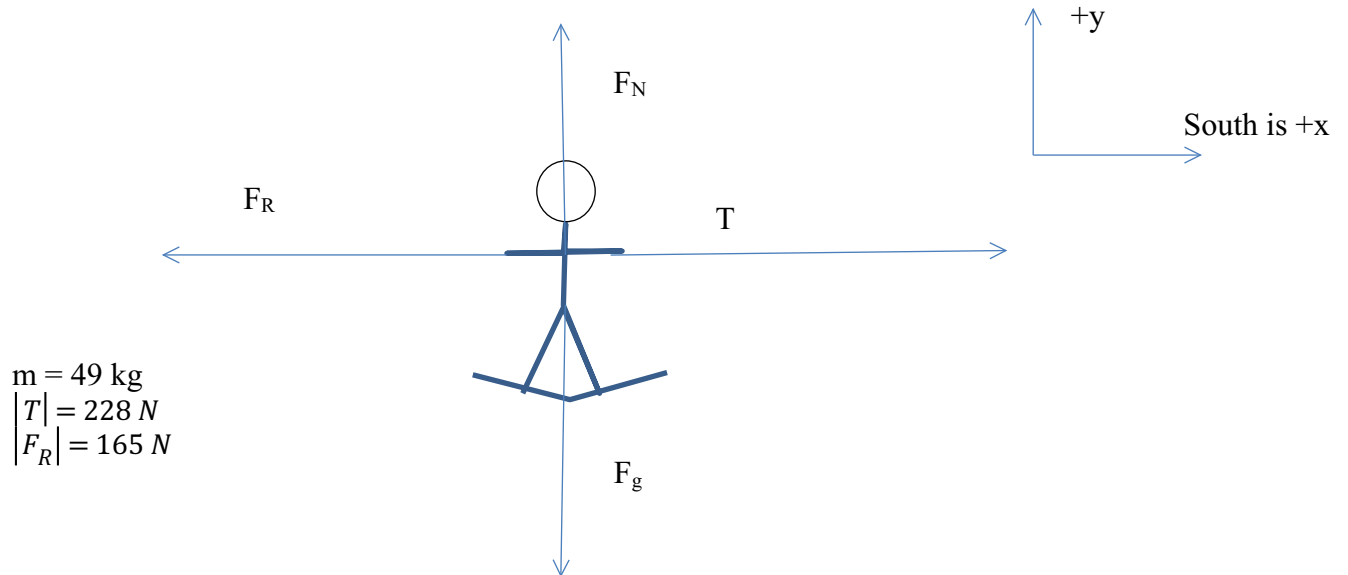
$F_{Net,x} = ma_x$
$|T| - |F_R| = ma_x$
228 N - 165 N = 49 kg a_x
63 = 49 a_x
$a_x = 1.29\ m/s^2$ (therefore north)

4. A woman stands on a scale in a moving elevator. Her mass is 60 kg and the mass of the elevator and scale is 815 kg. Starting from rest, the elevator begins accelerating upward. During this acceleration, the tension on the cable supporting the elevator is 9410 N. What is the reading on the scale during the acceleration?

There are two relevant masses in this problem, the woman and the whole system so we need two separate free body diagrams. Since we know the tension on the elevator and the mass of the elevator, we can use that to find the acceleration of the elevator. Being that the woman is in the elevator, she will have the same acceleration. The question asks us for the reading on the scale, i.e. the normal force on her.

Up +

$F_{N, woman}$

$F_{g, woman}$

T

$F_{g, all}$

$m_{woman} = 60$ kg

$m_{all} = 815$ kg $+ 60$ kg $= 875$ kg

$\left|F_{g, woman}\right| = m_{woman}g$
$\left|F_g\right| = (60 \ kg)(9.8\frac{N}{kg})$
$\left|F_g\right| = 588 \ N$

$\left|F_{g, all}\right| = m_{all}g$
$\left|F_g\right| = (875 \ kg)(9.8\frac{N}{kg})$
$\left|F_g\right| = 8575 \ N$

