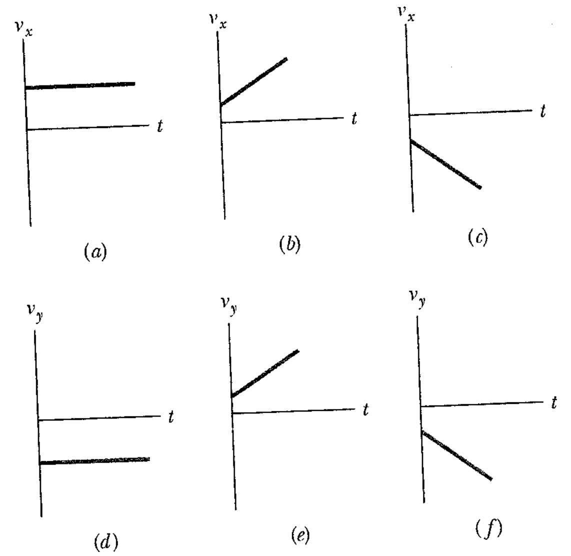

Fig. 5-25 Question 6.

correspond to each of the four situations in Question 5 and Fig. 5-24?

7 Figure 5-26 shows the same breadbox in four situations where horizontal forces are applied. Rank the situations according to the magnitude of the box's acceleration, greatest first.

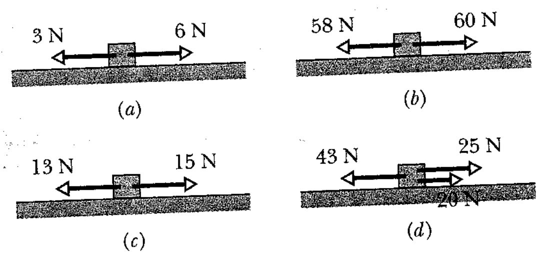

Fig. 5-26 Question 7.

8 Figure 5-27 shows a train of four blocks being pulled across a frictionless floor by force $\vec{F}$. What total mass is accelerated to the right by (a) force $\vec{F}$, (b) cord 3, and (c) cord 1? (d) Rank the blocks according to their accelerations, greatest first. (e) Rank the cords according to their tension, greatest first. (Warm-up for Problems 42 and 45)

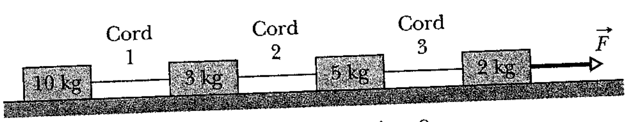

Fig. 5-27 Question 8.

9 A vertical force $\vec{F}$ is applied to a block of mass m that lies on a floor. What happens to the magnitude of the normal force $\vec{F}_N$ on the block from the floor as magnitude F is increased from zero if force $\vec{F}$ is (a) downward and (b) upward?

10 Figure 5-28 shows four choices for the direction of a force of magnitude F to be applied to a block on an inclined plane. The directions are either horizontal or vertical. (For choices a and b, the force is not enough to lift the block off the plane.) Rank the choices according to the magnitude of the normal force on the block from the plane, greatest first.

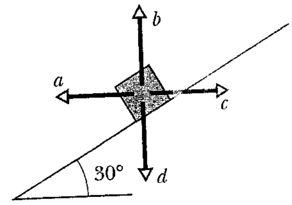

Fig. 5-28 Question 10.

11 Figure 5-29 shows three blocks being pushed across a frictionless floor by horizontal force $\vec{F}$. What total mass is accelerated to the right by (a) force $\vec{F}$, (b) force $\vec{F}_{21}$ on block 2 from block 1, and (c) force $\vec{F}_{32}$ on block 3 from block 2? (d) Rank the blocks according to their acceleration magnitudes, greatest first. (e) Rank forces $\vec{F}$, $\vec{F}_{21}$, and $\vec{F}_{32}$ according to magnitude, greatest first. (Warm-up for Problem 43)

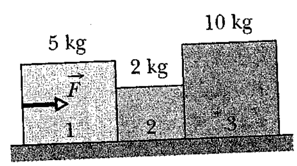

Fig. 5-29 Question 11.

