"Physics Coverage - Inspire"

Multiple Choice Question

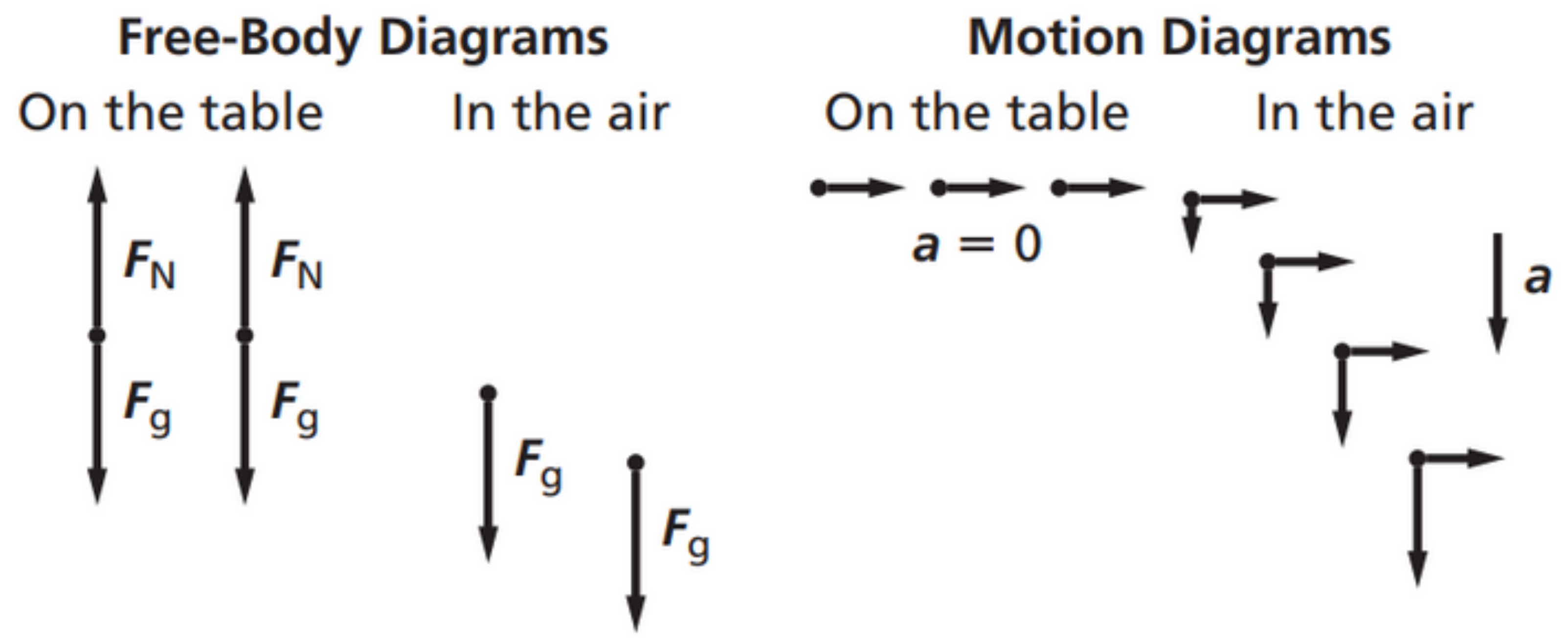
P(147)

Explain the motion of horizontally launched projectiles, and show schematically the components of velocity and acceleration throughout the motion.

7. **Initial Velocity** Two baseballs are pitched horizontally from the same height but at different speeds. The faster ball crosses home plate within the strike zone, but the slower ball is below the batter's knees. Why do the balls pass the batter at different heights?

The faster ball is in the air a shorter time, and thus gains a smaller vertical velocity.

8. **Free-Body Diagram** An ice cube slides without friction across a table at a constant velocity. It slides off the table and lands on the floor. Draw free-body and motion diagrams of the ice cube at two points on the table and at two points in the air.



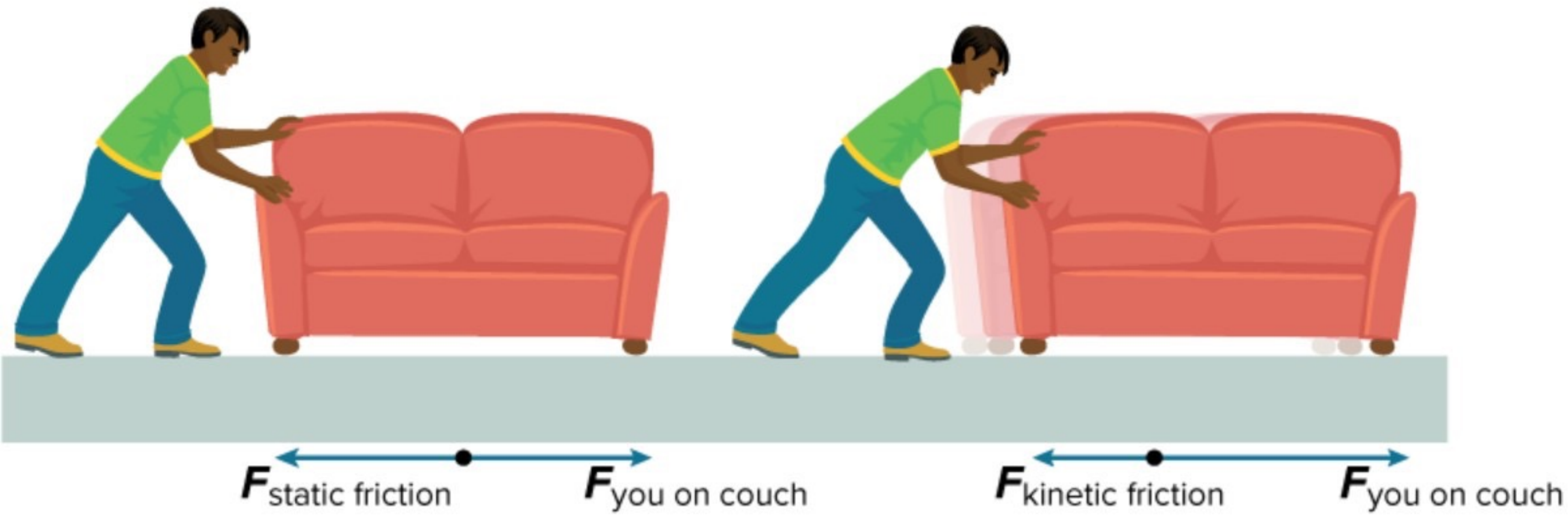
P(122)

2. Define the friction force as a type of force between two touching surfaces, and determine its direction.

→ Kinetic friction is exerted on one surface by another when the two surfaces rub against each other because one or both surfaces are moving.

always any type of friction will be in the opposite direction

→ The materials **sliding past each other** and the **normal force** between the two objects **affect friction forces.**



3. Recall that for an object to be in equilibrium, the net force acting on it should be zero.

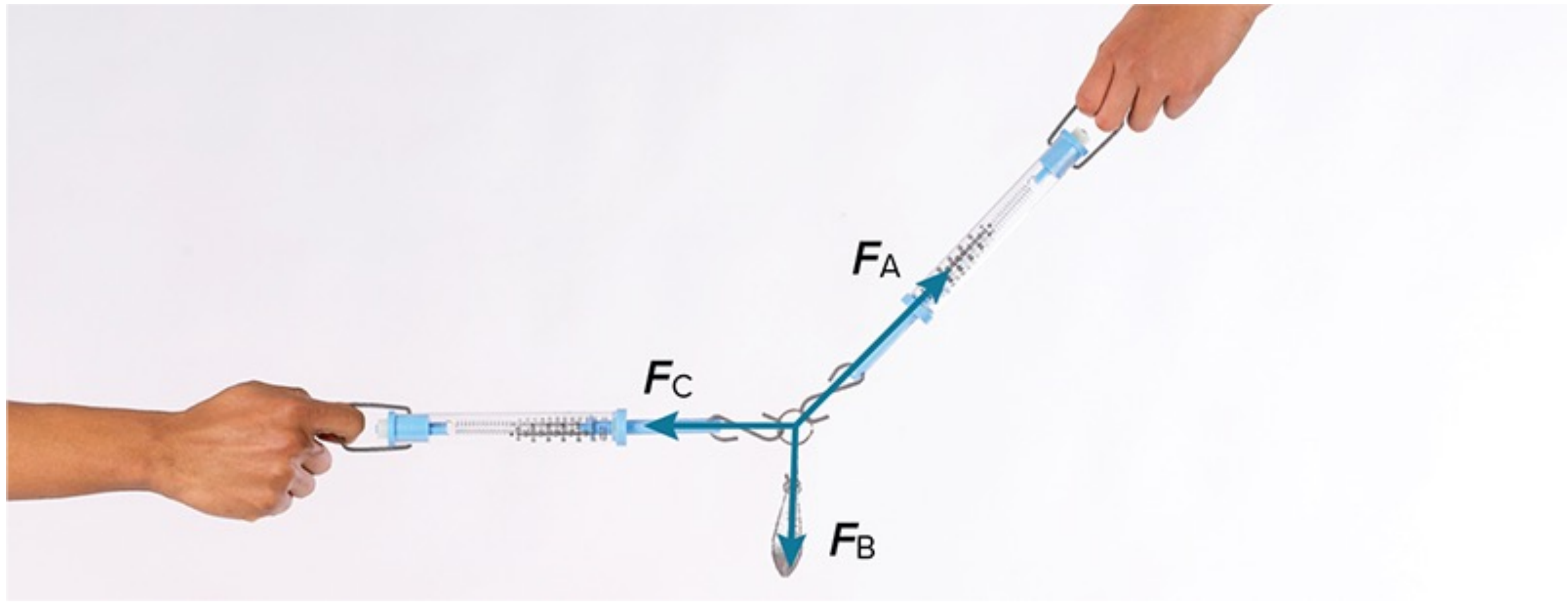
→ When the net force on an object is zero, the object is in equilibrium.

→ the object will not accelerate because there is no net force acting on it; an object in equilibrium moves with constant velocity.

If **Net Force** is ZERO
Acceleration is ZERO

If **Net Force** is ZERO It will be EQUILIBRIUM

CONSTANT SPEED OR VELOCITY
THE **ACCELERATION** IS ZERO



P(127)

4. Solve problems related to friction

19. You want to move a 41-kg bookcase to a different place in the living room. If you push with a force of 65 N and the bookcase accelerates at $0.12\ \mathrm{m/s^2}$, what is the coefficient of kinetic friction between the bookcase and the carpet?

$$\mu_k = \frac{F - ma}{mg}$$

$$= \frac{65\ \mathrm{N} - (41\ \mathrm{kg})(0.12\ \mathrm{m/s^2})}{(41\ \mathrm{kg})(9.8\ \mathrm{N/kg})}$$

$$= 0.15$$

20. Consider the force pushing the box in Example Problem 4. How long would it take for the velocity of the box to double to $2.0\ \mathrm{m/s}$?

