

later, because of a wind shift, the boat is instantaneously at rest. What is its average acceleration for this 3 s interval?

98 A frightened rabbit moving at 6.0 m/s due east runs onto a large area of level ice of negligible friction. As the rabbit slides across the ice, the force of the wind causes it to have a constant acceleration of 1.4 m/s^2 , due north. Choose a coordinate system with the origin at the rabbit's initial position on the ice and the positive x axis directed toward the east. In unit-vector notation, what are the rabbit's (a) velocity and (b) position when it has slid for 3.0 s?

99 A particle starts from the origin at $t = 0$ with a velocity of $8.0\hat{j} \text{ m/s}$ and moves in the xy plane with constant acceleration $(4.0\hat{i} + 2.0\hat{j}) \text{ m/s}^2$. When the particle's x coordinate is 29 m, what are its (a) y coordinate and (b) speed?

100 In 3.50 h, a balloon drifts 21.5 km north, 9.70 km east, and 2.88 km upward from its release point on the ground. Find (a) the magnitude of its average velocity and (b) the angle its average velocity makes with the horizontal.

101 The pilot of an aircraft flies due east relative to the ground in a wind blowing 20 km/h toward the south. If the speed of the aircraft in the absence of wind is 70 km/h, what is the speed of the aircraft relative to the ground?

102 A sprinter running on a circular track has a velocity of constant magnitude 9.2 m/s and a centripetal acceleration of magnitude 3.8 m/s^2 . What are (a) the track radius and (b) the period of the circular motion?

103 A ball is thrown horizontally from a height of 20 m and hits the ground with a speed that is three times its initial speed. What is the initial speed?

104 An electron having an initial horizontal velocity of magnitude $1.00 \times 10^9 \text{ cm/s}$ travels into the region between two horizontal metal plates that are electrically charged. In that region, the electron travels a horizontal distance of 2.00 cm and has a constant downward acceleration of magnitude $1.00 \times 10^{17} \text{ cm/s}^2$ due to the charged plates. Find (a) the time the electron takes to travel the 2.00 cm, (b) the vertical distance it travels during that time, and the magnitudes of its (c) horizontal and (d) vertical velocity components as it emerges from the region.

105 A projectile is launched with an initial speed of 30 m/s at an angle of 60° above the horizontal. What are the (a) magnitude and (b) angle of its velocity 2.0 s after launch, and (c) is the angle above or below the horizontal? What are the (d) magnitude and (e) angle of its velocity 5.0 s after launch, and (f) is the angle above or below the horizontal?

106 The pitcher in a slow-pitch softball game releases the ball at a point 3.0 ft above ground level. A stroboscopic plot of the position of the ball is shown in Fig. 4-57, where the

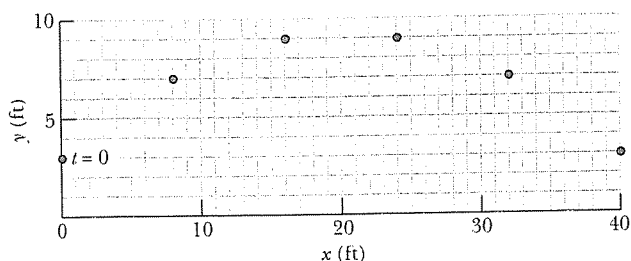


Fig. 4-57 Problem 106.

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readings are 0.25 s apart and the ball is released at $t = 0$. (a) What is the initial speed of the ball? (b) What is the speed of the ball at the instant it reaches its maximum height above ground level? (c) What is that maximum height?

107 An airport terminal has a moving sidewalk to speed passengers through a long corridor. Larry does not use the moving sidewalk; he takes 150 s to walk through the corridor. Curly, who simply stands on the moving sidewalk, covers the same distance in 70 s. Moe boards the sidewalk and walks along it. How long does Moe take to move through the corridor? Assume that Larry and Moe walk at the same speed.

108 A football player punts the football so that it will have a "hang time" (time of flight) of 4.5 s and land 46 m away. If the ball leaves the player's foot 150 cm above the ground, what must be the (a) magnitude and (b) angle (relative to the horizontal) of the ball's initial velocity?