12 An air-track glider can move along an x axis that lies along the air track. Figure 5-30 gives the glider's velocity component v_x as a function of time t, as a force with component F_x acts on the glider. For each lettered time interval, determine whether F_x is positive, negative, or zero and whether it is constant, increasing, or decreasing.

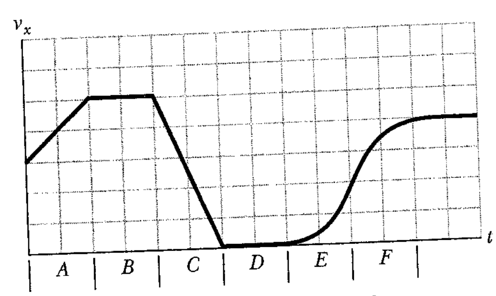

Fig. 5-30 Question 12.

Problems

SSM Solution is in the Student Solutions Manual.
WWW Solution is at http://www.wiley.com/college/halliday
ILW Interactive LearningWare solution is at http://www.wiley.com/college/halliday
• – ••• Number of dots indicates level of problem difficulty.

sec. 5-6 Newton's Second Law

•**1** Only two horizontal forces act on a 3.0 kg body. One force is 9.0 N, acting due east, and the other is 8.0 N, acting 62° north of west. What is the magnitude of the body's acceleration?

•**2** If the 1 kg standard body has an acceleration of 2.00 m/s^2 at 20.0° 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? (Neglect gravity)

•**3** 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) $\vec{F}_2 = (3.0\text{ N})\hat{i} + (-4.0\text{ N})\hat{j}$.

•4 Three astronauts, propelled by jet backpacks, push and guide a 120 kg asteroid toward a processing dock, exerting the forces shown in Fig. 5-31, with $F_1 = 32$ N, $F_2 = 55$ N, $F_3 = 41$ N, $\theta_1 = 30°$, and $\theta_3 = 60°$. What is the asteroid's acceleration (a) in unit-vector notation and as (b) a magnitude and (c) a direction relative to the positive direction of the x axis?

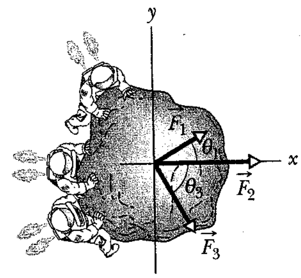

Fig. 5-31 Problem 4.

••5 There are two forces on the 2.00 kg box in the overhead view of Fig. 5-32, but only one is shown. For $F_1 = 20.0$ N, $a = 12.0\text{ m/s}^2$, and $\theta = 30.0°$, find the second force (a) in unit-vector notation and as (b) a magnitude and (c) an angle relative to the positive direction of the x axis. **SSM**

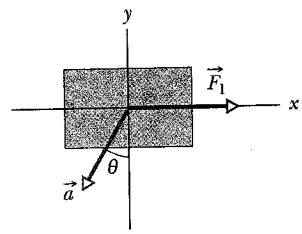

Fig. 5-32 Problem 5.

••6 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.

••7 While two forces act on it, a particle is to move at the constant velocity $\vec{v} = (3\text{ m/s})\hat{i} - (4\text{ m/s})\hat{j}$. One of the forces is $\vec{F}_1 = (2\text{ N})\hat{i} + (-6\text{ N})\hat{j}$. What is the other force?

•••8 Two horizontal forces $\vec{F}_1$ and $\vec{F}_2$ act on a 4.0 kg disk that slides over frictionless ice, on which an xy coordinate system is laid out. Force $\vec{F}_1$ is in the positive direction of the x axis and has a magnitude of 7.0 N. Force $\vec{F}_2$ has a magnitude of 9.0 N. Figure 5-33 gives the x component v_x of the velocity of the disk as a function of time t during the sliding. What is the angle between the constant directions of forces $\vec{F}_1$ and $\vec{F}_2$?