Find the acceleration of the system by analyzing the elevator
$F_{Net,y} = m_{all}a_y$
$\left|T\right| - \left|F_{g,all}\right| = m_{all}a_y$
9410 N – 8575 N = 875 kg a_y
835 N = 875 kg a_y
0.95 m/s² = a_y

Use with woman now
$F_{Net,y} = m_{all}a_y$
$\left|F_N\right| - \left|F_{g,woman}\right| = m_{woman}a_y$
$\left|F_N\right| - 588 \ N = (60 \ kg)\left(0.95\frac{m}{s^2}\right)$
$\left|F_N\right| = 645 \ N$

5. A person exerts a horizontal force of 267 N to the left in an attempt to push a 150 kg freezer across a room, but the freezer will not move. The freezer only moves if the person pushes in excess of 380 N. What is the direction and magnitude of the static frictional force experienced by the freezer when the person pushes with 267 N?
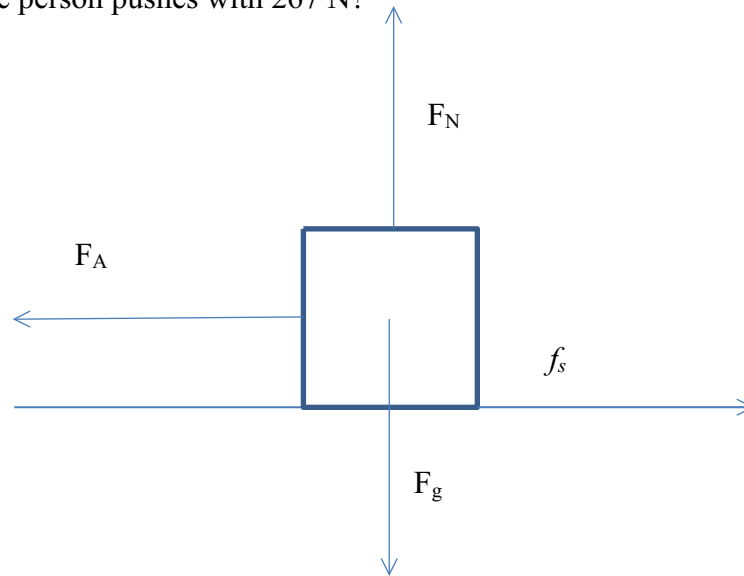
We are told the freezer remains at rest so the acceleration in the horizontal direction is zero. This is why we can presume the existence of the static frictional force going to the right otherwise the freezer would accelerate.

Additionally, based on the text, $f_{s,maz}$ = 380 N because that is what the person would need to push in excess of to get it moving.
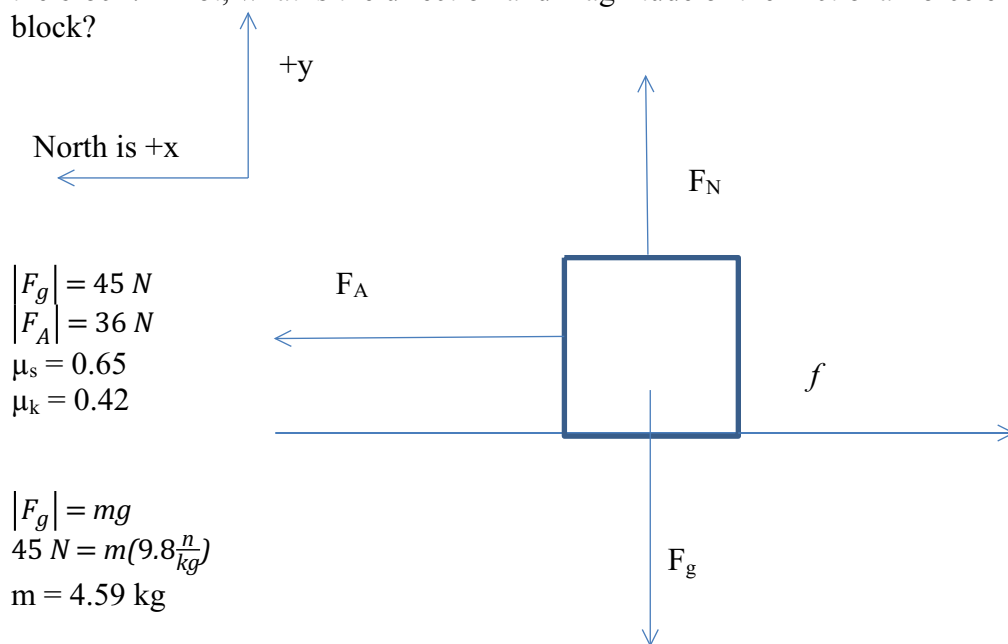
$$F_{Net,x} = ma_x$$
$$|F_A| - |f_s| = ma_x$$
$$267\ N - |f_s| = 0$$
$|f_s| = 267\ N$ and the sentences above already tell you why we know it is to the right.