109 The New Hampshire State Police use aircraft to enforce highway speed limits. Suppose that one of the airplanes has a speed of 135 mi/h in still air. It is flying straight north so that it is at all times directly above a north-south highway. A ground observer tells the pilot by radio that a 70.0 mi/h wind is blowing but neglects to give the wind direction. The pilot observes that in spite of the wind the plane can travel 135 mi along the highway in 1.00 h. In other words, the ground speed is the same as if there were no wind. (a) From what direction is the wind blowing? (b) What is the heading of the plane; that is, in what direction does it point?

110 For women's volleyball the top of the net is 2.24 m above the floor and the court measures 9.0 m by 9.0 m on each side of the net. Using a jump serve, a player strikes the ball at a point that is 3.0 m above the floor and a horizontal distance of 8.0 m from the net. If the initial velocity of the ball is horizontal, (a) what minimum magnitude must it have if the ball is to clear the net and (b) what maximum magnitude can it have if the ball is to strike the floor inside the back line on the other side of the net?

111 Figure 4-58 shows the straight path of a particle across an xy coordinate system as the particle is accelerated from rest during time interval Δt_1 . The acceleration is constant. The xy coordinates for point A are (4.00 m, 6.00 m); those for point B are (12.0 m, 18.0 m). (a) What is the ratio a_y/a_x of the acceleration components? (b) What are the coordinates of the particle if the motion is continued for another interval equal to Δt_1 ?

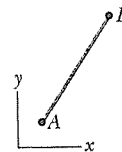


Fig. 4-58 Problem 111.

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

113 The position \vec{r} of a particle moving in the xy plane is given by $\vec{r} = 2t\hat{i} + 2 \sin[(\pi/4 \text{ rad/s})t]\hat{j}$, where \vec{r} is in meters and t is in seconds. (a) Calculate the x and y components of the particle's position at $t = 0, 1.0, 2.0, 3.0,$ and 4.0 s and sketch the particle's path in the xy plane for the interval $0 \leq t \leq 4.0$ s. (b) Calculate the components of the particle's velocity at $t = 1.0, 2.0,$ and 3.0 s. Show that the velocity is tangent to the path of the particle and in the direction the particle is moving at each time by drawing the velocity vectors on the plot of the

particle's path in part (a). (c) Calculate the components of the particle's acceleration at $t = 1.0, 2.0,$ and 3.0 s.

114 A golfer tees off from the top of a rise, giving the golf ball an initial velocity of 43 m/s at an angle of 30° above the horizontal. The ball strikes the fairway a horizontal distance of 180 m from the tee. Assume the fairway is level. (a) How high is the rise above the fairway? (b) What is the speed of the ball as it strikes the fairway?

115 An astronaut is rotated in a horizontal centrifuge at a radius of 5.0 m. (a) What is the astronaut's speed if the centripetal acceleration has a magnitude of $7.0g$? (b) How many revolutions per minute are required to produce this acceleration? (c) What is the period of the motion?

116 (a) What is the magnitude of the centripetal acceleration of an object on Earth's equator due to the rotation of Earth? (b) What would Earth's rotation period have to be for objects on the equator to have a centripetal acceleration of magnitude 9.8 m/s²?

117 An elevator without a ceiling is ascending with a constant speed of 10 m/s. A boy on the elevator shoots a ball directly upward, from a height of 2.0 m above the elevator floor, just as the elevator floor is 28 m above the ground. The initial speed of the ball with respect to the elevator is 20 m/s. (a) What maximum height above the ground does the ball reach? (b) How long does the ball take to return to the elevator floor?

118 A person walks up a stalled 15 -m-long escalator in 90 s. When standing on the same escalator, now moving, the person is carried up in 60 s. How much time would it take that person to walk up the moving escalator? Does the answer depend on the length of the escalator?

119 A track meet is held on a planet in a distant solar system. A shot-putter releases a shot at a point 2.0 m above ground level. A stroboscopic plot of the position of the shot is shown in Fig. 4-59, where the readings are 0.50 s apart and the shot is released at time $t = 0$. (a) What is the initial velocity of the shot in unit-vector notation? (b) What is the magnitude of the free-fall acceleration on the planet? (c) How long after it is released does the shot reach the ground? (d) If an identical throw of the shot is made on the surface of Earth, how long after it is released does it reach the ground?

