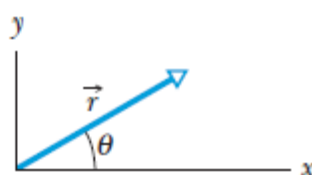


## VECTORS

•1 **SSM** What are (a) the  $x$  component and (b) the  $y$  component of a vector  $\vec{a}$  in the  $xy$  plane if its direction is  $250^\circ$  counterclockwise from the positive direction of the  $x$  axis and its magnitude is  $7.3\text{ m}$ ?

•2 A displacement vector  $\vec{r}$  in the  $xy$  plane is  $15\text{ m}$  long and directed at angle  $\theta = 30^\circ$  in Fig. 3-26. Determine (a) the  $x$  component and (b) the  $y$  component of the vector.



**Figure 3-26**  
Problem 2.

•3 **SSM** The  $x$  component of vector  $\vec{A}$  is  $-25.0\text{ m}$  and the  $y$  component is  $+40.0\text{ m}$ . (a) What is the magnitude of  $\vec{A}$ ? (b) What is the angle between the direction of  $\vec{A}$  and the positive direction of  $x$ ?

•4 Express the following angles in radians: (a)  $20.0^\circ$ , (b)  $50.0^\circ$ , (c)  $100^\circ$ . Convert the following angles to degrees: (d)  $0.330\text{ rad}$ , (e)  $2.10\text{ rad}$ , (f)  $7.70\text{ rad}$ .

•9 Two vectors are given by

$$\vec{a} = (4.0\text{ m})\hat{i} - (3.0\text{ m})\hat{j} + (1.0\text{ m})\hat{k}$$

and 
$$\vec{b} = (-1.0\text{ m})\hat{i} + (1.0\text{ m})\hat{j} + (4.0\text{ m})\hat{k}.$$

In unit-vector notation, find (a)  $\vec{a} + \vec{b}$ , (b)  $\vec{a} - \vec{b}$ , and (c) a third vector  $\vec{c}$  such that  $\vec{a} - \vec{b} + \vec{c} = 0$ .

•10 Find the (a)  $x$ , (b)  $y$ , and (c)  $z$  components of the sum  $\vec{r}$  of the displacements  $\vec{c}$  and  $\vec{d}$  whose components in meters are  $c_x = 7.4, c_y = -3.8, c_z = -6.1; d_x = 4.4, d_y = -2.0, d_z = 3.3$ .

•11 **SSM** (a) In unit-vector notation, what is the sum  $\vec{a} + \vec{b}$  if  $\vec{a} = (4.0\text{ m})\hat{i} + (3.0\text{ m})\hat{j}$  and  $\vec{b} = (-13.0\text{ m})\hat{i} + (7.0\text{ m})\hat{j}$ ? What are the (b) magnitude and (c) direction of  $\vec{a} + \vec{b}$ ?

•33 For the vectors in Fig. 3-32, with  $a = 4$ ,  $b = 3$ , and  $c = 5$ , what are (a) the magnitude and (b) the direction of  $\vec{a} \times \vec{b}$ , (c) the magnitude and (d) the direction of  $\vec{a} \times \vec{c}$ , and (e) the magnitude and (f) the direction of  $\vec{b} \times \vec{c}$ ? (The  $z$  axis is not shown.)

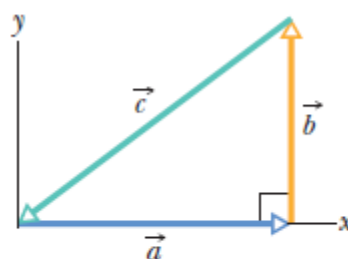


Figure 3-32  
Problems 33 and 54.

•34 Two vectors are presented as  $\vec{a} = 3.0\hat{i} + 5.0\hat{j}$  and  $\vec{b} = 2.0\hat{i} + 4.0\hat{j}$ . Find (a)  $\vec{a} \times \vec{b}$ , (b)  $\vec{a} \cdot \vec{b}$ , (c)  $(\vec{a} + \vec{b}) \cdot \vec{b}$ , and (d) the component of  $\vec{a}$  along the direction of  $\vec{b}$ . (Hint: For (d), consider Eq. 3-20 and Fig. 3-18.)

