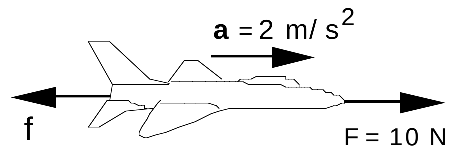
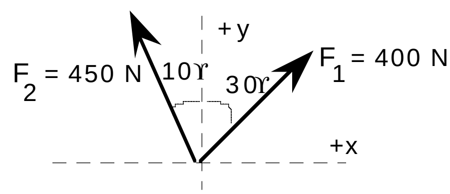
CHAPTER FOUR SOLUTIONS

4.5 Summing the forces on the plane shown gives
$\Sigma F_x = F - f = 10 \text{ N} - f$
$= (0.20 \text{ kg})(2.0 \text{ m/s}^2)$.
From which
$f = 9.6$ N



4.8 (a) We resolve the forces shown into their components as

	x comp	*y* comp
400 N:	200. N	346. N
450 N:	-78.1 N	443. N
F_R:	122 N	789 N



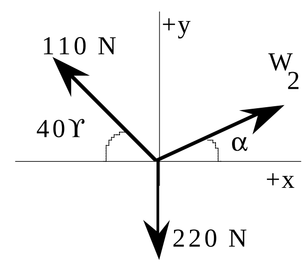
The magnitude of the resultant force is found from the Pythagorean theorem as $F_R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = \sqrt{(122 \text{ N})^2 + (789 \text{ N})^2} = 798$ N,

and $\tan\theta = \frac{\Sigma F_y}{\Sigma F_x} = \frac{789}{122} = 6.47$, from which $\theta = 81.2°$. Thus, the resultant force is at an angle of 8.8° to the right of the forward direction.

(b) The acceleration is in the same direction as F_R and is given by

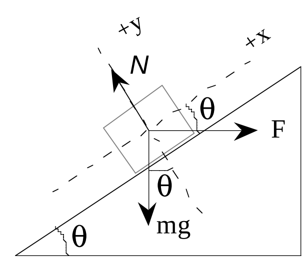
$a = F_R/m = 798 \text{ N}/ 3000 \text{ kg} = 0.266 \text{ m/s}^2$.

4.14 From $\Sigma F_x = 0$, we have
$W_2\cos\alpha - (110 \text{ N}) \cos 40° = 0$ (1)
From $\Sigma F_y = 0$, we have
$W_2\sin\alpha + (110 \text{ N}) \sin 40° - 220 \text{ N} = 0$ (2)
Dividing (2) by (1) yields
$\tan\alpha = \frac{149.3}{84.26} = 1.772$, or $\alpha = 60.55°$.
Then, from either (1) or (2), $W_2 = 171.4$ N.



4.21 (a) The resultant external force acting on this system having a total mass of 6.0 kg is 42 N directed horizontally toward the right. Thus, the acceleration produced is $a = \frac{F}{m} = \frac{42 \text{ N}}{6.0 \text{ kg}} = 7.0$ m/s^2.

The acceleration of the system is 7.0 m/s^2 horizontally toward the right.



(b) Draw a free body diagram of the 3.0 kg object and apply Newton's second law to the horizontal forces acting on this object. This gives

$\Sigma F_x = ma_x$ or $42 \text{ N} - T = (3.0 \text{ kg})(7.0 \text{ m/s}^2)$, and therefore $T = 21$ N.

(c) The force accelerating the 2.0 kg object is the force exerted on it by the 1.0 kg object. Therefore, this force is given by:

$\mathbf{F} = m\mathbf{a} = (2.0 \text{ kg})(7.0 \text{ m/s}^2)$, or

F = 14 N directed horizontally toward the right.

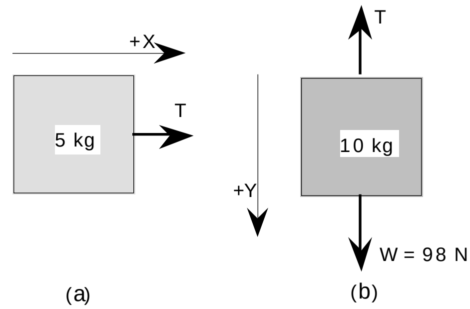
4.25 First consider the block moving along the horizontal. The only force in the direction of movement is T. Thus

$\Sigma F_x = ma$ gives

$T = (5.00\ \text{kg})a$. (1)

Next consider the block which moves vertically. The forces on it are the tension T and its weight, 98 N. Thus,

$\Sigma F_y = ma = 98\ \text{N} - T = (10.0\ \text{kg})a$. (2)



Note that both blocks must have the same magnitude of acceleration. Equations (1) and (2) can be solved simultaneously to give.