EXAMPLE Problem 4

UNBALANCED FRICTION FORCES Imagine that the force you exert on the 25.0-kg box in Example Problem 3 is doubled.

a. What is the resulting acceleration of the box? $= 2.0\ \mathrm{m/s^2}$

b. How far will you push the box if you push it for 3 s? $= 12\ \mathrm{m}$

The initial velocity is 1.0 m/s, the final velocity is 2.0 m/s, and the acceleration is $2.0\ \mathrm{m/s^2}$, so

$$a = \frac{v_f - v_i}{t_f - t_i};\ \text{let } t_i = 0 \text{ and solve for } t_f.$$

$$t_f = \frac{v_f - v_i}{a}$$

$$= \frac{2.0\ \mathrm{m/s} - 1.0\ \mathrm{m/s}}{2.0\ \mathrm{m/s^2}}$$

$$= 0.50\ \mathrm{s}$$

P(120)

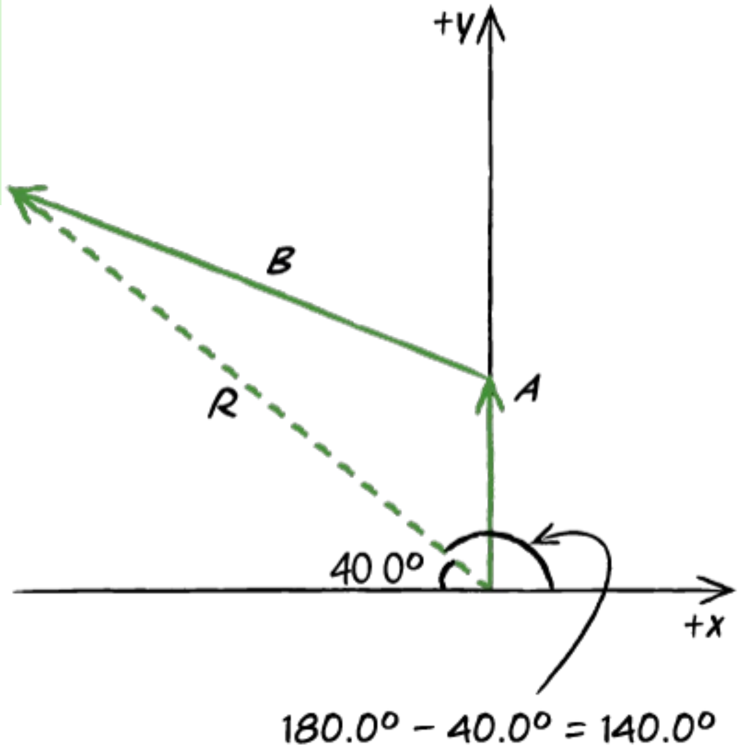
5. Determine the components of a vector in cartesian coordinate system using trigonometry

EXAMPLE Problem 2

FINDING YOUR WAY HOME You are on a hike. Your camp is 15.0 km away, in the direction 40.0° north of west. The only path through the woods leads directly north. If you follow the path 5.0 km before it opens into a field, how far, and in what direction, would you have to walk to reach your camp?

Known

A = 5.0 km, due north
R = 15.0 km, 40.0° north of west
θ = 140.0°



1

Find the components of R.

$$R_x = R\cos\theta$$
$$= (15.0\text{ km})\cos 140.0°$$
$$= 11.5\text{ km}$$
$$R_y = R\sin\theta$$
$$= (15.0\text{ km})\sin 140.0°$$
$$= 9.64\text{ km}$$

2

$$B_x = R_x - A_x$$
$$= -11.5\text{ km} - 0.0\text{ km}$$
$$= -11.5\text{ km}$$
$$B_y = R_y - A_y$$
$$= 9.64\text{ km} - 5.0\text{ km}$$
$$= 4.6\text{ km}$$

3

$$B = \sqrt{B_x^2 + B_y^2}$$
$$= \sqrt{(-11.5\text{ km})^2 + (4.6\text{ km})^2}$$
$$= 12.4\text{ km}$$

4

$$\theta = \tan^{-1}\left(\frac{B_y}{B_x}\right)$$
$$\theta = \tan^{-1}\left(\frac{4.6\text{ km}}{-11.5\text{ km}}\right)$$
$$= -22° \text{ or } 158°$$

5. Determine the components of a vector in cartesian coordinate system using trigonometry

EXAMPLE Problem 2

FINDING YOUR WAY HOME You are on a hike. Your camp is 15.0 km away, in the direction 40.0° north of west. The only path through the woods leads directly north. If you follow the path 5.0 km before it opens into a field, how far, and in what direction, would you have to walk to reach your camp?

Known

$A = 5.0$ km, due north
$R = 15.0$ km, 40.0° north of west
$\theta = 140.0°$

1 Find the components of R.

$$R_x = R\cos\theta = (15.0\text{ km})\cos 140.0° = 11.5\text{ km}$$

$$R_y = R\sin\theta = (15.0\text{ km})\sin 140.0° = 9.64\text{ km}$$

2

$$B_x = R_x - A_x = -11.5\text{ km} - 0.0\text{ km} = -11.5\text{ km}$$

$$B_y = R_y - A_y = 9.64\text{ km} - 5.0\text{ km} = 4.6\text{ km}$$

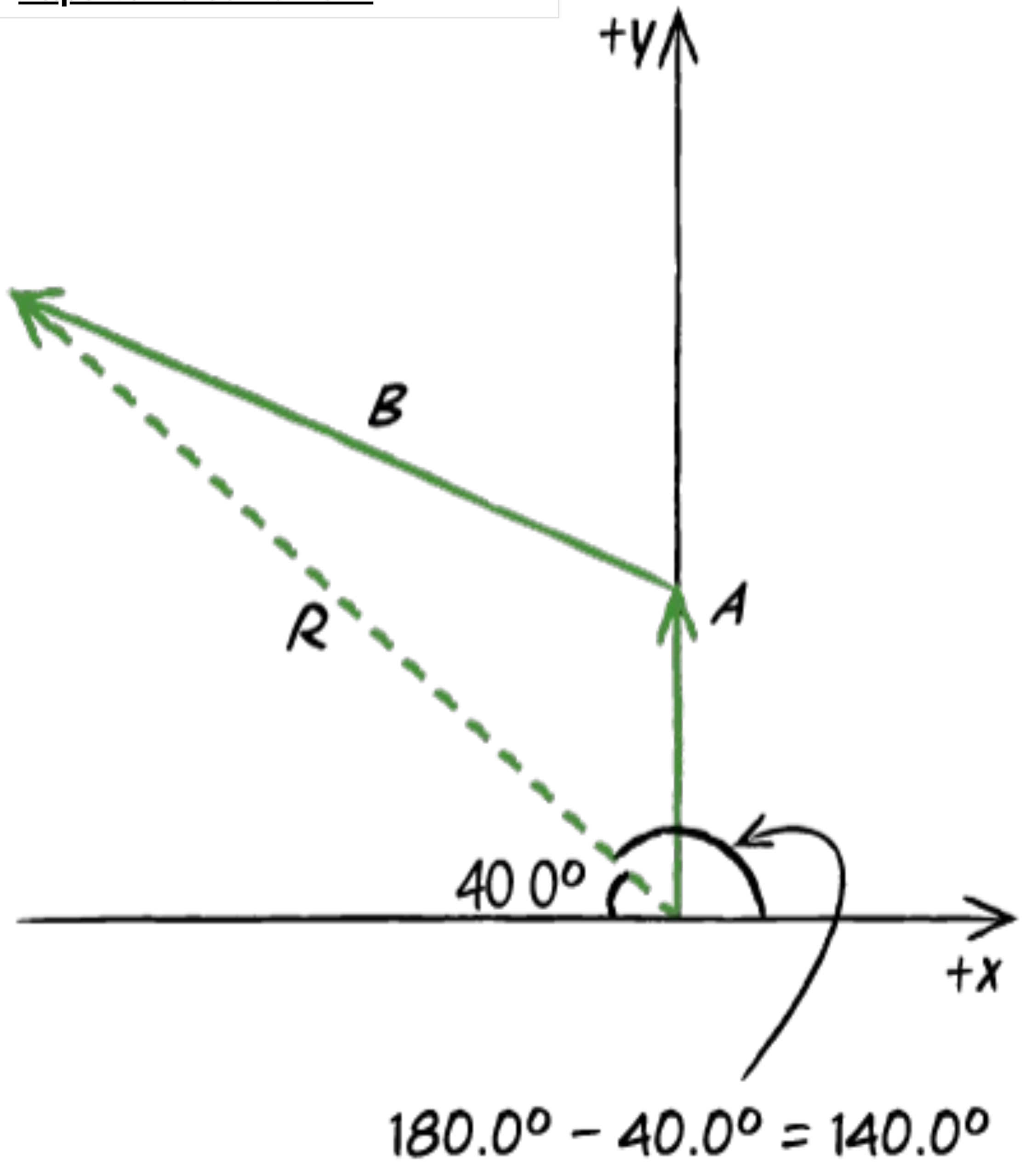
3

$$\theta = \tan^{-1}\left(\frac{B_y}{B_x}\right)$$

$$\theta = \tan^{-1}\left(\frac{4.6\text{ km}}{-11.5\text{ km}}\right) = -22° \text{ or } 158°$$

4

$$B = \sqrt{B_x^2 + B_y^2} = \sqrt{(-11.5\text{ km})^2 + (4.6\text{ km})^2} = 12.4\text{ km}$$

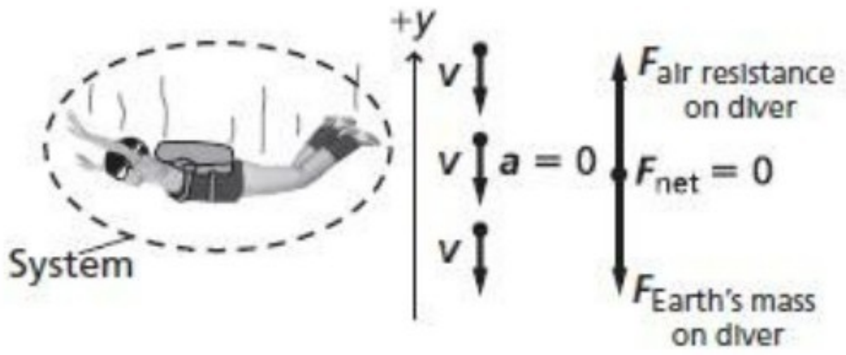


P(87)

6. Use free body diagrams to compare the direction of an object's acceleration with the direction of the unbalanced force exerted on the object

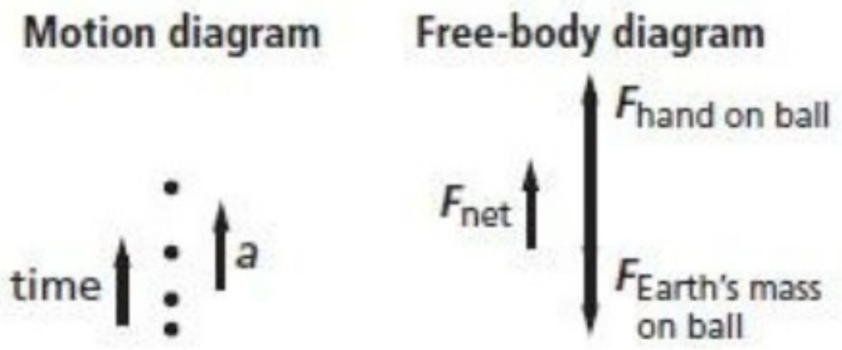
1. A skydiver falls downward through the air at constant velocity. (The air exerts an upward force on the person.)