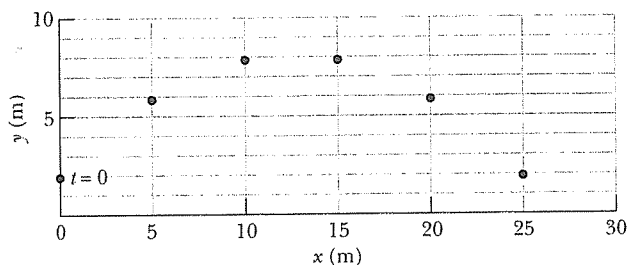


Fig. 4-59 Problem 119.

120 A hang glider is 7.5 m above ground level, moving with a velocity of 8.0 m/s at an angle of 30° below the horizontal and experiencing a constant upward acceleration of 1.0 m/s². (a) Assume $t = 0$ at the instant just described and write an equation for the elevation y of the hang glider as a function of t , with $y = 0$ at ground level. (b) Use the equation to determine the value of t when $y = 0$. (c) Explain why there are two solutions to part (b). Which one represents the time the

glider takes to reach the ground? (d) How far does the glider travel horizontally between $t = 0$ and the time it reaches the ground? (e) For the same initial position and velocity, what constant acceleration will cause the glider to land with zero velocity? Express your answer in unit-vector notation with \hat{i} horizontal in the direction of travel and \hat{j} upward.

121 In a detective story, a body is found 4.6 m from the base of a building and 24 m below an open window. (a) Assuming the victim left that window horizontally, what was the body's initial speed? (b) Would you guess the death to be accidental? Explain your answer.

122 A third baseman wishes to throw to first base, 127 ft away. His best throwing speed is 85 mi/h. (a) If he throws the ball horizontally 3.0 ft above the ground, how far from first base will it hit the ground? (b) From the same initial height, at what upward angle must the third baseman throw the ball if the first baseman is to catch it 3.0 ft above the ground? (c) What will be the time of flight in that case?

123 About 4000 car-train collisions occur in the United States each year. Many (perhaps most) occur when a driver spots an oncoming train and then attempts to beat it to a railroad crossing. (This is beyond foolish, and way past stupid as well.) Consider the following situation: One of those 4000 drivers spots a train on a track that is perpendicular to the roadway and judges the train's speed to be equal to his speed of 30.0 m/s. The train and the car are both approaching the rail crossing (Fig. 4-60). The driver figures that by accelerating his car at a constant 1.50 m/s² toward the crossing, he should reach it first. At the instant of this decision, the distance between car and crossing center and the distance between train and crossing center are both 40.0 m. The length of the car is 5.0 m, and the width of the train is 3.00 m. (a) Is there a collision? (b) If no, by how much time does the driver miss a collision; if yes, how much more time is needed to barely miss the collision? (c) On the same graph, plot the location of the train and the location of the car, both versus time.

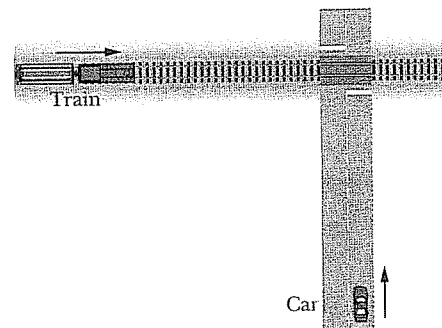


Fig. 4-60 Problem 123.

124 You are to ride a jet-cycle over a lake, starting from rest at point i . First, moving at 30° north of due east:

1. Increase your speed at 0.400 m/s² for 6.00 s.
2. With whatever speed you then have, move for 8.00 s.
3. Then slow at 0.400 m/s² for 6.00 s.

Immediately next, moving due west:

4. Increase your speed at 0.400 m/s² for 5.00 s.
5. With whatever speed you then have, move for 10.0 s.
6. Then slow at 0.400 m/s² until you stop.

In magnitude-angle notation, what is your average velocity for the trip from point i ?