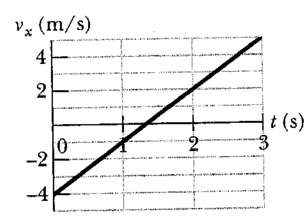

Fig. 5-33 Problem 8.

sec. 5-7 Some Particular Forces

•9 (a) An 11.0 kg salami is supported by a cord that runs to a spring scale, which is supported by a cord hung from the ceiling (Fig. 5-34a). What is the reading on the scale, which is marked in weight units? (b) In Fig. 5-34b the salami is supported by a cord that runs around a pulley and to a scale. The opposite end of the scale is attached by a cord to a wall. What is the reading on the scale? (c) In Fig. 5-34c the wall has been replaced with a second 11.0 kg salami, and the assembly is stationary. What is the reading on the scale? **SSM**

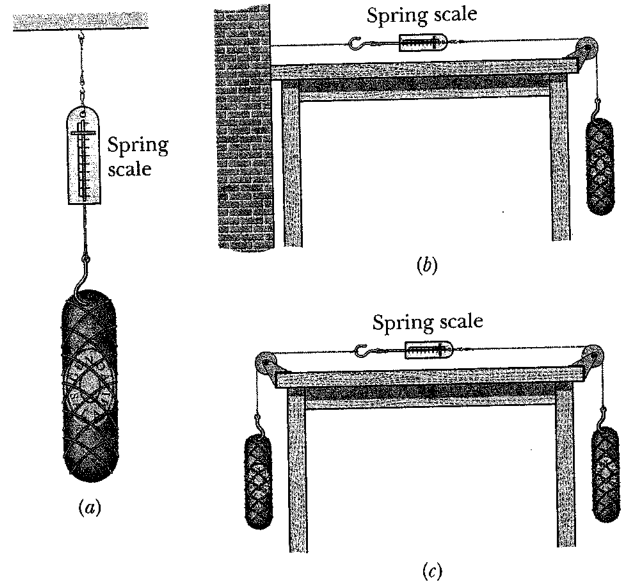

Fig. 5-34 Problem 9.

•10 A block with a weight of 3.0 N is at rest on a horizontal surface. A 1.0 N upward force is applied to the block by means of an attached vertical string. What are the (a) magnitude and (b) direction of the force of the block on the horizontal surface?

•11 Figure 5-35 shows an arrangement in which four disks are suspended by cords. The longer, top cord loops over a frictionless pulley and pulls with a force of magnitude 98 N on the wall to which it is attached. The tensions in the shorter cords are $T_1 = 58.8$ N, $T_2 = 49.0$ N, and $T_3 = 9.8$ N. What are the masses of (a) disk A, (b) disk B, (c) disk C, and (d) disk D?

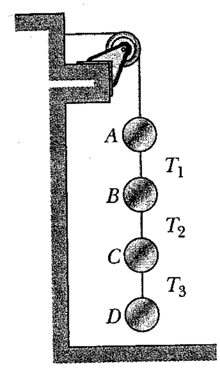

Fig. 5-35 Problem 11.

••12 Some insects can walk below a thin rod (such as a twig) by hanging from it. Suppose that such an insect has mass m and hangs from a horizontal rod as shown in Fig. 5-36, with angle $\theta = 40°$. Its six legs are all under the same tension, and the leg sections nearest the body are horizontal. (a) What is the ratio of the tension in each tibia (forepart of a leg) to the insect's weight? (b) If the insect straightens out its legs somewhat, does the tension in each tibia increase, decrease, or stay the same?

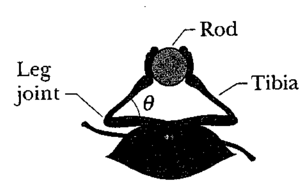

Fig. 5-36 Problem 12.

sec. 5-9 Applying Newton's Laws

•13 Refer to Fig. 5-18. Let the mass of the block be 8.5 kg and the angle θ be 30°. Find (a) the tension in the cord and (b) the normal force acting on the block. (c) If the cord is cut, find the magnitude of the block's acceleration. **SSM WWW**

•14 A 45 kg woman is ice-skating toward the east on a frictionless frozen lake when she collides with a 90 kg man who is ice-skating toward the west. The maximum force exerted on the woman by the man during the collision is 180 N, west. What are the (a) magnitude and (b) direction of the maximum force on the man from the woman? What are the (c) magnitude and (d) direction of the maximum acceleration of the woman and the (e) magnitude and (f) direction of the maximum acceleration of the man?