SOLUTION:



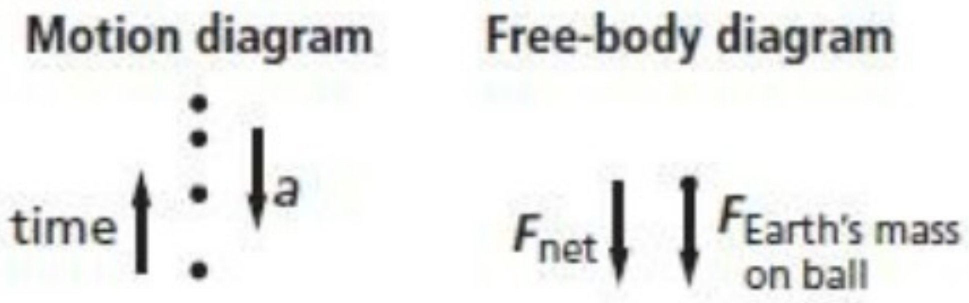
2. You hold a softball in the palm of your hand and toss it up. Draw the diagrams while the ball is still touching your hand.

SOLUTION:



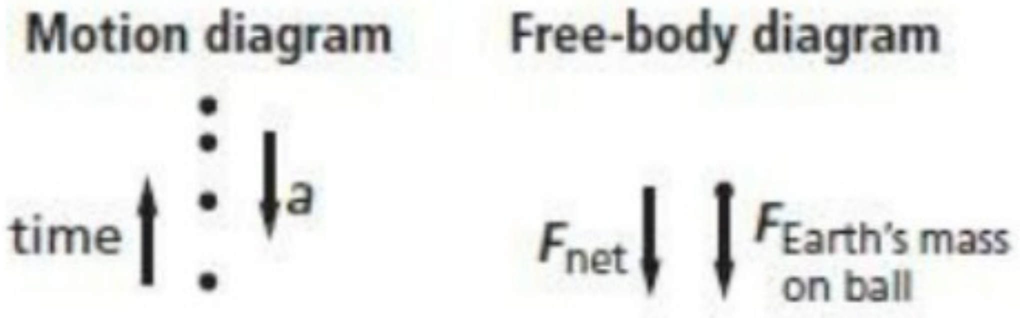
3. After the softball leaves your hand, it rises, slowing down.

SOLUTION:



4. After the softball reaches its maximum height, it falls down, speeding up.

SOLUTION:

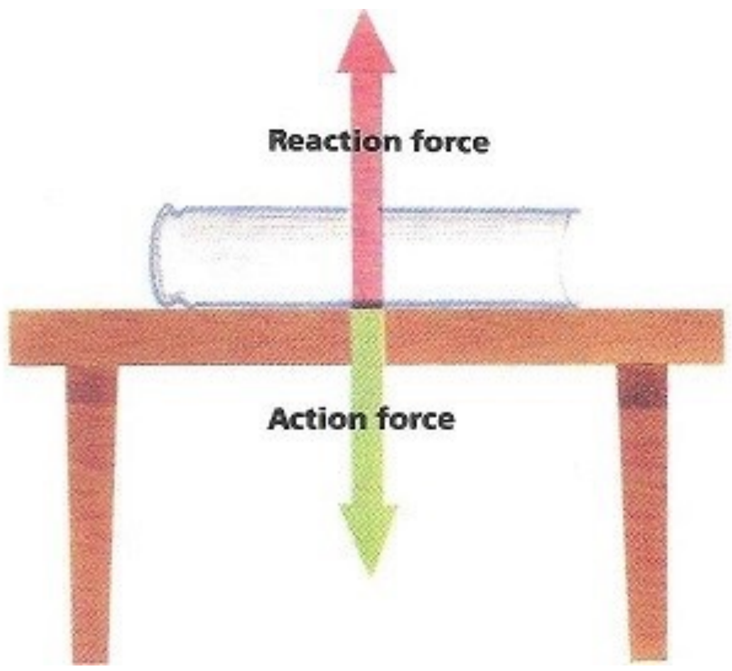


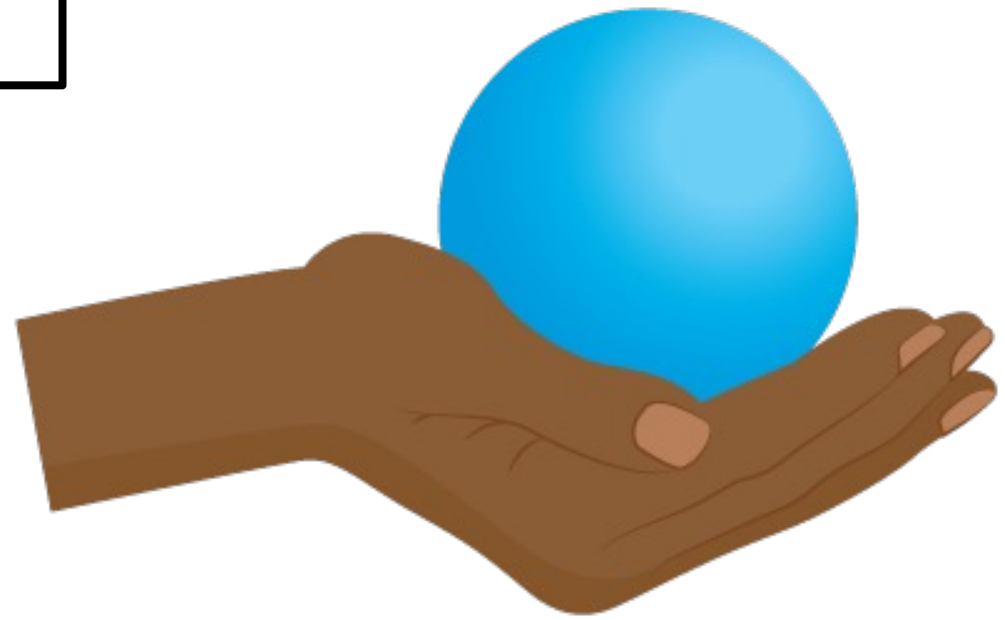
P(105)

7. Combine forces to find the net force acting on an object Relate the direction of the acceleration to the direction of the net force

34. **Interaction Pair** Identify each force acting on the ball and its interaction pair in **Figure 20.**

The forces on the ball are a downward force of gravity due to the mass of Earth and the upward force of the hand. The force of the ball on Earth and the force of the ball on the hand are the other halves of the interaction pairs.

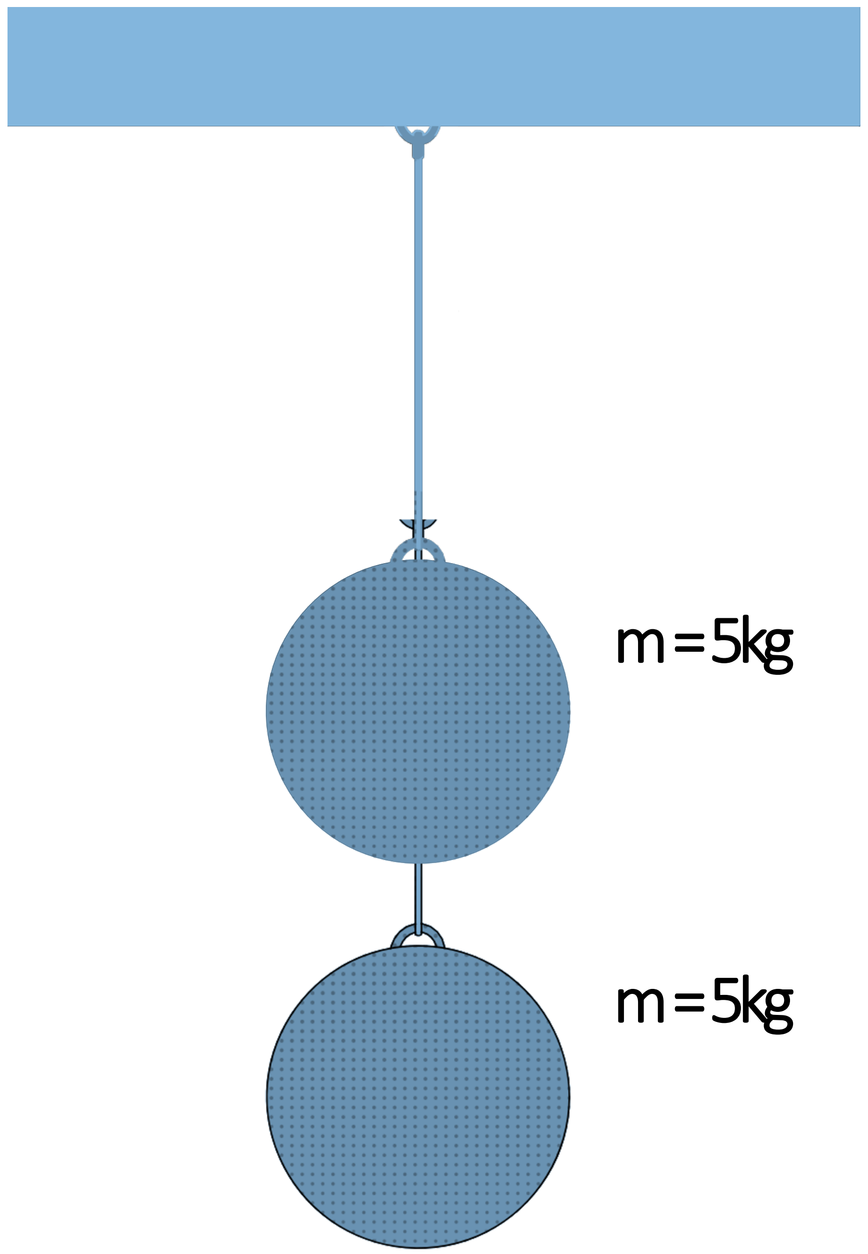




P(105)

7. Combine forces to find the net force acting on an object Relate the direction of the acceleration to the direction of the net force

36. **Tension** A block hangs from the ceiling by a massless rope. A second block is attached to the first block and hangs below it on another piece of massless rope. If each of the two blocks has a mass of 5.0 kg, what is the tension in the rope?