125 At one instant a butterfly has the position vector $\vec{D}_i = (2.00\text{ m})\hat{i} + (3.00\text{ m})\hat{j} + (1.00\text{ m})\hat{k}$ relative to the base of a birdbath. Then 40.0 s later, the butterfly has the position vector $\vec{D}_f = (3.00\text{ m})\hat{i} + (1.00\text{ m})\hat{j} + (2.00\text{ m})\hat{k}$. Find (if possible) (a) the displacement in unit-vector notation, (b) the magnitude of the displacement, (c) the average velocity in unit-vector notation, and (d) the average speed of the butterfly during the 40.0 s interval.

126 At time $t = 0$, you throw a ball from a cliff; the initial velocity has magnitude 15.0 m/s and is 20.0° below the horizontal. At $t = 2.30$ s, what is the ball's (a) horizontal (forward) and (b) vertical (downward) displacement?

127 A baseball is hit at ground level. The ball reaches its maximum height above ground level 3.0 s after being hit. Then 2.5 s after reaching its maximum height, the ball barely clears a fence that is 97.5 m from where it was hit. Assume the ground is level. (a) What maximum height above ground level is reached by the ball? (b) How high is the fence? (c) How far beyond the fence does the ball strike the ground?

128 Suppose that a space probe can withstand the stresses of a $20g$ acceleration. (a) What is the minimum turning radius of such a craft moving at a speed of one-tenth the speed of light? (b) How long would it take to complete a 90° turn at this speed?

129 A car travels around a flat circle on the ground, at a constant speed of 12 m/s. At a certain instant the car has an acceleration of 3 m/s^2 toward the east. What are its distance and direction from the center of the circle at that instant if it is traveling (a) clockwise around the circle and (b) counterclockwise around the circle?

130 A golfer chips balls toward a vertical wall 20.0 m straight ahead, trying to hit a 30.0-cm-diameter red circle painted on the wall. The target is centered about a point 1.20 m above the point where the wall intersects the horizontal ground. On one try, the ball leaves the ground with a speed of 15.0 m/s and at an angle of 35.0° above the horizontal and then hits the wall on a vertical line through the circle's center. (a) How long does the ball take to reach the wall? (b) Does the ball hit the red circle (give the distance to the circle's center)? (c) What is the speed of the ball just before it hits? (d) Has the ball passed the highest point of its trajectory when it hits?

131 The range of a projectile depends not only on v_0 and θ_0 but also on the value g of the free-fall acceleration, which varies from place to place. In 1936, Jesse Owens established a world's running broad jump record of 8.09 m at the Olympic Games at Berlin (where $g = 9.8128\text{ m/s}^2$). Assuming the same values of v_0 and θ_0 , by how much would his record have differed if he had competed instead in 1956 at Melbourne (where $g = 9.7999\text{ m/s}^2$)?

132 At what initial speed must the basketball player in Fig. 4-61 throw the ball, at angle $\theta_0 = 55^\circ$ above the horizontal, to make the foul shot? The horizontal distances are $d_1 = 1.0$ ft and $d_2 = 14$ ft, and the heights are $h_1 = 7.0$ ft and $h_2 = 10$ ft.

133 A helicopter is flying in a straight line over a level field at a constant speed of 6.2 m/s and at a constant altitude of 9.5 m. A package is ejected horizontally from the helicopter with

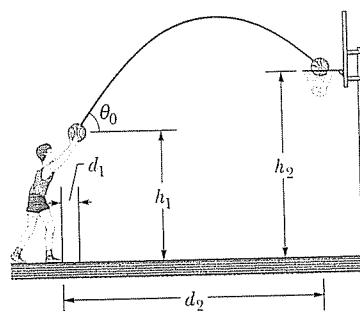


Fig. 4-61 Problem 132.

an initial velocity of 12 m/s relative to the helicopter and in a direction opposite the helicopter's motion. (a) Find the initial speed of the package relative to the ground. (b) What is the horizontal distance between the helicopter and the package at the instant the package strikes the ground? (c) What angle does the velocity vector of the package make with the ground at the instant before impact, as seen from the ground?