•35 Two vectors,  $\vec{r}$  and  $\vec{s}$ , lie in the  $xy$  plane. Their magnitudes are 4.50 and 7.30 units, respectively, and their directions are  $320^\circ$  and  $85.0^\circ$ , respectively, as measured counterclockwise from the positive  $x$  axis. What are the values of (a)  $\vec{r} \cdot \vec{s}$  and (b)  $\vec{r} \times \vec{s}$ ?

••38 GO For the following three vectors, what is  $3\vec{C} \cdot (2\vec{A} \times \vec{B})$ ?

$$\vec{A} = 2.00\hat{i} + 3.00\hat{j} - 4.00\hat{k}$$

$$\vec{B} = -3.00\hat{i} + 4.00\hat{j} + 2.00\hat{k} \quad \vec{C} = 7.00\hat{i} - 8.00\hat{j}$$

••39 Vector  $\vec{A}$  has a magnitude of 6.00 units, vector  $\vec{B}$  has a magnitude of 7.00 units, and  $\vec{A} \cdot \vec{B}$  has a value of 14.0. What is the angle between the directions of  $\vec{A}$  and  $\vec{B}$ ?

## MOTION IN ONE DIMENSION

**1** Figure 2-16 gives the velocity of a particle moving on an  $x$  axis. What are (a) the initial and (b) the final directions of travel? (c) Does the particle stop momentarily? (d) Is the acceleration positive or negative? (e) Is it constant or varying?

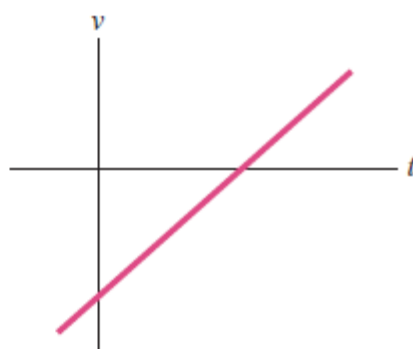


Figure 2-16 Question 1.

**2** Figure 2-17 gives the acceleration  $a(t)$  of a Chihuahua as it chases a German shepherd along an axis. In which of the time periods indicated does the Chihuahua move at constant speed?

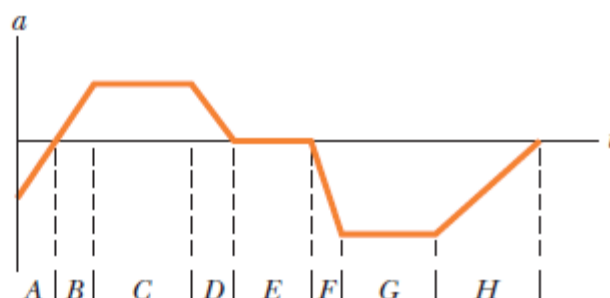


Figure 2-17 Question 2.

**5** Figure 2-20 gives the velocity of a particle moving along an axis. Point 1 is at the highest point on the curve; point 4 is at the lowest point; and points 2 and 6 are at the same height. What is the direction of travel at (a) time  $t = 0$  and (b) point 4? (c) At which of the six numbered points does the particle reverse its direction of travel? (d) Rank the six points according to the magnitude of the acceleration, greatest first.

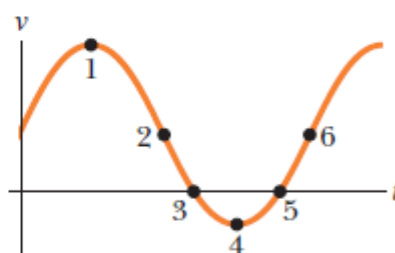


Figure 2-20 Question 5.

**11** Figure 2-23 shows that a particle moving along an  $x$  axis undergoes three periods of acceleration. Without written computation, rank the acceleration periods according to the increases they produce in the particle's velocity, greatest first.

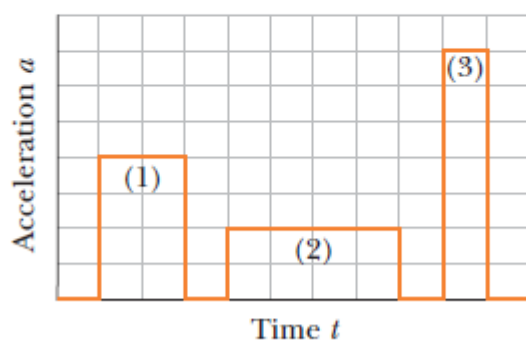




Figure 2-23 Question 11.