For the bottom rope with the positive direction upward

$$F_{net} = F_{\text{bottom rope on bottom block}} - F_{\text{Earth's mass on bottom block}} = ma = 0$$

$$F_{\text{bottom rope on bottom block}} = F_{\text{Earth's mass on bottom block}} = mg = (5.0\ \text{kg})(9.8\ \text{N/kg}) = 49\ \text{N}$$

For the top rope, with the positive direction upward

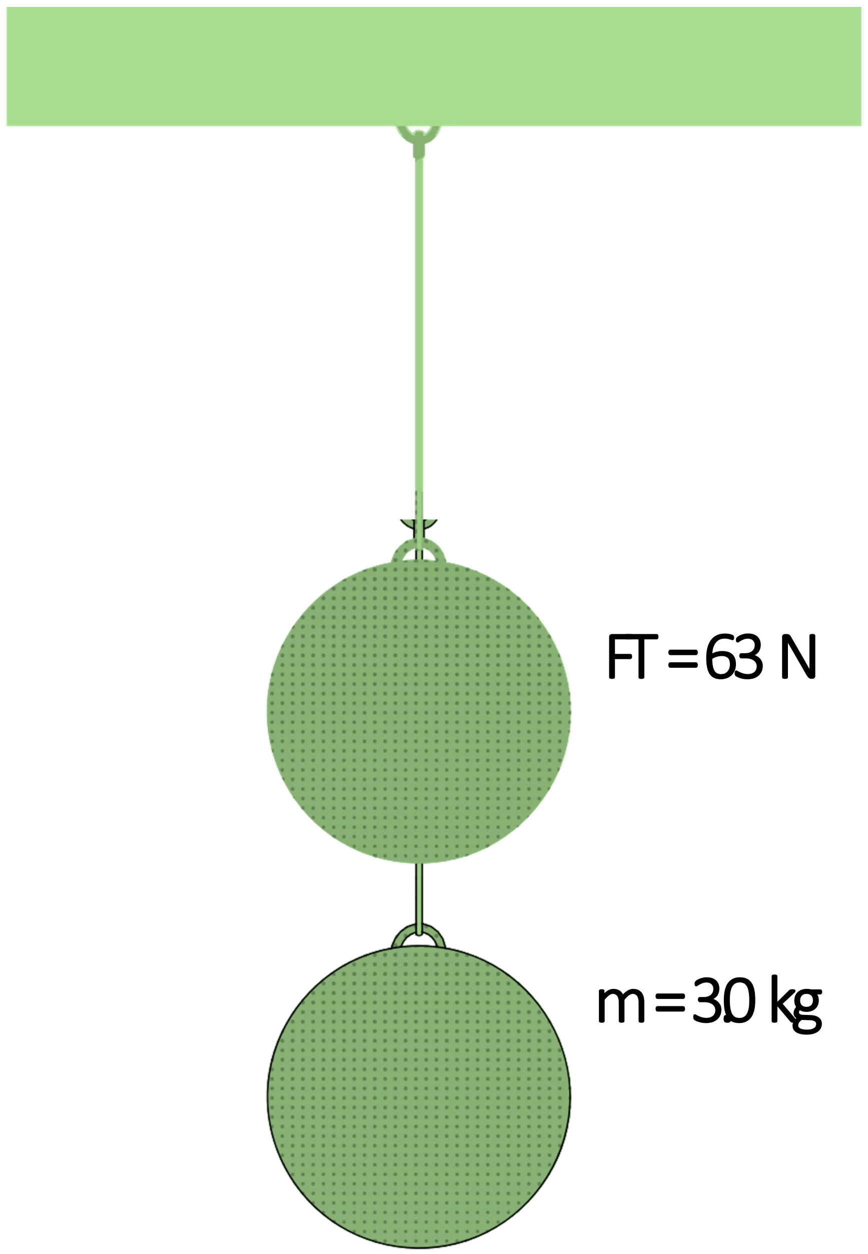
$$F_{net} = F_{\text{top rope on top block}} - F_{\text{bottom rope on top block}} - F_{\text{Earth's mass on top block}} = ma = 0$$

$$F_{\text{top rope on top block}} = F_{\text{Earth's mass on top block}} + F_{\text{bottom rope on top block}} = mg + F_{\text{bottom rope on top block}} = (5.0\ \text{kg})(9.8\ \text{N/kg}) + 49\ \text{N} = 98\ \text{N}$$

P(105)

7. Combine forces to find the net force acting on an object Relate the direction of the acceleration to the direction of the net force

37. **Tension** A block hangs from the ceiling by a massless rope. A 3.0-kg block is attached to the first block and hangs below it on another piece of massless rope. The tension in the top rope is 63.0 N. Find the tension in the bottom rope and the mass of the top block.



For the bottom rope with the positive direction upward

$$F_{net} = F_{\text{bottom rope on bottom block}} - F_{\text{Earth's mass on bottom block}} = ma = 0$$

$$F_{\text{bottom rope on bottom block}} = F_{\text{Earth's mass on bottom block}} = (3.0\ \text{kg})(9.8\ \text{N/kg}) = 29\ \text{N}$$

For the top rope, with the positive direction upward

$$F_{net} = F_{\text{top rope on top block}} - F_{\text{bottom rope on top block}} - F_{\text{Earth's mass on top block}} = ma = 0$$

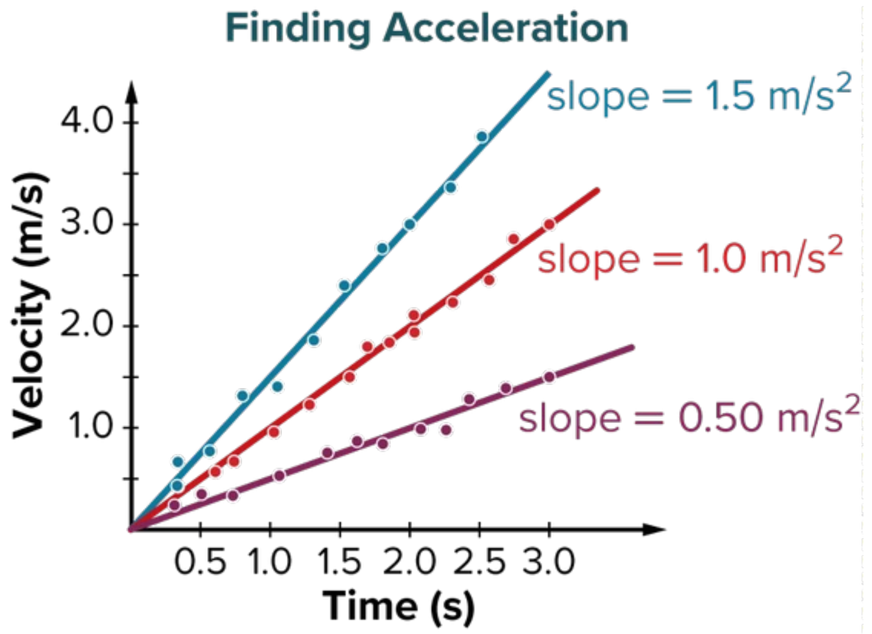
$$F_{\text{Earth's mass on top block}} = mg = F_{\text{top rope on top block}} - F_{\text{bottom rope on top block}}$$

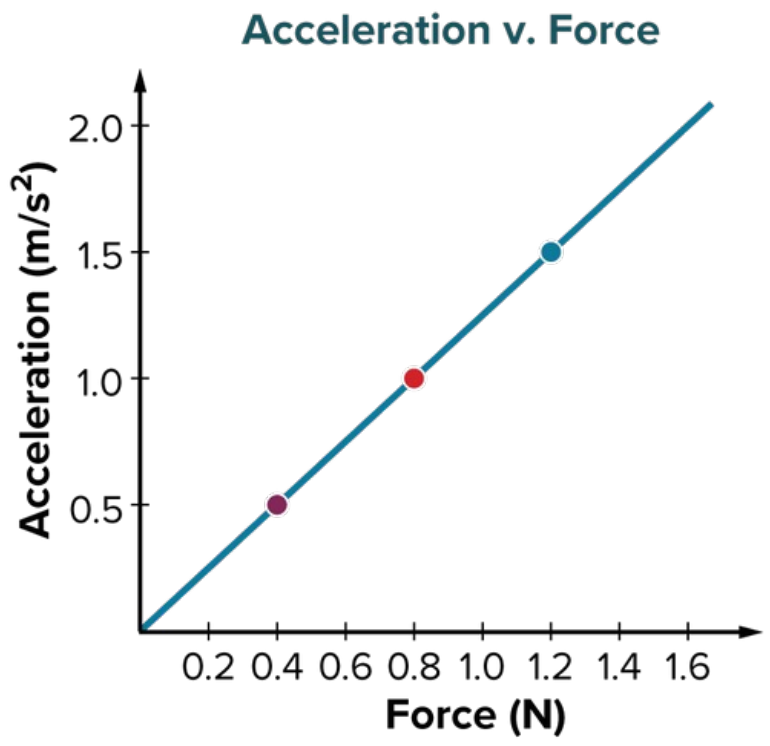
$$m = \frac{F_{\text{top rope on top block}} - F_{\text{bottom rope on top block}}}{g} = \frac{63.0\ \text{N} - 29\ \text{N}}{9.8\ \text{N/kg}} = 3.5\ \text{kg}$$

P(88)

8. Relate the direction of the acceleration to the direction of the net force

- The constant rate of change of velocity means the acceleration is constant
- This constant acceleration is a result of the constant unbalanced force applied by the spring scale to the cart.
- The graph indicates the relationship between force and acceleration is linear
- Acceleration is equal to the slope of the line multiplied by the applied net force





P(121)

9. Resolve a vector into two orthogonal vectors in a cartesian coordinate system.

11. **Vectors** Use **Figure 9** for these questions.

a. Find the components of vectors K, L, and M.

b. Find the sum of the three vectors.

c. Subtract vector K from vector L.