6. A block whose weight is 45 N rests on a horizontal table. The coefficient of static and kinetic friction are 0.650 and 0.420, respectively. A horizontal force of 36 N is applied to the block to the north. Will the block move? If so, what is the direction and magnitude of the acceleration of the block? If not, what is the direction and magnitude of the frictional force experienced by the block?

+y

North is +x

F_N

$|F_g| = 45\ N$

F_A

$|F_A| = 36\ N$

$\mu_s = 0.65$

$\mu_k = 0.42$

f

$|F_g| = mg$

$45\ N = m(9.8\frac{n}{kg})$

F_g

$m = 4.59\ kg$

Notice here on the FBD that I just have f. I don't know if it is static OR kinetic yet. I know it acts to the south (right) because if this object remains at rest, the friction will need to counteract the applied force. I know that if the block moves due to the applied force, the velocity of the object will be to the north (left), therefore the kinetic friction will be to the south (right).

First let's find the Normal Force and use this to find the max static friction force.

$F_{Net,y} = ma_y$

$|F_n| - |F_g| = m\,a_y{}^{0}$

$|F_n| - 45N = 0$

$|F_n| = 45\ N$

$f_{s,max} = \mu_s F_N$

$f_{s,max} = (0.65)(45N)$

$f_{s,max} = (0.65)(45N)$

$f_{s,max} = 29.25\ N$

Because the applied force (as the force that is attempting to accelerate the mass) is larger than the maximum value of static friction, the mass begins to move and accelerate. Therefore the mass will experience kinetic friction

$f_K = \mu_k F_N$

$f_K = (0.42)(45\ N)$

$f_K = 18.9\ N$

$F_{Net,x} = ma_x$

$|F_A| - |f_K| = ma_x$

$36\ N - 29.25\ N = 4.59\ kg\ a_x$
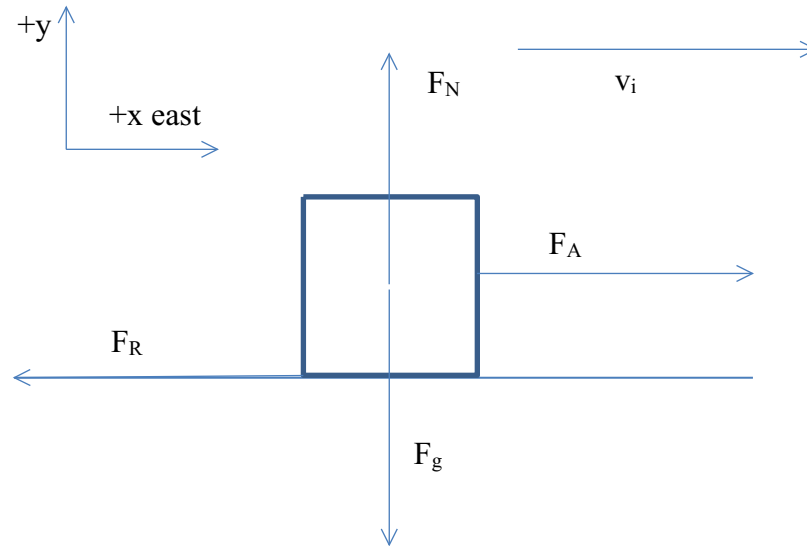
$a_x = 1.47\ m/s^2$

7. A water skier of mass 89 kg is being pulled at a constant velocity of 10 m/s east by a force of 350 N.
a) Find the magnitude and direction of the resistive force experienced by the skier?
b) Find the magnitude of the upward support force exerted on the skier by the surface of the water.