- 2 Compute your average velocity in the following two cases: (a) You walk 73.2 m at a speed of 1.22 m/s and then run 73.2 m at a speed of 3.05 m/s along a straight track. (b) You walk for 1.00 min at a speed of 1.22 m/s and then run for 1.00 min at 3.05 m/s along a straight track. (c) Graph  $x$  versus  $t$  for both cases and indicate how the average velocity is found on the graph.
- 4 A car moves uphill at 40 km/h and then back downhill at 60 km/h. What is the average speed for the round trip?
- 5 **SSM** The position of an object moving along an  $x$  axis is given by  $x = 3t - 4t^2 + t^3$ , where  $x$  is in meters and  $t$  in seconds. Find the position of the object at the following values of  $t$ : (a) 1 s, (b) 2 s, (c) 3 s, and (d) 4 s. (e) What is the object's displacement between  $t = 0$  and  $t = 4$  s? (f) What is its average velocity for the time interval from  $t = 2$  s to  $t = 4$  s? (g) Graph  $x$  versus  $t$  for  $0 \leq t \leq 4$  s and indicate how the answer for (f) can be found on the graph.

•14  An electron moving along the  $x$  axis has a position given by  $x = 16te^{-t}$  m, where  $t$  is in seconds. How far is the electron from the origin when it momentarily stops?

•15  (a) If a particle's position is given by  $x = 4 - 12t + 3t^2$  (where  $t$  is in seconds and  $x$  is in meters), what is its velocity at  $t = 1$  s? (b) Is it moving in the positive or negative direction of  $x$  just then? (c) What is its speed just then? (d) Is the speed increasing or decreasing just then? (Try answering the next two questions without further calculation.) (e) Is there ever an instant when the velocity is zero? If so, give the time  $t$ ; if not, answer no. (f) Is there a time after  $t = 3$  s when the particle is moving in the negative direction of  $x$ ? If so, give the time  $t$ ; if not, answer no.

•16 The position function  $x(t)$  of a particle moving along an  $x$  axis is  $x = 4.0 - 6.0t^2$ , with  $x$  in meters and  $t$  in seconds. (a) At what time and (b) where does the particle (momentarily) stop? At what (c) negative time and (d) positive time does the particle pass through the origin? (e) Graph  $x$  versus  $t$  for the range  $-5$  s to  $+5$  s. (f) To shift the curve rightward on the graph, should we include the term  $+20t$  or the term  $-20t$  in  $x(t)$ ? (g) Does that inclusion increase or decrease the value of  $x$  at which the particle momentarily stops?

•17 The position of a particle moving along the  $x$  axis is given in centimeters by  $x = 9.75 + 1.50t^3$ , where  $t$  is in seconds. Calculate (a) the average velocity during the time interval  $t = 2.00$  s to  $t = 3.00$  s; (b) the instantaneous velocity at  $t = 2.00$  s; (c) the instantaneous velocity at  $t = 3.00$  s; (d) the instantaneous velocity at  $t = 2.50$  s; and (e) the instantaneous velocity when the particle is midway between its positions at  $t = 2.00$  s and  $t = 3.00$  s. (f) Graph  $x$  versus  $t$  and indicate your answers graphically.



•18 The position of a particle moving along an  $x$  axis is given by  $x = 12t^2 - 2t^3$ , where  $x$  is in meters and  $t$  is in seconds. Determine (a) the position, (b) the velocity, and (c) the acceleration of the particle at  $t = 3.0$  s. (d) What is the maximum positive coordinate reached by the particle and (e) at what time is it reached? (f) What is the maximum positive velocity reached by the particle and (g) at what time is it reached? (h) What is the acceleration of the particle at the instant the particle is not moving (other than at  $t = 0$ )? (i) Determine the average velocity of the particle between  $t = 0$  and  $t = 3$  s.

•19 **SSM** At a certain time a particle had a speed of 18 m/s in the positive  $x$  direction, and 2.4 s later its speed was 30 m/s in the opposite direction. What is the average acceleration of the particle during this 2.4 s interval?