134 In a common movie stunt, a performer is thrown through the air because of an explosion, a motorcycle crash, a tornado blast, or such. Actually, the performer is launched by an Air Ramp, which consists of a plate on the end of a launching arm, powered by pneumatic cylinders of pressurized air. As the performer runs onto the plate, electric switches suddenly allow the pressurized air to whip the launching arm, sending the plate upward and throwing the performer across the movie set. Approximate the performer's flight as that of a particle returning to its initial elevation. In g units, find the magnitude of the average acceleration of the performer during the launch for the following situations: (a) The acceleration lasts 0.25 s, and the performer is thrown through a shallow arc (for an indoor set) with a range of 4.0 m, at launch angle 30° with the horizontal. (b) The acceleration lasts 0.29 s, and the performer is thrown through a higher arc (for an outdoor set) with a range of 12 m, at launch angle 45° .

135 A baseball is hit at Fenway Park in Boston at a point 0.762 m above home plate with an initial velocity of 33.53 m/s directed 55.0° above the horizontal. The ball is observed to clear the 11.28-m-high wall in left field (known as the "green monster") 5.00 s after it is hit, at a point just inside the left-field foul-line pole. Find (a) the horizontal distance down the left-field foul line from home plate to the wall; (b) the vertical distance by which the ball clears the wall; the (c) horizontal and (d) vertical displacements of the ball with respect to home plate 0.500 s before it clears the wall.

136 A wooden boxcar is moving along a straight railroad track at speed v_1 . A sniper fires a bullet (initial speed v_2) at it from a high-powered rifle. The bullet passes through both lengthwise walls of the car, its entrance and exit holes being exactly opposite each other as viewed from within the car. From what direction, relative to the track, is the bullet fired? Assume that the bullet is not deflected upon entering the car, but that its speed decreases by 20%. Take $v_1 = 85\text{ km/h}$ and $v_2 = 650\text{ m/s}$. (Why don't you need to know the width of the boxcar?)

On-Line Simulation Problems

The website <http://www.wiley.com/college/halliday> has simulation problems about this chapter.

(c) -3.2 m ; (d) 8.2 m **55.** (a) -83.4 ; (b) $(1.14 \times 10^3)\hat{k}$; (c) 1.14×10^3 , θ not defined, $\phi = 0^\circ$; (d) 90.0° ; (e) $-5.14\hat{i} + 6.13\hat{j} + 3.00\hat{k}$; (f) 8.54 , $\theta = 130^\circ$, $\phi = 69.4^\circ$ **57.** (a) 15 m ; (b) south; (c) 6.0 m ; (d) north **59.** (a) $(-3.18 \text{ m})\hat{i} + (4.72 \text{ m})\hat{j}$; (b) 5.69 m ; (c) $+124^\circ$ **61.** (a) 3.0 m^2 ; (b) 52 m^3 ; (c) $(11 \text{ m}^2)\hat{i} + (9.0 \text{ m}^2)\hat{j} + (3.0 \text{ m}^2)\hat{k}$ **63.** (a) 1.8 m ; (b) 69° north of due east **65.** (a) 2.97 ; (b) $1.51\hat{i} + 2.67\hat{j} - 1.36\hat{k}$; (c) 48° **67.** 3.6 m **69.** (a) 10 m ; (b) north; (c) 7.5 m ; (d) south **71.** 70.5° **73.** (a) 0 ; (b) 0 ; (c) -1 ; (d) west; (e) up; (f) west **75.** Walpole (where the state prison is located)