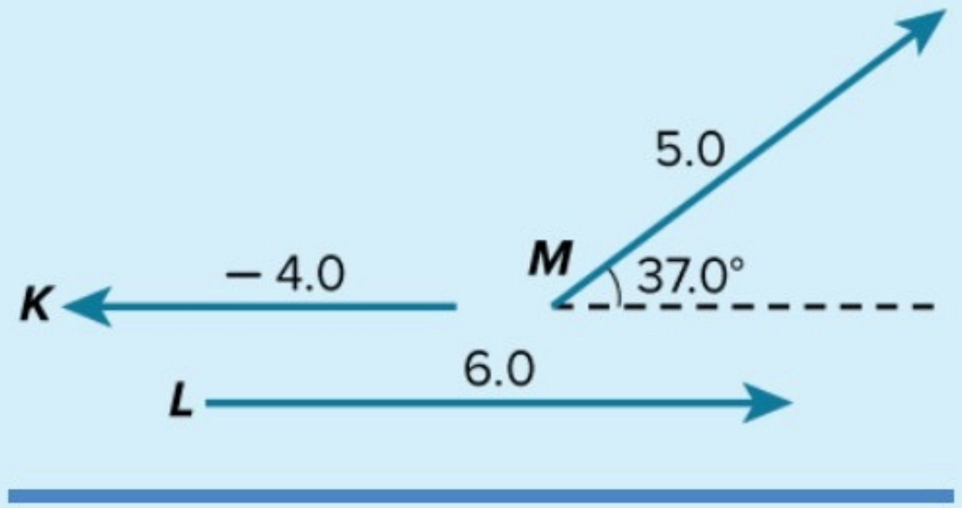


Figure 9

b

SOLUTION:

$R_x = K_x + L_x + M_x$

$= -4.0 + 6.0 + 5.0(\cos 37°)$

$= -4.0 + 6.0 + 4.0$

$= 6.0$

$R_y = K_y + L_y + M_y$

$= 0.0 + 0.0 + 5.0(\sin 37°)$

$= 3.0$

$R = \sqrt{R_x^2 + R_y^2}$

$= \sqrt{6.0^2 + 3.0^2}$

$= 6.7$

$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right)$

$= \tan^{-1}\left(\frac{3}{6}\right)$

$= 27°$

$R = 6.7$ at $27°$

c

SOLUTION:

$6.0 - (-4.0) = 10.0$ to the right

a

SOLUTION:

$M_x = m \cos \theta$

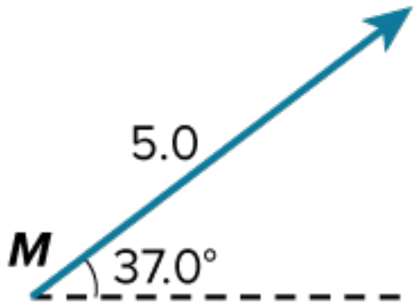
$= (5.0)(\cos 37.0°)$

$= 4.0$ to the right

$M_y = m \sin \theta$

$= (5.0)(\sin 37.0°)$

$= 3.0$ upward

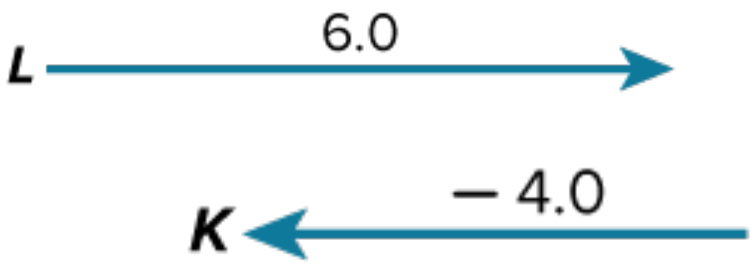


SOLUTION:

Both vectors are horizontal, so they do not have any y-component.

$K_x = -4.0$, $K_y = 0$

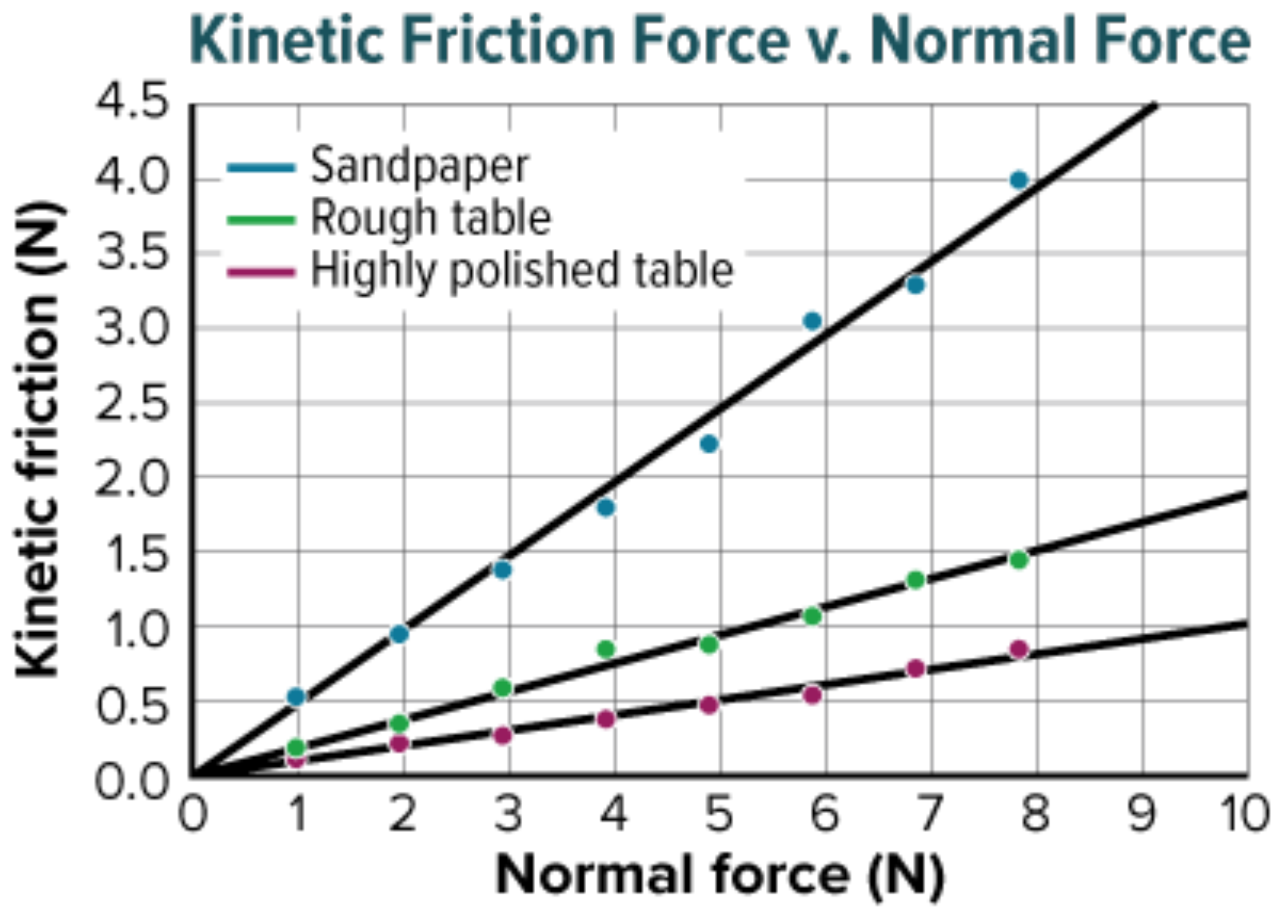
$L_x = 6.0$, $L_y = 0$



9. Resolve a vector into two orthogonal vectors in a cartesian coordinate system.

- A plot of **kinetic friction v. normal force** for a block pulled along different surfaces shows a **linear relationship** between the two forces for each surface.
- The slope of the line is μk .

  the slope must be related to the magnitude of the resulting friction force



P(125)

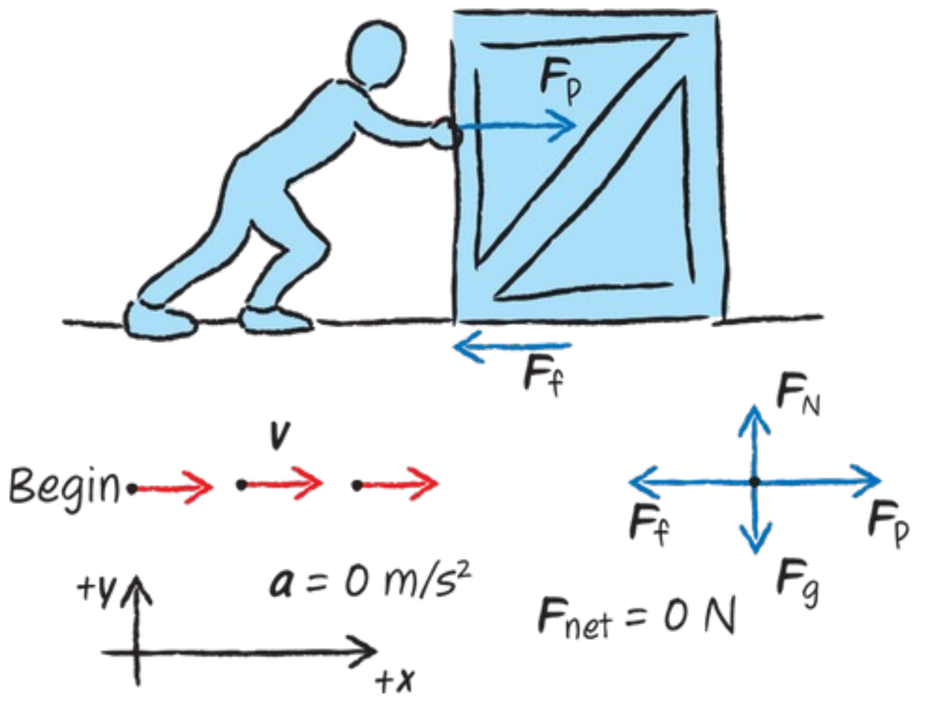
11. Apply the relationships that relate the normal force to maximum static friction and to kinetic friction to calculate unknown parameters like friction force, coefficient of friction or the normal force (Ff,static= μ sN and Ff,kinetic= μ kN).