•20 (a) If the position of a particle is given by  $x = 20t - 5t^3$ , where  $x$  is in meters and  $t$  is in seconds, when, if ever, is the particle's velocity zero? (b) When is its acceleration  $a$  zero? (c) For what time range (positive or negative) is  $a$  negative? (d) Positive? (e) Graph  $x(t)$ ,  $v(t)$ , and  $a(t)$ .

•25 An electric vehicle starts from rest and accelerates at a rate of  $2.0 \text{ m/s}^2$  in a straight line until it reaches a speed of 20 m/s. The vehicle then slows at a constant rate of  $1.0 \text{ m/s}^2$  until it stops. (a) How much time elapses from start to stop? (b) How far does the vehicle travel from start to stop?

•30 The brakes on your car can slow you at a rate of  $5.2 \text{ m/s}^2$ . (a) If you are going 137 km/h and suddenly see a state trooper, what is the minimum time in which you can get your car under the 90 km/h speed limit? (The answer reveals the futility of braking to keep your high speed from being detected with a radar or laser gun.) (b) Graph  $x$  versus  $t$  and  $v$  versus  $t$  for such a slowing.

•37 Figure 2-29 depicts the motion of a particle moving along an  $x$  axis with a constant acceleration. The figure's vertical scaling is set by  $x_s = 6.0 \text{ m}$ . What are the (a) magnitude and (b) direction of the particle's acceleration?

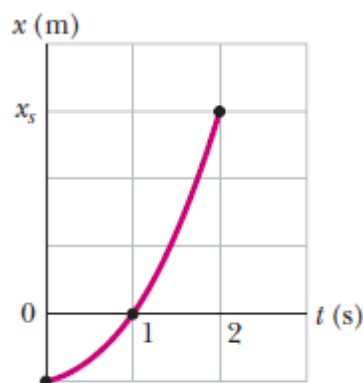


Figure 2-29 Problem 37.

•45 **SSM** **WWW** (a) With what speed must a ball be thrown vertically from ground level to rise to a maximum height of 50 m? (b) How long will it be in the air? (c) Sketch graphs of  $y$ ,  $v$ , and  $a$  versus  $t$  for the ball. On the first two graphs, indicate the time at which 50 m is reached.

•46 Raindrops fall 1700 m from a cloud to the ground. (a) If they were not slowed by air resistance, how fast would the drops be moving when they struck the ground? (b) Would it be safe to walk outside during a rainstorm?

•49 **SSM** A hot-air balloon is ascending at the rate of 12 m/s and is 80 m above the ground when a package is dropped over the side. (a) How long does the package take to reach the ground? (b) With what speed does it hit the ground?

## MOTION IN TWO DIMENSIONS

- 3 A positron undergoes a displacement  $\Delta\vec{r} = 2.0\hat{i} - 3.0\hat{j} + 6.0\hat{k}$ , ending with the position vector  $\vec{r} = 3.0\hat{j} - 4.0\hat{k}$ , in meters. What was the positron's initial position vector?
  
- 5 **SSM** A train at a constant 60.0 km/h moves east for 40.0 min, then in a direction  $50.0^\circ$  east of due north for 20.0 min, and then west for 50.0 min. What are the (a) magnitude and (b) angle of its average velocity during this trip?
  
- 6 An electron's position is given by  $\vec{r} = 3.00t\hat{i} - 4.00t^2\hat{j} + 2.00\hat{k}$ , with  $t$  in seconds and  $\vec{r}$  in meters. (a) In unit-vector notation, what is the electron's velocity  $\vec{v}(t)$ ? At  $t = 2.00$  s, what is  $\vec{v}$  (b) in unit-vector notation and as (c) a magnitude and (d) an angle relative to the positive direction of the  $x$  axis?
  
- 7 An ion's position vector is initially  $\vec{r} = 5.0\hat{i} - 6.0\hat{j} + 2.0\hat{k}$ , and 10 s later it is  $\vec{r} = -2.0\hat{i} + 8.0\hat{j} - 2.0\hat{k}$ , all in meters. In unit-vector notation, what is its  $\vec{v}_{\text{avg}}$  during the 10 s?
  
- 11 **GO** The position  $\vec{r}$  of a particle moving in an  $xy$  plane is given by  $\vec{r} = (2.00t^3 - 5.00t)\hat{i} + (6.00 - 7.00t^4)\hat{j}$ , with  $\vec{r}$  in meters and  $t$  in seconds. In unit-vector notation, calculate (a)  $\vec{r}$ , (b)  $\vec{v}$ , and (c)  $\vec{a}$  for  $t = 2.00$  s. (d) What is the angle between the positive direction of the  $x$  axis and a line tangent to the particle's path at  $t = 2.00$  s?
  