+y

F_N v_i

+x east

m = 89 kg
v_i = + 10 m/s
$|F_A|$ = 350 N
a = 0

F_A

F_R

F_g

a) $F_{Net,x} = ma_x$
$|F_A| - |F_R| = ma_x$
$350\ N - |F_R| = m\ (0)$
$|F_R| = 350\ N$

b)
$|F_g| = mg$
$|F_g| = (89\ kg)(9.8\dfrac{N}{kg})$
$|F_g| = 872.2\ N$

b) $F_{Net,\ y} = ma_y$
$|F_n| - |F_g| = m\ a_y \nearrow^{\ 0}$
$|F_n| - 872.2\ N = 0$
$|F_n| = 872.2\ N$

8. A student is skateboarding down a ramp that is 6 m long and inclined at a 18° angle with respect to the horizontal. The initial velocity of the skateboarder at the top of the ramp is 2.6 m/s

heading down the ramp. Assuming there is no friction, what is the speed of the skateboarder at the bottom of the ramp?
I drew the mass at the center of the ramp but it should have been at the top of the ramp. Oh NO! I didn't give a mass!
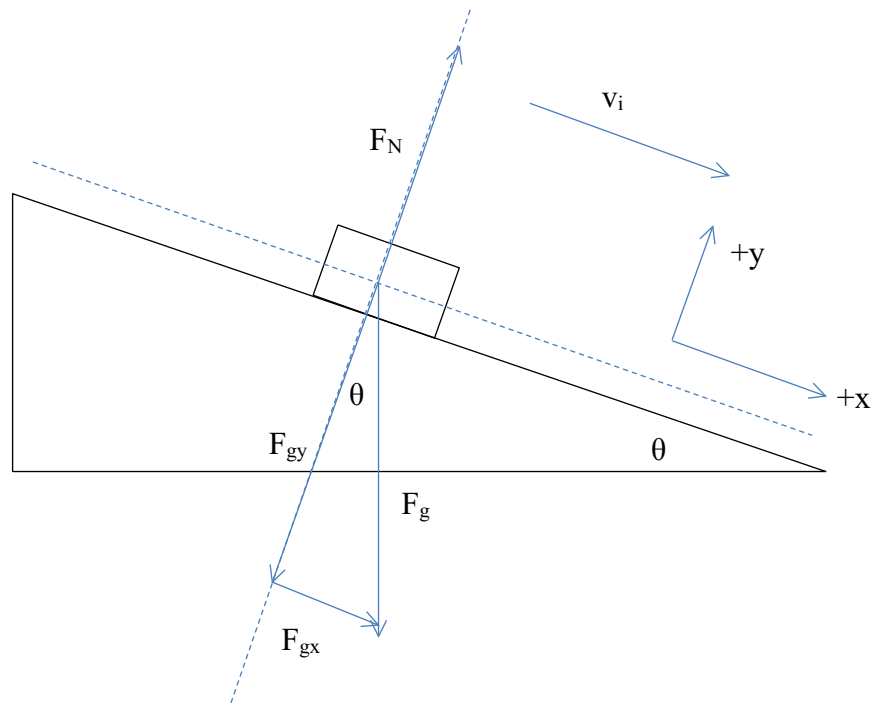
Side calcs
$$\left|F_{gx}\right| = \left|F_g\right| \sin \theta$$
$$\left|F_{gx}\right| = mg \sin \theta$$

First we need to find the acceleration down the ramp.
$$F_{Net,x} = ma_x$$
$$\left|F_{gx}\right| = ma_x$$
$mg \sin \theta = ma_x$ [BREATHE IN QUICKLY! Masses cancel...therefore I don't need to
$g \sin \theta = a_x$ know the mass]
$(9.8\frac{m}{s^2})\sin 18 = a_x$
$a_x = 3.03$ m/s^2