chapter 4

CP 1. (a) $(8\hat{i} - 6\hat{j}) \text{ m}$; (b) yes, the xy plane (no z component) **2.** (draw \vec{v} tangent to path, tail on path) (a) first; (b) third **3.** (take second derivative with respect to time) (1) and (3) a_x and a_y are both constant and thus \vec{a} is constant; (2) and (4) a_y is constant but a_x is not, thus \vec{a} is not **4.** 4 m/s^3 , -2 m/s , 3 m **5.** (a) v_x constant; (b) v_y initially positive, decreases to zero, and then becomes progressively more negative; (c) $a_x = 0$ throughout; (d) $a_y = -g$ throughout **6.** (a) $(-4 \text{ m/s})\hat{i}$; (b) $(-8 \text{ m/s}^2)\hat{j}$ **7.** (a) 0 , distance not changing; (b) $+70 \text{ km/h}$, distance increasing; (c) $+80 \text{ km/h}$, distance decreasing **8.** (a)–(c) increase **Q 1.** (a) $(7 \text{ m})\hat{i} + (1 \text{ m})\hat{j} + (-2 \text{ m})\hat{k}$; (b) $(5 \text{ m})\hat{i} + (-3 \text{ m})\hat{j} + (1 \text{ m})\hat{k}$; (c) $(-2 \text{ m})\hat{i}$ **3.** yes (the vertical component of the velocity is downward) **5.** (a) all tie; (b) 1 and 2 tie (the rocket is shot upward), then 3 and 4 tie (it is shot into the ground!) **7.** (a) 0 ; (b) 350 km/h ; (c) 350 km/h ; (d) same (nothing changed about the vertical motion) **9.** (a) all tie; (b) all tie; (c) 3, 2, 1; (d) 3, 2, 1 **11.** 2, then 1 and 4 tie, then 3 **13.** (a) yes; (b) no; (c) yes **P 1.** (a) 6.2 m **3.** $(-2.0 \text{ m})\hat{i} + (6.0 \text{ m})\hat{j} - (10 \text{ m})\hat{k}$ **5.** (a) 7.59 km/h ; (b) 22.5° east of due north **7.** $(-0.70 \text{ m/s})\hat{i} + (1.4 \text{ m/s})\hat{j} - (0.40 \text{ m/s})\hat{k}$ **9.** (a) $(8 \text{ m/s}^2)\hat{i} + (1 \text{ m/s})\hat{k}$; (b) $(8 \text{ m/s}^2)\hat{j}$ **11.** (a) $(6.00 \text{ m})\hat{i} - (106 \text{ m})\hat{j}$; (b) $(19.0 \text{ m/s})\hat{i} - (224 \text{ m/s})\hat{j}$; (c) $(24.0 \text{ m/s}^2)\hat{i} - (336 \text{ m/s}^2)\hat{j}$; (d) -85.2° **13.** $(32 \text{ m/s})\hat{i}$ **15.** (a) $(-1.50 \text{ m/s})\hat{j}$; (b) $(4.50 \text{ m})\hat{i} - (2.25 \text{ m})\hat{j}$ **17.** (a) 3.03 s ; (b) 758 m ; (c) 29.7 m/s **19.** (a) 11 m ; (b) 23 m ; (c) 17 m/s ; (d) 63° **21.** (a) 18 cm ; (b) 1.9 m **23.** (a) 10.0 s ; (b) 897 m **25.** (a) 1.60 m ; (b) 6.86 m ; (c) 2.86 m **27.** (a) 202 m/s ; (b) 806 m ; (c) 161 m/s ; (d) -171 m/s **29.** 78.5° **31.** 4.84 cm **33.** (a) 32.3 m ; (b) 21.9 m/s ; (c) 40.4° ; (d) below **35.** (a) ramp; (b) 5.82 m ; (c) 31.0° **37.** (a) yes; (b) 2.56 m **39.** (a) 31° ; (b) 63° **41.** the third **43.** (a) 75.0 m ; (b) 31.9 m/s ; (c) 66.9° ; (d) 25.5 m **45.** (a) 12 s ; (b) 4.1 m/s^2 ; (c) down; (d) 4.1 m/s^2 ; (e) up **47.** (a) 7.32 m ; (b) west; (c) north **49.** $(3.00 \text{ m/s}^2)\hat{i} + (6.00 \text{ m/s}^2)\hat{j}$ **51.** 2.92 m **53.** 160 m/s^2 **55.** (a) 13 m/s^2 ; (b) eastward; (c) 13 m/s^2 ; (d) eastward **57.** 1.67 **59.** 60° **61.** (a) 38 knots ; (b) 1.5° east of due north; (c) 4.2 h ; (d) 1.5° west of due south **63.** 32 m/s **65.** (a) $(-32 \text{ km/h})\hat{i} - (46 \text{ km/h})\hat{j}$; (b) $[(2.5 \text{ km}) - (32 \text{ km/h})t]\hat{i} + [(4.0 \text{ km}) - (46 \text{ km/h})t]\hat{j}$; (c) 0.084 h ; (d) $2 \times 10^2 \text{ m}$ **67.** (a) 2.7 km ; (b) 76° clockwise **69.** (a) 55.6° ; (b) 6.85 m ; (c) 6.78 m/s **71.** (a) 0.83 cm/s ; (b) 0° ; (c) 0.11 m/s ; (d) -63° **73.** $(-2.69 \text{ m/s})\hat{i} + (-1.80 \text{ m/s})\hat{j}$ **75.** (a) 10 m/s ; (b) 19.6 m/s ; (c) 40 m ; (d) 40 m **77.** (a) 6.29° ; (b) 83.7° **79.** (a) -30° ; (b) 69 min ; (c) 80 min ; (d) 80 min ; (e) 0° ; (f) 60 min **81.** (a) 63 km ; (b) 18° south of due east; (c) 0.70 km/h ; (d) 18° south of due east; (e) 1.6 km/h ; (f) 1.2 km/h ; (g) 33° north of due east