- 12 At one instant a bicyclist is 40.0 m due east of a park's flagpole, going due south with a speed of 10.0 m/s. Then 30.0 s later, the cyclist is 40.0 m due north of the flagpole, going due east with a speed of 10.0 m/s. For the cyclist in this 30.0 s interval, what are the (a) magnitude and (b) direction of the displacement, the (c) magnitude and (d) direction of the average velocity, and the (e) magnitude and (f) direction of the average acceleration?
  
- 13 **SSM** A particle moves so that its position (in meters) as a function of time (in seconds) is  $\vec{r} = \hat{i} + 4t^2\hat{j} + t\hat{k}$ . Write expressions for (a) its velocity and (b) its acceleration as functions of time.
  
- 14 A proton initially has  $\vec{v} = 4.0\hat{i} - 2.0\hat{j} + 3.0\hat{k}$  and then 4.0 s later has  $\vec{v} = -2.0\hat{i} - 2.0\hat{j} + 5.0\hat{k}$  (in meters per second). For that 4.0 s, what are (a) the proton's average acceleration  $\vec{a}_{\text{avg}}$  in unit-vector notation, (b) the magnitude of  $\vec{a}_{\text{avg}}$ , and (c) the angle between  $\vec{a}_{\text{avg}}$  and the positive direction of the  $x$  axis?



**•15** **SSM** **ILW** A particle leaves the origin with an initial velocity  $\vec{v} = (3.00\hat{i})$  m/s and a constant acceleration  $\vec{a} = (-1.00\hat{i} - 0.500\hat{j})$  m/s<sup>2</sup>. When it reaches its maximum  $x$  coordinate, what are its (a) velocity and (b) position vector?

**•16** **GO** The velocity  $\vec{v}$  of a particle moving in the  $xy$  plane is given by  $\vec{v} = (6.0t - 4.0t^2)\hat{i} + 8.0\hat{j}$ , with  $\vec{v}$  in meters per second and  $t$  ( $> 0$ ) in seconds. (a) What is the acceleration when  $t = 3.0$  s? (b) When (if ever) is the acceleration zero? (c) When (if ever) is the velocity zero? (d) When (if ever) does the speed equal 10 m/s?

**•22** A small ball rolls horizontally off the edge of a tabletop that is 1.20 m high. It strikes the floor at a point 1.52 m horizontally from the table edge. (a) How long is the ball in the air? (b) What is its speed at the instant it leaves the table?

**•23** A projectile is fired horizontally from a gun that is 45.0 m above flat ground, emerging from the gun with a speed of 250 m/s. (a) How long does the projectile remain in the air? (b) At what horizontal distance from the firing point does it strike the ground? (c) What is the magnitude of the vertical component of its velocity as it strikes the ground?

**•56** An Earth satellite moves in a circular orbit 640 km (uniform circular motion) above Earth's surface with a period of 98.0 min. What are (a) the speed and (b) the magnitude of the centripetal acceleration of the satellite?

**•57** A carnival merry-go-round rotates about a vertical axis at a constant rate. A man standing on the edge has a constant speed of 3.66 m/s and a centripetal acceleration  $\vec{a}$  of magnitude 1.83 m/s<sup>2</sup>. Position vector  $\vec{r}$  locates him relative to the rotation axis. (a) What is the magnitude of  $\vec{r}$ ? What is the direction of  $\vec{r}$  when  $\vec{a}$  is directed (b) due east and (c) due south?

**•58** A rotating fan completes 1200 revolutions every minute. Consider the tip of a blade, at a radius of 0.15 m. (a) Through what distance does the tip move in one revolution? What are (b) the tip's speed and (c) the magnitude of its acceleration? (d) What is the period of the motion?