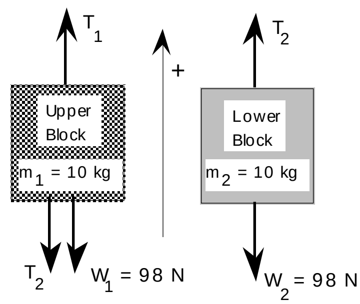
a = 6.53 m/s^2, and T = 32.7 N

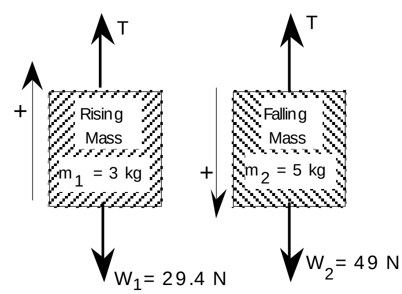
4.28 First, consider the 3.00 kg rising mass. The forces on it are the tension, **T**, and its weight, 29.4 N. With the upward direction as positive, the second law becomes

$T - 29.4\ \text{N} = (3.00\ \text{kg})a$. (1)

The forces on the falling 5.00 kg mass are its weight and **T**, and its acceleration is the same as that of the rising mass. Calling the positive direction down for this mass, gives

$49\ \text{N} - T = (5.00\ \text{kg})a$. (2)





Equations (1) and (2) can be solved simultaneously to give

(a) the tension as T = 36.8 N,

(b) and the acceleration as a = 2.45 m/s^2.

(c) Consider the 3.00 kg mass. We have

$$y = v_0 t + \frac{1}{2}at^2 = 0 + \frac{1}{2}(2.45\ \text{m/s}^2)(1.00\ \text{s})^2 = 1.23\ \text{m}.$$

4.31 (a) Applying Newton's second law, the horizontal components of the forces give $F\cos 20° - f = 0$,

yielding a frictional force $f = 300\cos 20.0° = 282$ N.

The vertical component equation is: $N - F\sin 20° - W = 0$,

yielding a normal force $N = 300\sin 20.0° + 1000 = 1103$ N.

The coefficient of friction is then $\mu_k = \frac{f}{N} = \frac{282}{1103} = 0.256$

(b) The vertical equation becomes $F\sin 20.0° + N - w = 0$, yielding a normal force $N = w - F\sin 20.0° = 897$ N.

The friction force now becomes $f = \mu_k N = 0.256(897) = 230$ N.

The horizontal component equation is $F\cos 20.0° - f = ma = \frac{w}{g}a$. The resulting acceleration is

$$a = \frac{(F\cos 20.0° - f)g}{w} = \frac{(300\cos 20° - 230)9.80}{1000} = 0.509\ \text{m/s}^2$$

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4.38 (a) The force of friction is found as $f = \mu_k N = \mu_k m g$.
Now, choose the positive direction of the x axis in the direction of motion and apply the second law. We have:
$-f = ma_x$, or $a_x = -f/m = \mu_k g$.
Use $v^2 = v_o^2 + 2ax$, with $v = 0$, $v_o = 50.0$ km/h = 13.9 m/s. We have

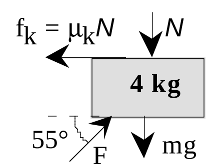
$$0 = (13.9 \text{ m/s})^2 + 2(-\mu_k g)x, \text{ or } \quad x = \frac{(13.9 \text{ m/s})^2}{2\mu_k g}. \quad (1)$$

With $\mu_k = 0.100$, this gives a value for x of $x = 98.6$ m
(b) With $\mu_k = 0.600$, (1) above gives $x = 16.4$ m

4.49 (a) The friction force between the box and the truck bed causes the box to move with the truck.
(b) The maximum value of the acceleration the truck can have before the box slides can be found by finding the maximum value of the static friction force on the box. This is: $f_{max} = \mu_s N = \mu_s mg$.
Thus, from Newton's Second Law,

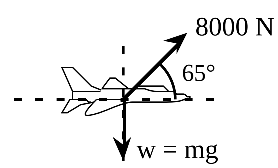
$$a_{max} = f_{max}/m = \mu_s g = 0.300(9.80 \text{ m/s}^2) = 2.94 \text{ m/s}^2.$$

4.55 (a) Apply the 2nd law to the 10 kg block:



$T = (10 \text{ kg})a$, (1)
and for the 20 kg block:
$50 \text{ N} - T = (20 \text{ kg})a$. (2)
Solving (1) and (2) simultaneously:
$T = 17$ N,
and $a = 1.7$ m/s^2.
(b) The friction force on the 10 kg block is:
$f_1 = \mu_k N = 0.1(98 \text{ N}) = 9.8$ N.
On the 20 kg block, we have $f_2 = 0.1(196 \text{ N}) = 19.6$ N.
Thus, the second law for the 10 kg block is $T - 9.8 \text{ N} = (10 \text{ kg})a$, (3)
and for the 20 kg block $50 \text{ N} - T - 19.6 \text{ N} = (20 \text{ kg})a$. (4)
Solving (3) and (4) together, we have: $T = 17$ N, $a = 0.69$ m/s^2.