$v_f^2 = v_i^2 + 2a\Delta x$
$v_f^2 = (2.6$ m/s$)^2 + 2(3.03$m/s$^2)(6$ m$)$
$v_f = +/- 6.57$ m/s
$v_f = + 6.57$ m/s (reject the negative)

9. A 205 kg log is pulled up a ramp by means of a rope that is parallel to the surface of the ramp. The ramp is inclined at 30° from the horizontal. The coefficient of kinetic friction between the

log and ramp is 0.900 and the log has an acceleration of 0.800 m/s² up the incline. Find the tension in the rope.
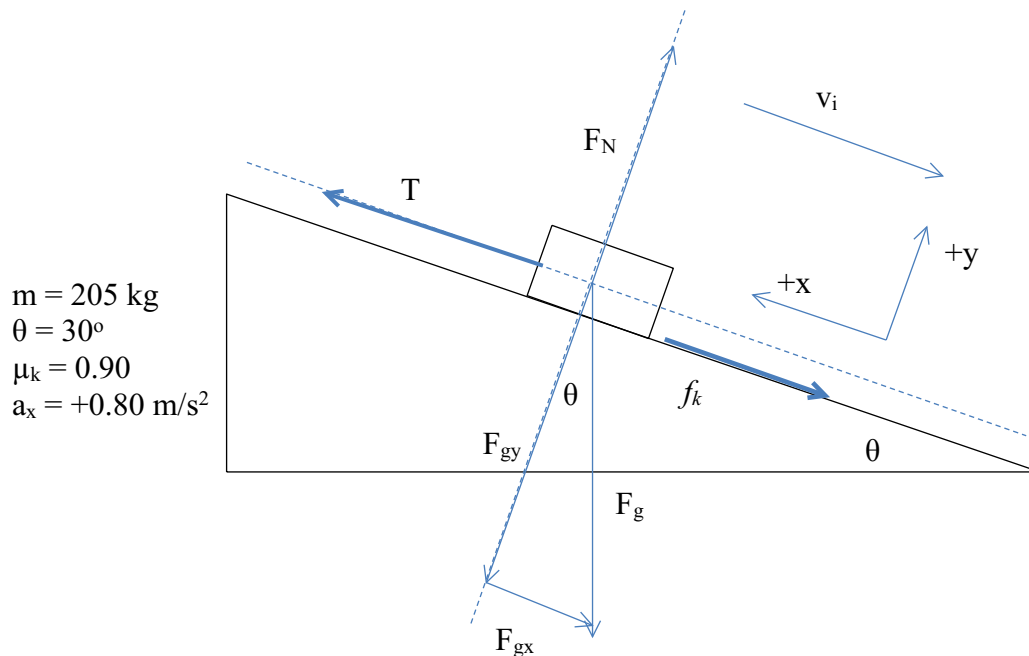
$$\left|F_g\right| = mg \qquad\qquad \left|F_{gx}\right| = \left|F_g\right|\sin\theta \qquad\qquad \left|F_{gy}\right| = \left|F_g\right|\cos\theta$$
$$\left|F_g\right| = (205\ kg)(9.8\tfrac{N}{kg}) \quad \left|F_{gx}\right| = 2009\ N\sin 30 \qquad \left|F_{gy}\right| = 2009\ N\cos 30$$
$$\left|F_g\right| = 2009\ N \qquad\qquad \left|F_{gx}\right| = 1004.5\ N \qquad\qquad \left|F_{gy}\right| = 1739.8\ N$$

Since friction is in the problem, I first need to find the normal force so I can calculate f_k

$$F_{Net,y} = ma_y$$
$$\left|F_n\right| - \left|F_{gy}\right| = m\,a_y \nearrow^{0}$$
$$\left|F_n\right| - 1739.8\ N = 0$$
$$\left|F_n\right| = 1739.8\ N$$

$$f_k = \mu_k F_N$$
$$f_k = (0.90)(1739.8N)$$
$$f_k = 1565.8\ N$$

Now deal with the x direction

$$F_{Net,x} = ma_x$$
$$\left|T\right| - \left|f_k\right| - \left|F_{gx}\right| = ma_x$$
$$\left|T\right| - (1565.8\ N) - (1004.5\ N) = (205\ kg)(+0.80\tfrac{m}{s^2})$$
$$\left|T\right| = 2734.3\ N$$