## FORCE AND NEWTON'S LAWS

•2 Two horizontal forces act on a 2.0 kg chopping block that can slide over a frictionless kitchen counter, which lies in an  $xy$  plane. One force is  $\vec{F}_1 = (3.0 \text{ N})\hat{i} + (4.0 \text{ N})\hat{j}$ . Find the acceleration of the chopping block in unit-vector notation when the other force is (a)  $\vec{F}_2 = (-3.0 \text{ N})\hat{i} + (-4.0 \text{ N})\hat{j}$ , (b)  $\vec{F}_2 = (-3.0 \text{ N})\hat{i} + (4.0 \text{ N})\hat{j}$ , and (c)  $\vec{F}_2 = (3.0 \text{ N})\hat{i} + (-4.0 \text{ N})\hat{j}$ .


•3 If the 1 kg standard body has an acceleration of  $2.00 \text{ m/s}^2$  at  $20.0^\circ$  to the positive direction of an  $x$  axis, what are (a) the  $x$  component and (b) the  $y$  component of the net force acting on the body, and (c) what is the net force in unit-vector notation?

••8 A 2.00 kg object is subjected to three forces that give it an acceleration  $\vec{a} = -(8.00 \text{ m/s}^2)\hat{i} + (6.00 \text{ m/s}^2)\hat{j}$ . If two of the three forces are  $\vec{F}_1 = (30.0 \text{ N})\hat{i} + (16.0 \text{ N})\hat{j}$  and  $\vec{F}_2 = -(12.0 \text{ N})\hat{i} + (8.00 \text{ N})\hat{j}$ , find the third force.

## WORK AND KINETIC ENERGY

•8 A ice block floating in a river is pushed through a displacement  $\vec{d} = (15 \text{ m})\hat{i} - (12 \text{ m})\hat{j}$  along a straight embankment by rushing water, which exerts a force  $\vec{F} = (210 \text{ N})\hat{i} - (150 \text{ N})\hat{j}$  on the block. How much work does the force do on the block during the displacement?

•11 A 12.0 N force with a fixed orientation does work on a particle as the particle moves through the three-dimensional displacement  $\vec{d} = (2.00\hat{i} - 4.00\hat{j} + 3.00\hat{k}) \text{ m}$ . What is the angle between the force and the displacement if the change in the particle's kinetic energy is (a) +30.0 J and (b) -30.0 J?

•15  Figure 7-28 shows three forces applied to a trunk that moves leftward by 3.00 m over a frictionless floor. The force magnitudes are  $F_1 = 5.00 \text{ N}$ ,  $F_2 = 9.00 \text{ N}$ , and  $F_3 = 3.00 \text{ N}$ , and the indicated angle is  $\theta = 60.0^\circ$ . During the displacement, (a) what is the net work done on the trunk by the three forces and (b) does the kinetic energy of the trunk increase or decrease?

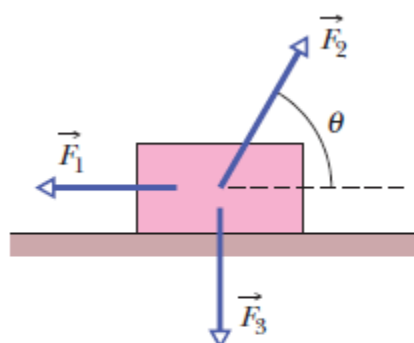





Figure 7-28 Problem 15.

•31   The only force acting on a 2.0 kg body as it moves along a positive  $x$  axis has an  $x$  component  $F_x = -6x \text{ N}$ , with  $x$  in meters. The velocity at  $x = 3.0 \text{ m}$  is 8.0 m/s. (a) What is the velocity of the body at  $x = 4.0 \text{ m}$ ? (b) At what positive value of  $x$  will the body have a velocity of 5.0 m/s?

•34  A 10 kg brick moves along an  $x$  axis. Its acceleration as a function of its position is shown in Fig. 7-38. The scale of the figure's vertical axis is set by  $a_s = 20.0 \text{ m/s}^2$ . What is the net work performed on the brick by the force causing the acceleration as the brick moves from  $x = 0$  to  $x = 8.0 \text{ m}$ ?

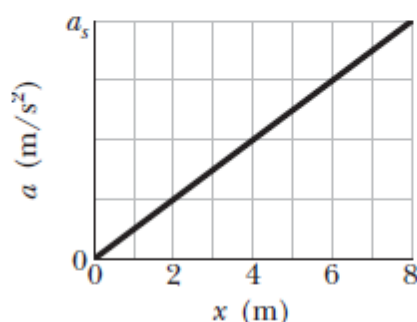


Figure 7-38 Problem 34.