83. (c) 2.10 s ; (d) 25.7 m ; (e) 25.7 m ; (f) 0 ; (g) 1.71 s ; (h) 13.5 m ; (i) 4.76 m ; (j) 12.6 m **85.** (a) 1030 m ; (b) west **87.** (a) 62 ms ; (b) $4.8 \times 10^2 \text{ m/s}$ **89.** (a) $6.7 \times 10^6 \text{ m/s}$; (b) $1.4 \times 10^{-7} \text{ s}$ **91.** $3 \times 10^4 \text{ m}$ **93.** (a) $5.4 \times 10^{-13} \text{ m}$; (b) decrease **95.** (a) $(-1.5 \text{ m/s}^2)\hat{i} + (0.50 \text{ m/s}^2)\hat{k}$; (b) 1.6 m/s^2 ; (c) 162° **97.** $(-2.1 \text{ m/s}^2)\hat{i} + (2.8 \text{ m/s}^2)\hat{j}$ **99.** (a) 45 m ; (b) 22 m/s **101.** 67 km/h **103.** 7.0 m/s **105.** (a) 16 m/s ; (b) 23° ; (c) above; (d) 27 m/s ; (e) 57° ; (f) below **107.** 48 s **109.** (a) from 75° east of due south; (b) 30° east of due north. For a second set of solutions, substitute west for east in both answers. **111.** (a) 1.5 ; (b) $(36 \text{ m}, 54 \text{ m})$ **113.** (a) $0, 0, 2.0 \text{ m}, 1.4 \text{ m}; 4.0 \text{ m}, 2.0 \text{ m}; 6.0 \text{ m}, 1.4 \text{ m}; 8.0 \text{ m}, 0$; (b) $2.0 \text{ m/s}, 1.1 \text{ m/s}; 2.0 \text{ m/s}, 0; 2.0 \text{ m/s}, -1.1 \text{ m/s}$; (c) $0, -0.87 \text{ m/s}^2; 0, -1.2 \text{ m/s}^2; 0, -0.87 \text{ m/s}^2$ **115.** (a) 19 m/s ; (b) 35 rev/min ; (c) 1.7 s **117.** (a) 76 m ; (b) 4.2 s **119.** (a) $(10\hat{i} + 10\hat{j}) \text{ m/s}$; (b) 8.0 m/s^2 ; (c) 2.7 s ; (d) 2.2 s **121.** (a) 2.1 m/s ; (b) not accidental because horizontal launch speed is about 20% of world-class sprint speed **123.** (a) yes; (b) 0.16 s **125.** (a) $(1.00 \text{ m})\hat{i} - (2.00 \text{ m})\hat{j} + (1.00 \text{ m})\hat{k}$; (b) 2.45 m ; (c) $(2.50 \text{ cm/s})\hat{i} - (5.00 \text{ cm/s})\hat{j} + (2.50 \text{ cm/s})\hat{k}$; (d) insufficient information **127.** (a) 44 m ; (b) 13 m ; (c) 8.9 m **129.** (a) 48 m , west of center; (b) 48 m , west of center **131.** longer by about 1 cm **133.** (a) 5.8 m/s ; (b) 17 m ; (c) 67° **135.** (a) 96.2 m ; (b) 4.31 m ; (c) 86.5 m forward; (d) 25.1 m up