BALANCED FRICTION FORCES You push a 25.0-kg wooden box across a wooden floor at a constant speed of 1.0 m/s. The coefficient of kinetic friction is 0.20. How large is the force that you exert on the box?

$$F_N = -F_g = -mg = -(25.0\ \text{kg})(-9.8\ \text{N/kg}) = +245\ \text{N}$$

$$F_{\text{person on box}} = \mu_k F_N = (0.20)(245\ \text{N}) = 49\ \text{N}$$

$F_{\text{person on box}}$ = 49 N, to the right



15. Gwen exerts a 36-N horizontal force as she pulls a 52-N sled across a cement sidewalk at constant speed. What is the coefficient of kinetic friction between the sidewalk and the metal sled runners? Ignore air resistance.

μk = Fk/Fn --> 36/52 = 0.69

16. Mr. Ames is dragging a box full of books from his office to his car. The box and books together have a combined weight of 134 N. If the coefficient of static friction between the pavement and the box is 0.55, how hard must Mr. Ames push horizontally on the box in order to start it moving?

Fs = μs x Fn --> 0.55 x 134 = 74 N

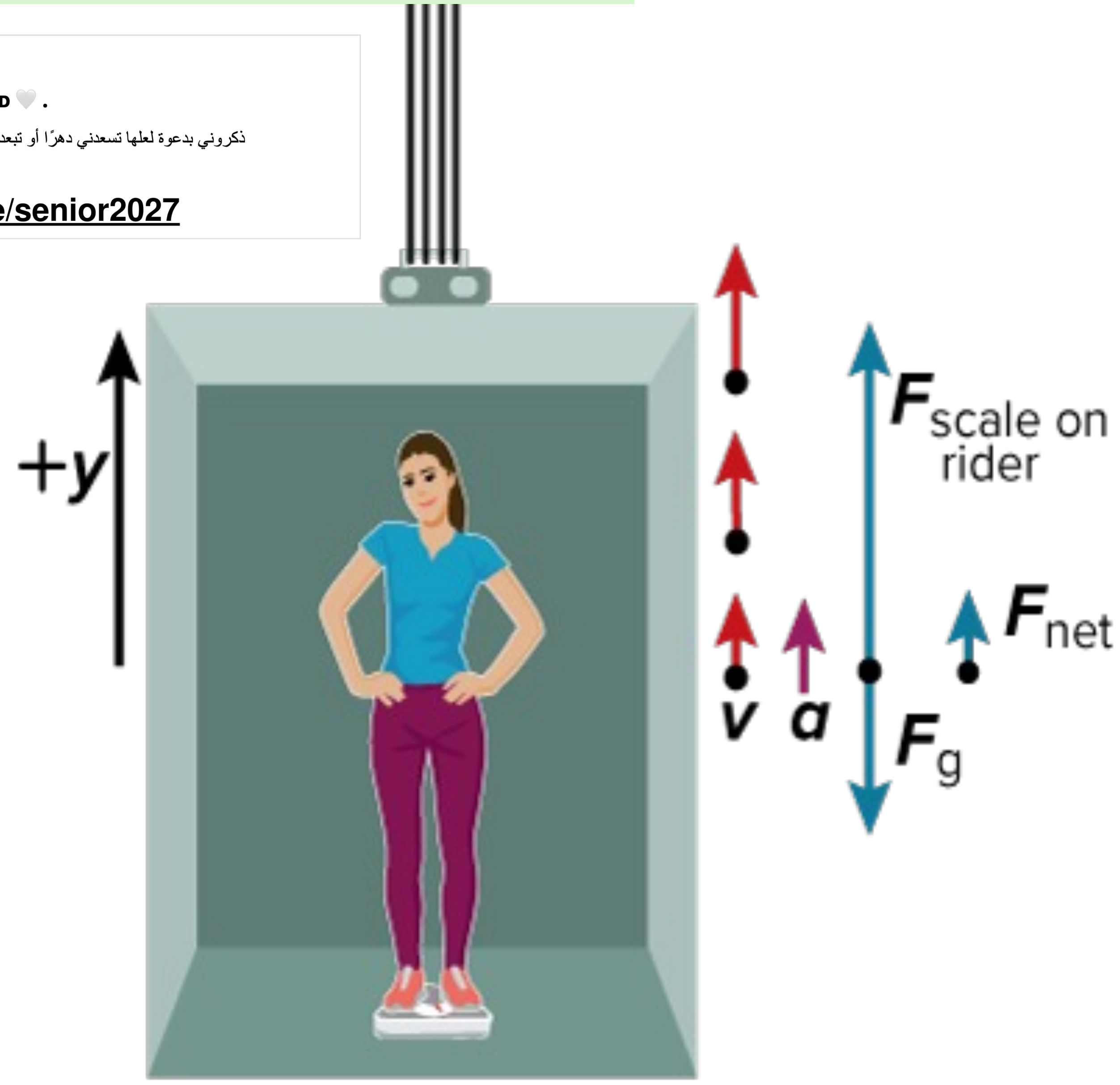
Start moving = STATIC FRICTION
Constant speed = KINETIC FRICTION

P(96-97)

12. Describe the apparent weight for an object accelerating vertically upward or downward (starts from rest, reaches a constant speed, then comes to a stop)

Your mass is 75.0 kg, and you are standing on a bathroom scale in an elevator. Starting from rest, the elevator accelerates upward at 2.00 m/s^2 for 2.00 s and then continues at a constant speed. Is the scale reading during acceleration greater than, equal to, or less than the scale reading when the elevator is at rest?

$$F_{scal} = m(a+g)$$
$$= 75\ (\ 2 + 9.8\ )$$
$$= 885\ N$$



P(131)

12. Describe the apparent weight for an object accelerating vertically upward or downward (starts from rest, reaches a constant speed, then comes to a stop)

COMPONENTS OF WEIGHT FOR AN OBJECT ON AN INCLINE A 562-N crate is resting on a plane inclined 30.0° above the horizontal. Find the components of the crate's weight that are parallel and perpendicular to the plane.

$$\theta + \phi = 270^\circ$$

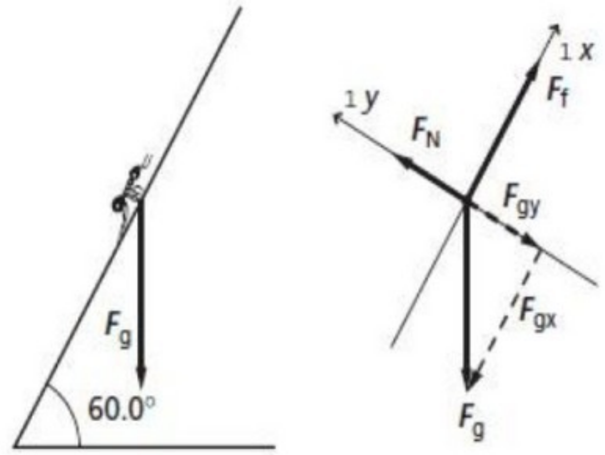
$$\theta = 270^\circ - 30^\circ = 240^\circ$$

$$F_{gx} = F_g(\cos\theta) = (562\text{ N})(\cos 240.0^\circ) = -281\text{ N}$$

$$F_{gy} = F_g(\sin\theta) = (562\text{ N})(\sin 240.0^\circ) = -487\text{ N}$$

29. An ant climbs at a steady speed up the side of its anthill, which is inclined 30.0° from the vertical. Sketch a free-body diagram for the ant.

SOLUTION:



30.0 from the vertical

90-30 = 60.0

31. Fernando, who has a mass of 43.0 kg, slides down the banister at his grandparents' house. If the banister makes an angle of 35.0° with the horizontal, what is the normal force between Fernando and the banister?

Fn= ?

Fn=mg cos (θ)

43x9.8 cos (35) = 345 N

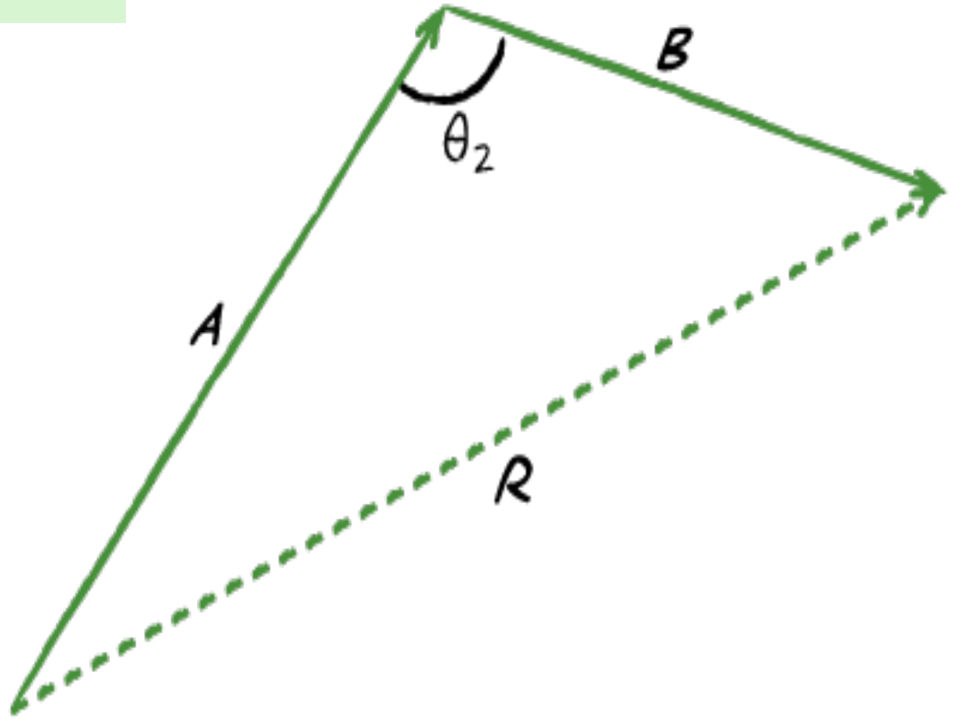
P(116)

14. Determine the magnitude and direction of the resultant of two vectors in two dimensions using trigonometry, the Pythagorean theorem (case of perpendicular vectors), and the laws of sines and cosines.

FINDING THE MAGNITUDE OF THE SUM OF TWO VECTORS Find the magnitude of the sum of a 15-km displacement and a 25-km displacement when the angle θ between them is 90° and when the angle θ between them is 135°.