•36 **GO** A 5.0 kg block moves in a straight line on a horizontal frictionless surface under the influence of a force that varies with position as shown in Fig. 7-39. The scale of the figure's vertical axis is set by  $F_s = 10.0$  N. How much work is done by the force as the block moves from the origin to  $x = 8.0$  m?

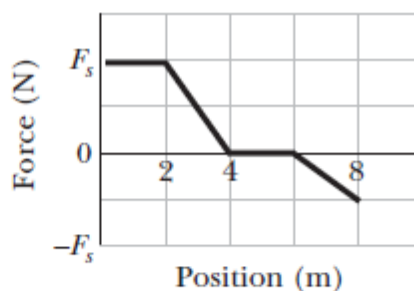


Figure 7-39 Problem 36.

•37 **GO** Figure 7-40 gives the acceleration of a 2.00 kg particle as an applied force  $\vec{F}_a$  moves it from rest along an  $x$  axis from  $x = 0$  to  $x = 9.0$  m. The scale of the figure's vertical axis is set by  $a_s = 6.0$  m/s<sup>2</sup>. How much work has the force done on the particle when the particle reaches (a)  $x = 4.0$  m, (b)  $x = 7.0$  m, and (c)  $x = 9.0$  m? What is the particle's speed and direction of travel when it reaches (d)  $x = 4.0$  m, (e)  $x = 7.0$  m, and (f)  $x = 9.0$  m?

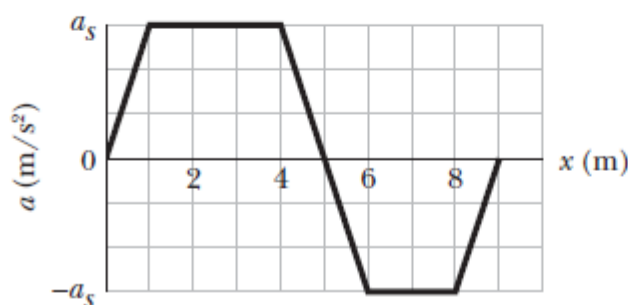


Figure 7-40 Problem 37.

•38 A 1.5 kg block is initially at rest on a horizontal frictionless surface when a horizontal force along an  $x$  axis is applied to the block. The force is given by  $\vec{F}(x) = (2.5 - x^2)\hat{i}$  N, where  $x$  is in meters and the initial position of the block is  $x = 0$ . (a) What is the kinetic energy of the block as it passes through  $x = 2.0$  m? (b) What is the maximum kinetic energy of the block between  $x = 0$  and  $x = 2.0$  m?

•39 **GO** A force  $\vec{F} = (cx - 3.00x^2)\hat{i}$  acts on a particle as the particle moves along an  $x$  axis, with  $\vec{F}$  in newtons,  $x$  in meters, and  $c$  a constant. At  $x = 0$ , the particle's kinetic energy is 20.0 J; at  $x = 3.00$  m, it is 11.0 J. Find  $c$ .

•43 **SSM** A force of 5.0 N acts on a 15 kg body initially at rest. Compute the work done by the force in (a) the first, (b) the second, and (c) the third seconds and (d) the instantaneous power due to the force at the end of the third second.

**•45 SSM ILW** A 100 kg block is pulled at a constant speed of 5.0 m/s across a horizontal floor by an applied force of 122 N directed  $37^\circ$  above the horizontal. What is the rate at which the force does work on the block?

**•46** The loaded cab of an elevator has a mass of  $3.0 \times 10^3$  kg and moves 210 m up the shaft in 23 s at constant speed. At what average rate does the force from the cable do work on the cab?

**••47** A machine carries a 4.0 kg package from an initial position of  $\vec{d}_i = (0.50 \text{ m})\hat{i} + (0.75 \text{ m})\hat{j} + (0.20 \text{ m})\hat{k}$  at  $t = 0$  to a final position of  $\vec{d}_f = (7.50 \text{ m})\hat{i} + (12.0 \text{ m})\hat{j} + (7.20 \text{ m})\hat{k}$  at  $t = 12$  s. The constant force applied by the machine on the package is  $\vec{F} = (2.00 \text{ N})\hat{i} + (4.00 \text{ N})\hat{j} + (6.00 \text{ N})\hat{k}$ . For that displacement, find (a) the work done on the package by the machine's force and (b) the average power of the machine's force on the package.