4.63 In the vertical direction, we have
$(8000 \text{ N}) \sin 65° - w = 0$, so $w = 7250$ N.



$$m = \frac{w}{g} = \frac{7250 \text{ N}}{9.80 \text{ m/s}^2} = 739.8 \text{ kg}.$$

Along the horizontal, the second law becomes,
$(8000 \text{ N}) \cos 65° = (739.8 \text{ kg})a_x$, so $a_x = 4.57$ m/s^2.

4.67 Let M = mass of keg = $\frac{300 \text{ N}}{g}$ = 30.6 kg. Then mass of Bob = $\frac{900 \text{ N}}{g}$ = 3 M, and mass of Kathy = mass of nails = 2M.
Also, the time to move 10 m from

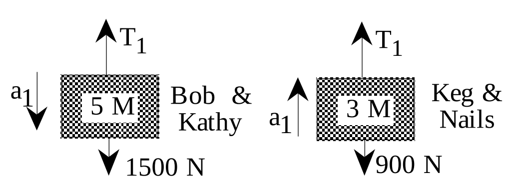


Figure 1

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rest is given by 10 m = 0 + $\frac{1}{2}at^2$, or $t = \sqrt{\frac{20\text{ m}}{a}}$. (1)

For downward trip of Bob and Kathy:

Apply Newton's 2nd law to each object shown in Figure 1 to get: 1500 N - T_1 = (5M)a_1, and T_1 - 900 N = (3M)a_1, which yield $a_1 = \frac{600\text{ N}}{8\text{M}} = \frac{600\text{ N}}{244.8\text{ kg}}$ = 2.45 m/s^2, and equation (1) gives t_1 = 2.86 s as the time for this part of the trip.

After Bob lets go and Kathy starts toward the top, the 2nd law applied to each object shown in Figure 2 gives:

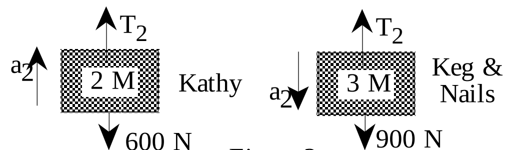

Figure 2

T_2 - 600 N = (2M)a_2, and

900 N - T_2 = (3M)a_2,

which gives $a_2 = \frac{300\text{ N}}{5\text{M}} = \frac{300\text{ N}}{153\text{ kg}}$ = 1.96 m/s^2. Then equation (1) yields t_2 = 3.19 s as the time for this part.

When the nails spill and Kathy starts back down, the 2nd law applied to each object in Figure 3 yields:

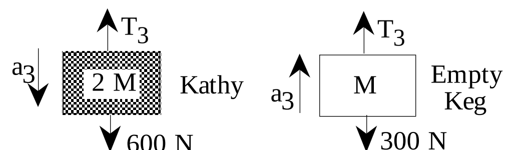

Figure 3

600 N - T_3= (2M)a_3, and

T_3 - 300 N = Ma_3, giving

$a_3 = \frac{300\text{ N}}{3M} = \frac{100\text{ N}}{30.6\text{ kg}}$ = 3.27 m/s^2 , and equation (1) yields t_3 = 2.47 s as the time for this part of the motion. After Kathy lets go, the tension in the rope is zero, and the empty keg falls freely (a = g) to the ground. The time for this part is

$$t_4 = \sqrt{\frac{20\text{ m}}{9.80\text{ m/s}^2}} = 1.43\text{ s.}$$

The total time for the entire accident is $t_1 + t_2 + t_3 + t_4$ = 9.95 s.

ANSWERS TO EVEN ASSIGNED CONCEPTUAL QUESTIONS

12. Any object will increase in speed any time there is a net force on it. Thus, there must be a net force to produce a changing speed. A changing acceleration can be produced by a constant force acting on an object that has a decreasing mass. This is happening to the rocket as it burns fuel.

18. Consider a boy sitting on a chair in the back of a truck when the truck begins to move forward. If the boy is to move along with the truck, the force in the direction of motion to speed him up is the force of friction between the chair and his pants. This force will be in the direction of motion of the truck and the boy.