chapter 5

CP 1. c , d , and e (\vec{F}_1 and \vec{F}_2 must be head-to-tail, \vec{F}_{net} must be from tail of one of them to head of the other) **2.** (a) and (b) 2 N , leftward (acceleration is zero in each situation) **3.** (a) and (b) 1, 4, 3, 2 **4.** (a) equal; (b) greater (acceleration is upward, thus net force on body must be upward) **5.** (a) equal; (b) greater; (c) less **6.** (a) increase; (b) yes; (c) same; (d) yes **7.** (a) $F \sin \theta$; (b) increase **8.** 0 (because now $a = -g$) **Q 1.** (a) 2 and 4; (b) 2 and 4 **3.** increase **5.** (a) 2, 3, 4; (b) 1, 3, 4; (c) 1, $+y$; 2, $+x$; 3, fourth quadrant; 4, third quadrant **7.** a , then b , c , and d tie **9.** (a) increases from initial value mg ; (b) decreases from mg to zero (after which the block moves up away from the floor) **11.** (a) 17 kg ; (b) 12 kg ; (c) 10 kg ; (d) all tie; (e) \vec{F} , \vec{F}_{21} , \vec{F}_{32} **P 1.** 2.9 m/s^2 **3.** (a) 0 ; (b) $(4.0 \text{ m/s}^2)\hat{j}$; (c) $(3.0 \text{ m/s}^2)\hat{i}$ **5.** (a) $(-32.0 \text{ N})\hat{i} - (20.8 \text{ N})\hat{j}$; (b) 38.2 N ; (c) -147° **7.** $(-2 \text{ N})\hat{i} + (6 \text{ N})\hat{j}$ **9.** (a) 108 N ; (b) 108 N ; (c) 108 N **11.** (a) 4.0 kg ; (b) 1.0 kg ; (c) 4.0 kg ; (d) 1.0 kg **13.** (a) 42 N ; (b) 72 N ; (c) 4.9 m/s^2 **15.** (a) 11.7 N ; (b) -59.0° **17.** $1.2 \times 10^5 \text{ N}$ **19.** (a) 0.022 m/s^2 ; (b) $8.3 \times 10^4 \text{ km}$; (c) $1.9 \times 10^3 \text{ m/s}$ **21.** (a) 494 N ; (b) up; (c) 494 N ; (d) down **23.** 1.5 mm **25.** (a) $(285 \text{ N})\hat{i} + (705 \text{ N})\hat{j}$; (b) $(285 \text{ N})\hat{i} - (115 \text{ N})\hat{j}$; (c) 307 N ; (d) -22.0° ; (e) 3.67 m/s^2 ; (f) -22.0° **27.** (a) 0.62 m/s^2 ; (b) 0.13 m/s^2 ; (c) 2.6 m **29.** (a) 1.18 m ; (b) 0.674 s ; (c) 3.50 m/s **31.** (a) $2.2 \times 10^{-3} \text{ N}$; (b) $3.7 \times 10^{-3} \text{ N}$ **33.** $1.8 \times 10^4 \text{ N}$ **35.** (a) 31.3 kN ; (b) 24.3 kN **37.** (a) 1.4 m/s^2 ; (b) 4.1 m/s **39.** (a) 1.23 N ; (b) 2.46 N ; (c) 3.69 N ; (d) 4.92 N ; (e) 6.15 N ; (f) 0.250 N **41.** (a) 2.18 m/s^2 ; (b) 116 N ; (c) 21.0 m/s^2 **43.** (a) 1.1 N **45.** (a) 0.970 m/s^2 ; (b) 11.6 N ; (c) 34.9 N **47.** (a) 3.6 m/s^2 ; (b) 17 N **49.** (a) 4.9 m/s^2 ; (b) 2.0 m/s^2 ; (c) up; (d) 120 N **51.** (a) 0.735 m/s^2 ; (b) down; (c) 20.8 N **53.** $2Ma/(a + g)$ **55.** (a) 8.0 m/s ; (b) $+x$ **57.** (a) 13 597 kg ; (b) 4917 L ; (c) 6172 kg ; (d) 20 075 L ; (e) 45% **59.** 9.0 m/s^2 **61.** (a) 0 ;