**••50** (a) At a certain instant, a particle-like object is acted on by a force  $\vec{F} = (4.0 \text{ N})\hat{i} - (2.0 \text{ N})\hat{j} + (9.0 \text{ N})\hat{k}$  while the object's velocity is  $\vec{v} = -(2.0 \text{ m/s})\hat{i} + (4.0 \text{ m/s})\hat{k}$ . What is the instantaneous rate at which the force does work on the object? (b) At some other time, the velocity consists of only a y component. If the force is unchanged and the instantaneous power is  $-12$  W, what is the velocity of the object?



## POTENTIAL ENERGY AND CONSERVATION OF ENERGY

•1 **SSM** What is the spring constant of a spring that stores 25 J of elastic potential energy when compressed by 7.5 cm?

•2 In Fig. 8-29, a single frictionless roller-coaster car of mass  $m = 825$  kg tops the first hill with speed  $v_0 = 17.0$  m/s at height  $h = 42.0$  m. How much work does the gravitational force do on the car from that point to (a) point A, (b) point B, and (c) point C? If the gravitational potential energy of the car–Earth system is taken to be zero at C, what is its value when the car is at (d) B and (e) A? (f) If mass  $m$  were doubled, would the change in the gravitational potential energy of the system between points A and B increase, decrease, or remain the same?

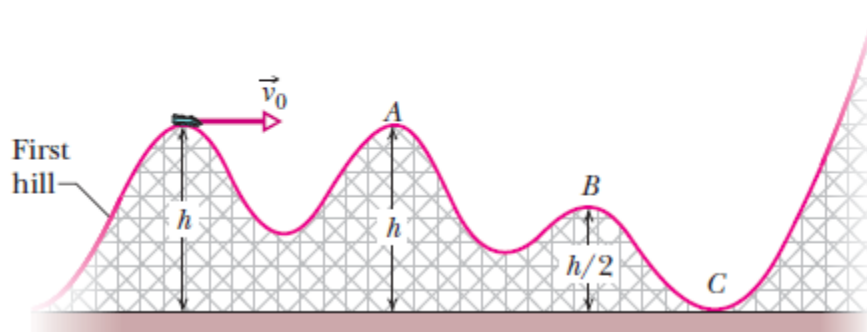


Figure 8-29 Problems 2 and 9.

•3 You drop a 2.00 kg book to a friend who stands on the ground at distance  $D = 10.0$  m below. If your friend's outstretched hands are at distance  $d = 1.50$  m above the ground (Fig. 8-30), (a) how much work  $W_g$  does the gravitational force do on the book as it drops to her hands? (b) What is the change  $\Delta U$  in the gravitational potential energy of the book–Earth system during the drop? If the gravitational potential energy  $U$  of that system is taken to be zero at ground level, what is  $U$  (c) when the book is released and (d) when it reaches her hands? Now take  $U$  to be 100 J at ground level and again find (e)  $W_g$ , (f)  $\Delta U$ , (g)  $U$  at the release point, and (h)  $U$  at her hands.

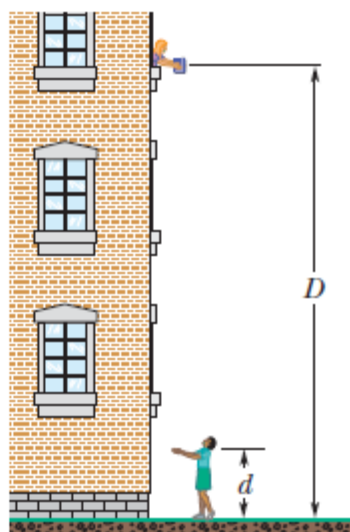



Figure 8-30  
Problems 3 and 10.

•9  In Problem 2, what is the speed of the car at (a) point *A*, (b) point *B*, and (c) point *C*? (d) How high will the car go on the last hill, which is too high for it to cross? (e) If we substitute a second car with twice the mass, what then are the answers to (a) through (d)?

•10 (a) In Problem 3, what is the speed of the book when it reaches the hands? (b) If we substituted a second book with twice the mass, what would its speed be? (c) If, instead, the book were thrown down, would the answer to (a) increase, decrease, or remain the same?