10. A 40 kg mass is initially at rest on an inclined plane whose angle of inclination is 30°. Find the magnitude and direction of the acceleration of the mass if
a) no other forces act

b) the plane is frictionless and there is an applied force of 800 N acting up the hill.
c) the plane is frictionless and there is an applied force of 200 N acting down the hill.
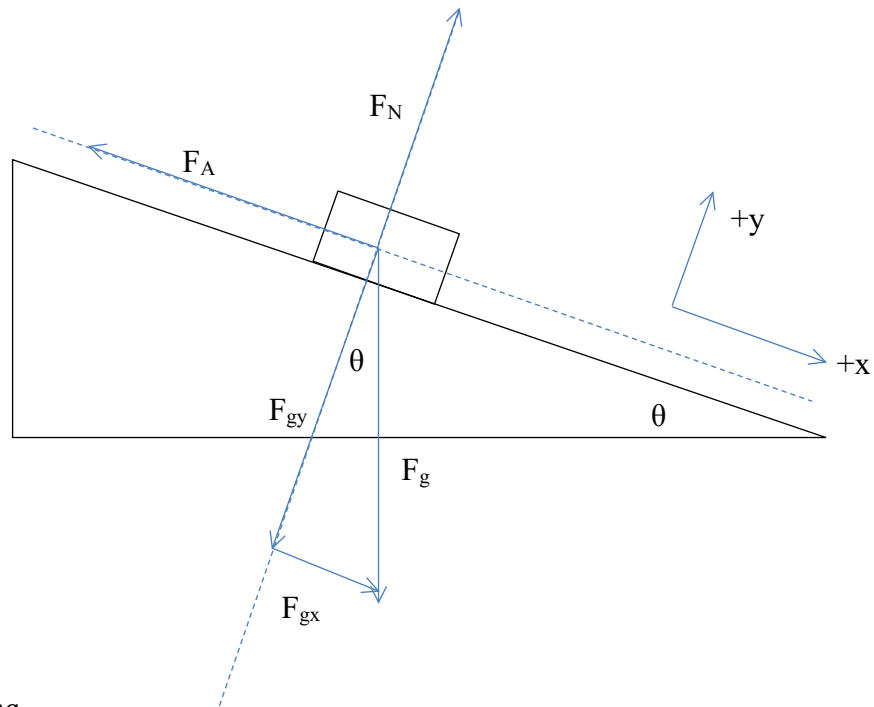d) the plane has a coefficient of friction of 0.20 (assuming the mass moves).
a)
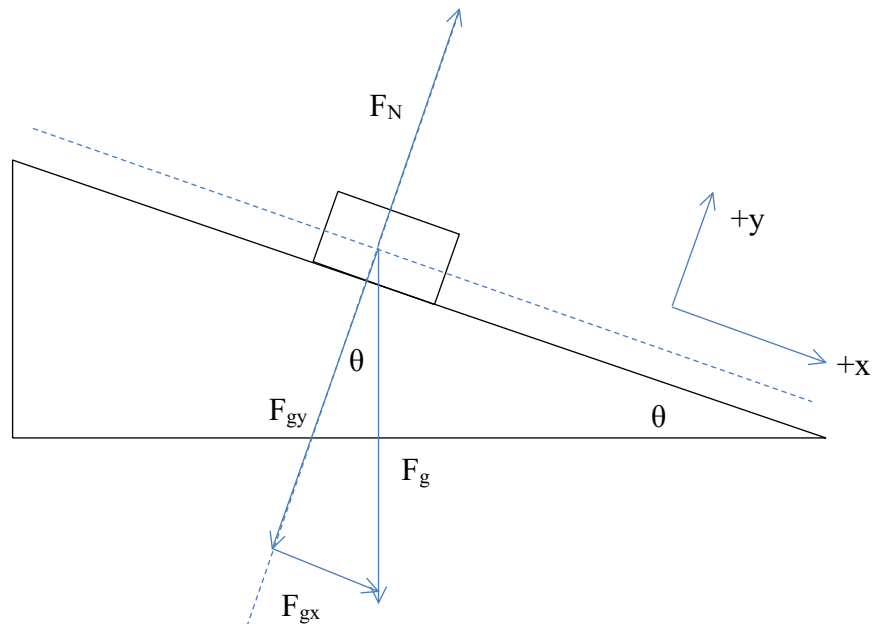
True for all parts of this problem:

$$\left|F_g\right| = mg$$
$$\left|F_g\right| = (40\ kg)(9.8\tfrac{N}{kg})$$
$$\left|F_g\right| = 392\ N$$

$$\left|F_{gx}\right| = \left|F_g\right|\sin\theta$$
$$\left|F_{gx}\right| = 392\ N\sin 30$$
$$\left|F_{gx}\right| = 196\ N$$

$$\left|F_{gy}\right| = \left|F_g\right|\cos\theta$$
$$\left|F_{gy}\right| = 392\ N\cos 30$$
$$\left|F_{gy}\right| = 339.5\ N$$

a) $F_{Net,x} = ma_x$
$$\left|F_{gx}\right| = ma_x$$
$$196\ N = 40\ kg\ a_x$$
$$a_x = +4.9\ m/s^2$$

b)

$\left|F_A\right| = 800\ N$

$F_{Net,x} = ma_x$
$\left|F_{gx}\right| - \left|F_A\right| = ma_x$
196 N – 800 N = 40 kg a_x
-604 N = 40 kg a_x
a_x = -15.1 m/s^2

c)
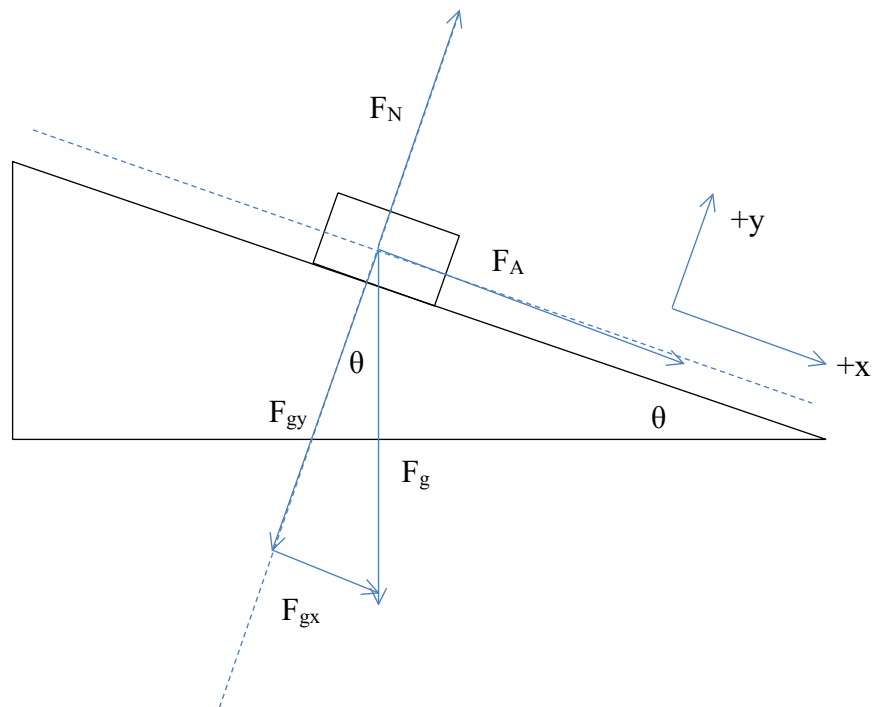
$\left|F_A\right| = 200\ N$

(Continued)