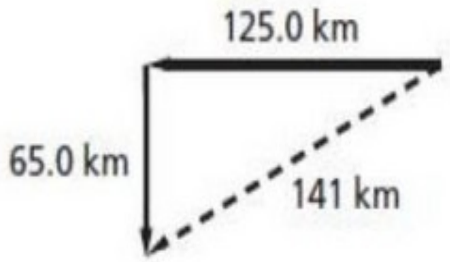
$$R_2 = A^2 + B^2$$
$$R_2 = \sqrt{A^2 + B^2}$$
$$= \sqrt{(25\text{ km})^2 + (15\text{ km})^2}$$
$$= 29\text{ km}$$

$$R_2 = A^2 + B^2 - 2AB(\cos\theta_2)$$
$$R = \sqrt{A^2 + B^2 - 2AB(\cos\theta_2)}$$
$$= \sqrt{(25\text{ km})^2 + (15\text{ km})^2 - 2(25\text{ km})(15\text{ km})(\cos 135°)}$$
$$= 37\text{ km}$$



1. You and your family are out for a drive. You drive 125.0 km due west, then turn due south and drive for another 65.0 km. What is the magnitude of your displacement? Solve this problem both graphically and mathematically, and check your answers against each other.

$$R^2 = A^2 + B^2$$
$$R = \sqrt{A^2 + B^2}$$
$$= \sqrt{(65.0\text{ km})^2 + (125.0\text{ km})^2}$$
$$= 141\text{ km}$$



2. On a fine, sunny day, you and your siblings decide to go for a nearby hike. You walk 4.5 km in one direction, then make a 45° turn to the right and walk another 6.4 km. What is the magnitude of your displacement?

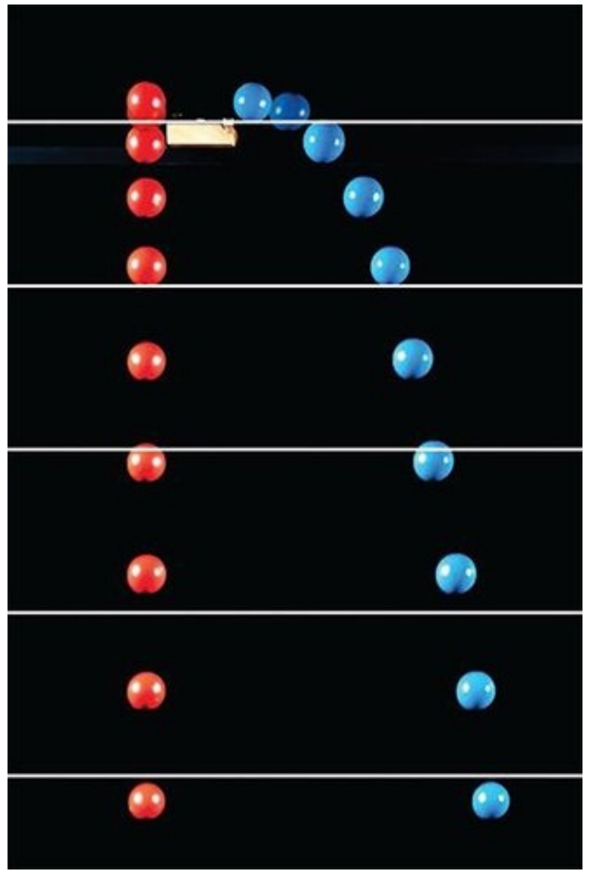
SOLUTION:

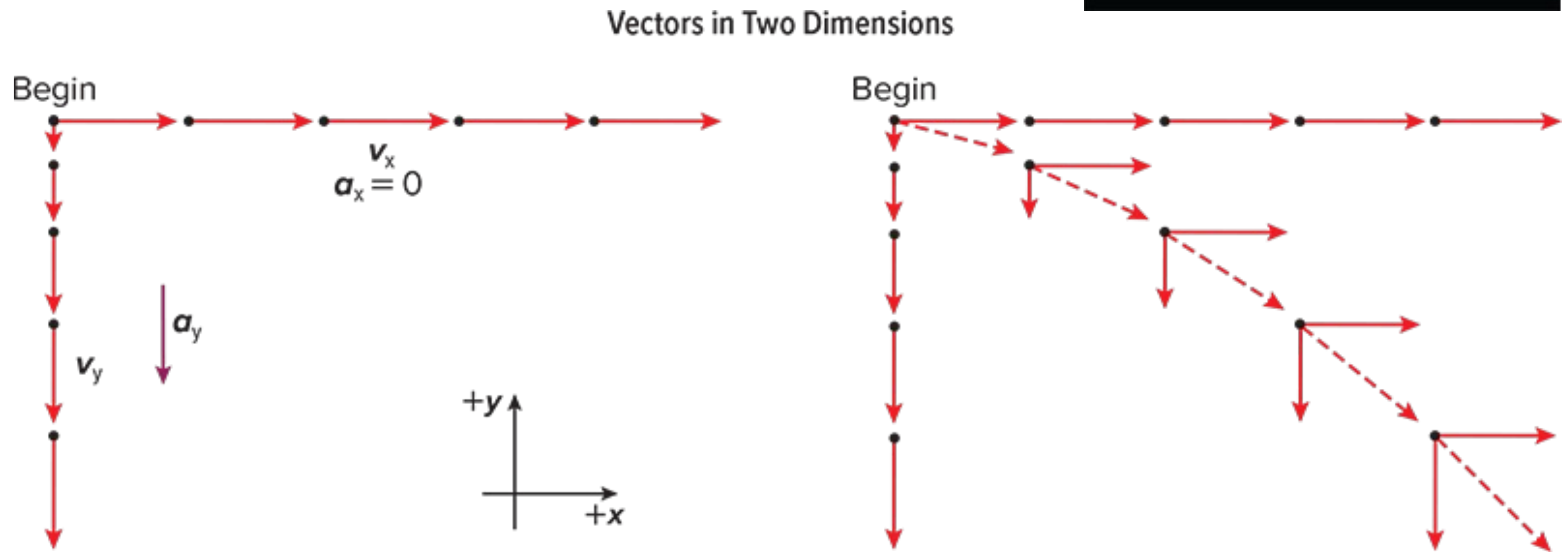
$$R^2 = A^2 + B^2 - 2AB\cos\theta$$
$$R = \sqrt{A^2 + B^2 - 2AB\cos\theta}$$
$$= \sqrt{(4.5\text{ km})^2 + (6.4\text{ km})^2 - 2(4.5\text{ km})(6.4\text{ km})(\cos 135°)}$$
$$= 1.0 \times 10^1\text{ km}$$

P(141-142)

15. Explain the motion of horizontally launched projectiles, and show schematically the components of velocity and acceleration

The object is moving in a downward parabolic path.
The vertical component of velocity (Vy) is increasing.
The horizontal component of velocity(Vx) is constant.
The vertical component of acceleration (ay)= -9.8m/s2
The horizontal component of acceleration (ax)=0 .





Writing Questions

P(90)

16. Demonstrate by experiments that acceleration of an object is directly proportional to the force applied and inversely proportional to the mass of the object State Newton's second law of motion and write it in equation form (a=Fnet/m)

- The net force acting on an object is the vector sum of all the forces acting on that object
- Newton's second law states that the acceleration of an object is proportional to the net force and inversely proportional to the mass of the object being accelerated.

11. CHALLENGE Two horizontal forces are exerted on a large crate. The first force is 317 N to the right. The second force is 173 N to the left.

a. Draw a force diagram for the horizontal forces acting on the crate.

b. What is the net force acting on the crate?

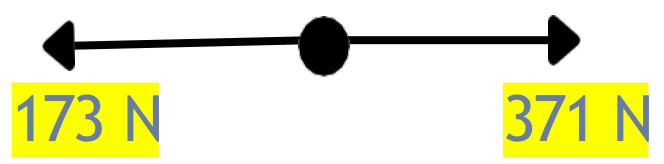
c. The box is initially at rest. Five seconds later, its velocity is 6.5 m/s to the right. What is the crate's mass?

Find a ?

$a = v / t \rightarrow 6.5 / 5 = 1.3$ m/s2

Find m ?

m = Fnet / a --> 144 / 1.3 = 110.8kg



Fnet = F1+ F2

371 - 173 = 144

P(113) 16. Demonstrate by experiments that acceleration of an object is directly proportional to the force applied and inversely proportional to the mass of the object State Newton's second law of motion and write it in equation form (a=Fnet/m)

33. Consider the crate on the incline in Example Problem 5. Calculate the magnitude of the acceleration. After 4.00 s, how fast will the crate be moving?

$$a = \frac{F}{m} = \frac{F_g \sin\theta}{m} = \frac{mg \sin\theta}{m} = g \sin\theta = (9.8\ \text{N/kg})(\sin 30.0°) = 4.90\ \text{m/s}^2$$

$$a = \frac{v_f - v_i}{t_f - t_i}; \text{ let } v_i = t_i = 0.$$

Solve for v_f.

$$v_f = at_f = (4.90\ \text{m/s}^2)(4.00\ \text{s}) = 19.6\ \text{m/s}$$

37. **Acceleration** A rope pulls a 63-kg water skier up a 14.0° incline with a tension of 512 N. The coefficient of kinetic friction between the skier and the ramp is 0.27. What are the magnitude and direction of the skier's acceleration?

$$F_N = mg\cos\theta$$

$$F_{\text{rope on skier}} - F_g - F_f = ma$$

$$F_{\text{rope on skier}} - mg\sin\theta - \mu_k mg\cos\theta = ma$$

$$a = \frac{F_{\text{rope on skier}} - mg\sin\theta - \mu_k mg\cos\theta}{m}$$

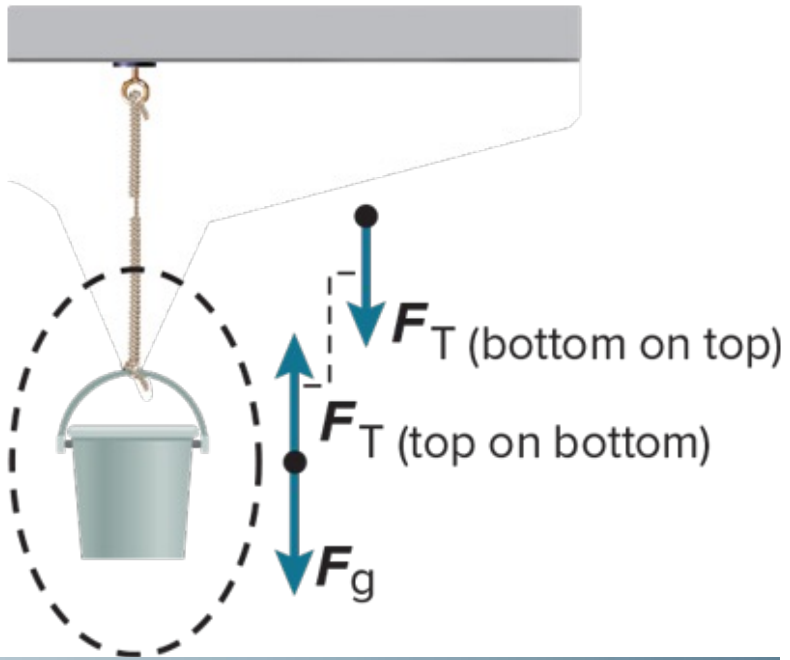
$$= \frac{512\text{N} - (63\ \text{kg})(9.8\ \text{N/kg})(\sin 14.0°) - (0.27)(63\ \text{kg})(9.8\ \text{N/kg})(\cos 14.0°)}{63\ \text{kg}}$$