c) from last page
$F_{Net,x} = ma_x$
$|F_{gx}| + |F_A| = ma_x$
196 N + 200 N = 40 kg a_x
396 N = 40 kg a_x
a_x = 9.9 m/s^2
 d)
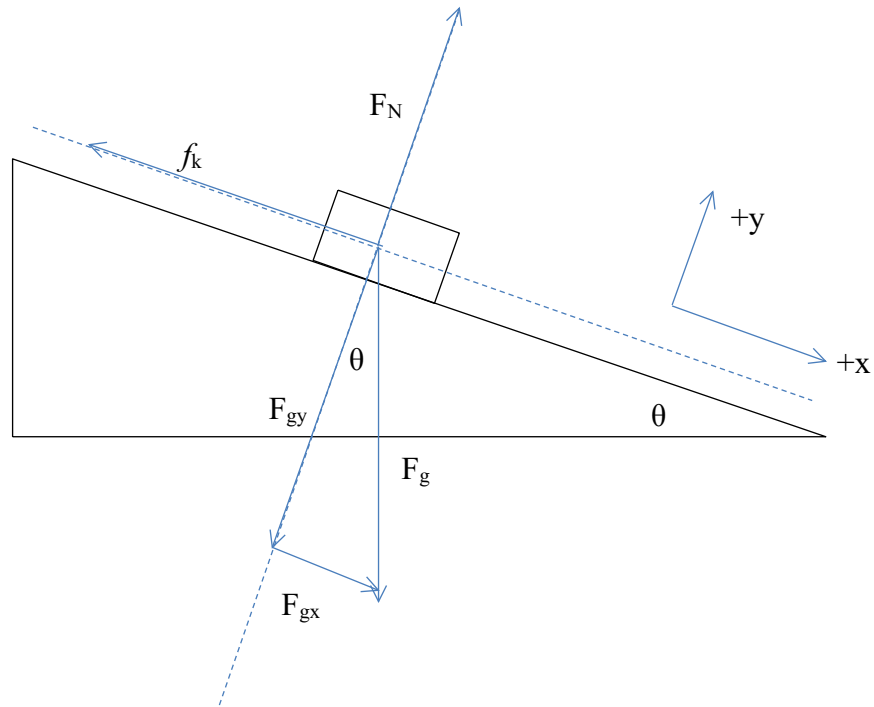
$f_k = \mu_k F_N$

$f_k = (0.2)(339.5\ N)$

$f_k = 67.9\ N$

$F_{Net,x} = ma_x$
$|F_{gx}| - |f_k| = ma_x$
196 N – 67.9 N = 40 kg a_x
128.1 N = 40 kg a_x
a_x = 3.20 m/s^2

Multiple Choice Review – This book assumes a rounded value of $g = 10 \text{ m/s}^2$

5. 3

6. 4

7. 2 (can be at a constant velocity or if v = 0)

8. 1

9. 3 (this means a force that acts opposite the velocity so it slows down)

10. 3 (600 N up and 800 N down so net force is down)

11. 2

12. 1 (inverse relationship between a and m for constant force)

13. 1 (because F_x decreases as angle increases)

Page 2

14. 3 (acceleration is zero)

15. 4 (fancy way of saying net force is zero)

16. 3 (when net force is zero)

17. 4

18. 3

19. 3 (because uniformly accelerating therefore the force causing that is constant)

20. 4

21. 3 (slope is velocity and slope is constant so acceleration is zero)

22. 2

23. 2

Page 3

1. 1

2. 2 (if at a constant speed, friction and applied force must cancel)

3. 2

4. 2 (opposite the velocity)

5. 3 (surfaces in contact don't change…just F_N)

6. 2 (because F_N is increased)

Page 4

34. 1 (surface area does not matter)

35. 4 (least coefficient so least friction)

1. B (they are equal and opposite but the existence of one does not imply the existence than the other. Also they are not of the same type)

2. D

$F_N - F_g = ma$ (up is positive)

$F_g = 800N$, therefore mass is 81.6 kg

$F_N - 800N = 81.6$ kg $(4.9$ m/s$^2)$