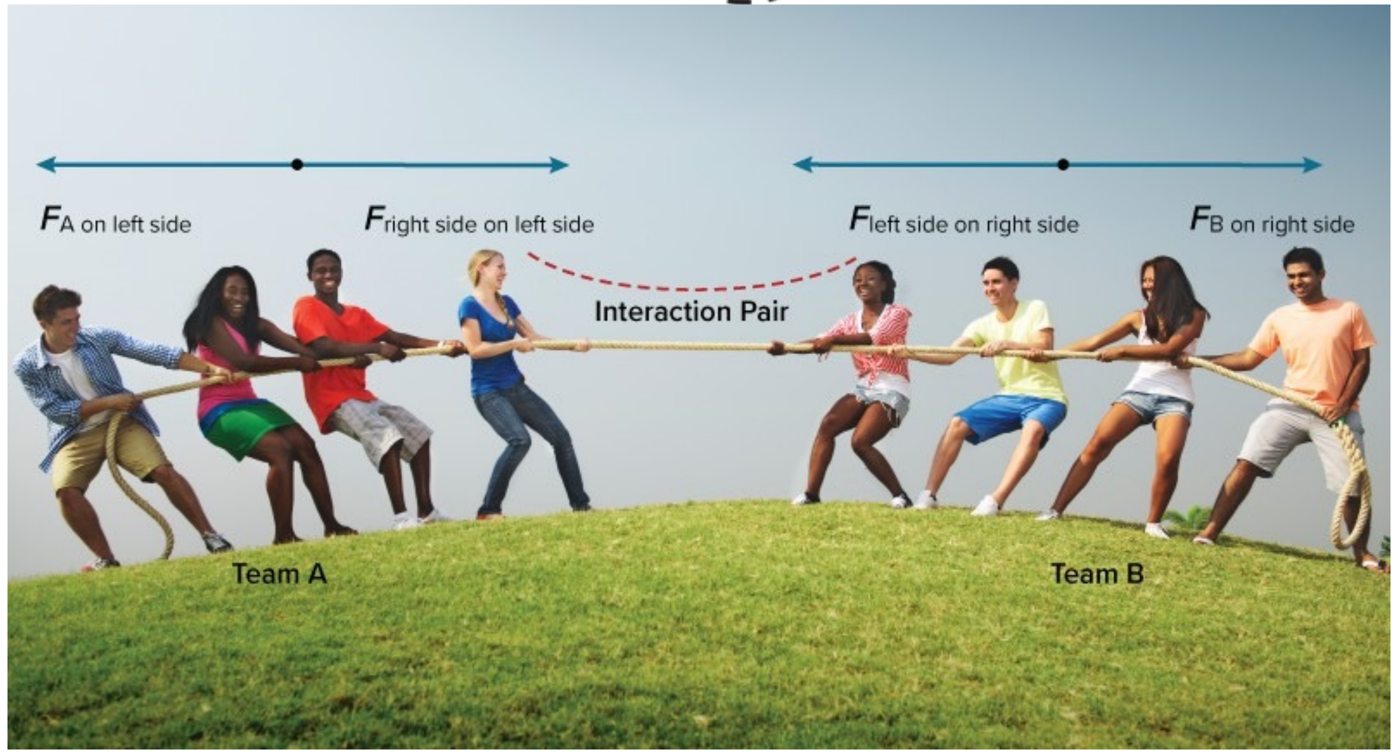
$$= 3.2\ \text{m/s}^2, \text{ up the incline}$$

P(103)

18. List the characteristics of the interaction pair and identify the action-reaction pairs for different situations

- The action and reaction forces have the same magnitude.
- They are opposite to each other.
- These two forces, act on different objects ; therefore, the two forces do not cancel each other .





P(104)

19. Apply Newton's laws to solve problems involving normal and tension forces including systems of objects connected by strings and Atwood's machine

A 50.0-kg bucket is being lifted by a rope. The rope will not break if the tension is 525 N or less. The bucket started at rest, and after being lifted 3.0 m, it moves at 3.0 m/s. If the acceleration is constant, is the rope in danger of breaking?

KNOWN		UNKNOWN
$m = 50.0\ \text{kg}$	$v_t = 3.0\ \text{m/s}$	$F_T = ?$
$v_i = 0.0\ \text{m/s}$	$d = 3.0\ m$	

$$F_{net} = F_T + (-Fg)$$

$$F_T = F_{net} + F_g = ma + mg$$

v_i, v_f, and d are known.

$$v_f^2 = v_i + 2ad$$

$$a = \frac{v_f^2 - v_i^2}{2d} = \frac{v_f^2}{2d}$$

$$F_T = ma + mg$$

$$= m\left(\frac{v_f^2}{2d}\right) + mg$$

$$= (50.0\ \text{kg})\left(\frac{(3.0\ \text{m/s})^2}{2\,(3.0\ \text{m})}\right) + (50.0\ \text{kg})\,(9.8\ \text{N/kg})$$

$$= 560\ \text{N}$$

P(144)

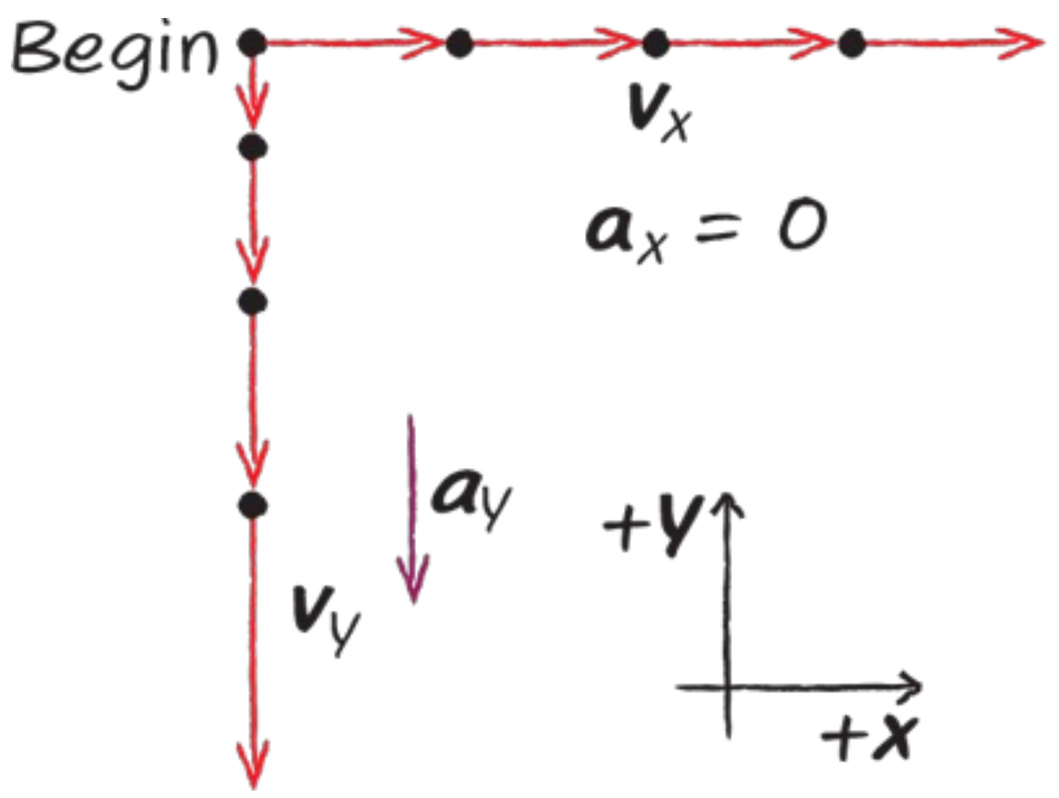
20. Explain the motion of projectiles launched at an angle with the horizontal, and show schematically the components of velocity and acceleration throughout the motion.

A SLIDING PLATE You are preparing breakfast and slide a plate on the countertop. Unfortunately, you slide it too fast, and it flies off the end of the countertop. If the countertop is 1.05 m above the floor and the plate leaves the top at 0.74 m/s, how long does it take to fall, and how far from the end of the counter does it land?

$$y_f = y_i + \frac{1}{2}a_y t^2$$

$$t = \sqrt{\frac{2(y_f - y_i)}{a_y}}$$

$$= \sqrt{\frac{2(-1.05\text{ m} - 0\text{ m})}{-9.8\text{ m/s}^2}} = 0.46\text{ s}$$



P(144)

20. Explain the motion of projectiles launched at an angle with the horizontal, and show schematically the components of velocity and acceleration throughout the motion.

1. You throw a stone horizontally at a speed of 5.0 m/s from the top of a cliff that is 78.4 m high.

a. How long does it take the stone to reach the bottom of the cliff?

b. How far from the base of the cliff does the stone hit the ground?

c. What are the horizontal and vertical components of the stone's velocity just before it hits the ground?

a

yf=(yi)+(viy)+(1/2)(a)(tf)
0=78.4+0+1/2-9.8xtf
t=4.00s

b

xf= vix tf +xi
xf-xi = (vix) (tf)
= 5 x 4 =20

c

vf = vi + at
vyf = viy + (a)(t)
= 0-9.8x4
-39.2

P(144)

20. Explain the motion of projectiles launched at an angle with the horizontal, and show schematically the components of velocity and acceleration throughout the motion.

2. Lucy and her friend are working at an assembly plant making wooden toy giraffes. At the end of the line, the giraffes go horizontally off the edge of a conveyor belt and fall into a box below. If the box is 0.60 m below the level of the conveyor belt and 0.40 m away from it, what must be the horizontal velocity of giraffes as they leave the conveyor belt?

$$x = v_x t = v_x\sqrt{\frac{-2y}{g}}$$

$$\text{so } v_x = \frac{x}{\sqrt{\frac{-2y}{g}}}$$

$$= \frac{0.4\text{ m}}{\sqrt{\frac{(-2)(-0.6\text{ m})}{9.80\text{ m/s}^2}}}$$

$$= 1\text{ m/s}$$