•15 A constant horizontal force $\vec{F}_a$ pushes a 2.00 kg FedEx package across a frictionless floor on which an xy coordinate system has been drawn. Figure 5-37 gives the package's x and y velocity components versus time t. What are the (a) magnitude and (b) direction of $\vec{F}_a$?

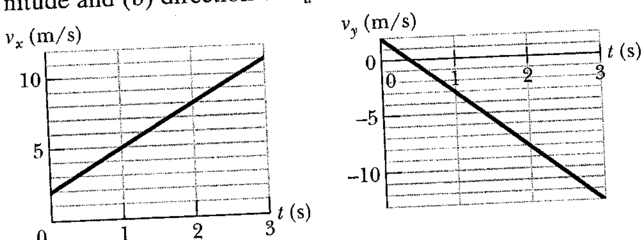

Fig. 5-37 Problem 15.

•16 There are two horizontal forces on the 2.0 kg box in the overhead view of Fig. 5-38 but only one (of magnitude F_1 = 20 N) is shown. The box moves along the x axis. For each of the following values for the acceleration a_x of the box, find the second force in unit-vector notation: (a) 10 m/s^2, (b) 20 m/s^2, (c) 0, (d) −10 m/s^2, and (e) −20 m/s^2.

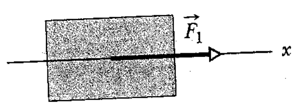

Fig. 5-38 Problem 16.

•17 A 500 kg rocket sled can be accelerated at a constant rate from rest to 1600 km/h in 1.8 s. What is the magnitude of the required net force? **SSM**

•18 The tension at which a fishing line snaps is commonly called the line's "strength." What minimum strength is needed for a line that is to stop a salmon of weight 85 N in 11 cm if the fish is initially drifting at 2.8 m/s? Assume a constant deceleration.

•19 *Sunjamming.* A "sun yacht" is a spacecraft with a large sail that is pushed by sunlight. Although such a push is tiny in everyday circumstances, it can be large enough to send the spacecraft outward from the Sun on a cost-free but slow trip. Suppose that the spacecraft has a mass of 900 kg and receives a push of 20 N. (a) What is the magnitude of the resulting acceleration? If the craft starts from rest, (b) how far will it travel in 1 day and (c) how fast will it then be moving?

•20 A car traveling at 53 km/h hits a bridge abutment. A passenger in the car moves forward a distance of 65 cm (with respect to the road) while being brought to rest by an inflated air bag. What magnitude of force (assumed constant) acts on the passenger's upper torso, which has a mass of 41 kg?

•21 A firefighter who weighs 712 N slides down a vertical pole with an acceleration of 3.00 m/s^2, directed downward. What are the (a) magnitude and (b) direction (up or down) of the vertical force on the firefighter from the pole and the (c) magnitude and (d) direction of the vertical force of the pole on the firefighter?

•22 A car that weighs 1.30×10^4 N is initially moving at 40 km/h when the brakes are applied and the car is brought to a stop in 15 m. Assuming the force that stops the car is constant, find (a) the magnitude of that force and (b) the time required for the change in speed. If the initial speed is doubled, and the car experiences the same force during the braking, by what factors are (c) the stopping distance and (d) the stopping time multiplied? (There could be a lesson here about the danger of driving at high speeds.)

•23 An electron with a speed of 1.2×10^7 m/s moves horizontally into a region where a constant vertical force of 4.5×10^{-16} N acts on it. The mass of the electron is 9.11×10^{-31} kg. Determine the vertical distance the electron is deflected during the time it has moved 30 mm horizontally. **SSM**

•24 In Fig. 5-39, a crate of mass m = 100 kg is pushed at constant speed up a frictionless ramp (θ = 30.0°) by a horizontal force $\vec{F}$. What are the magnitudes of (a) $\vec{F}$ and (b) the force on the crate from the ramp?

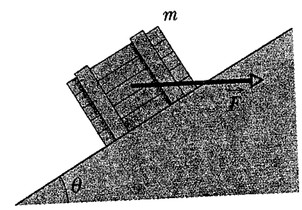

Fig. 5-39 Problem 24.

•25 Tarzan, who weighs 820 N, swings from a cliff at the end of a 20.0 m vine that hangs from a high tree limb and initially makes an angle of 22.0° with the vertical. Assume that an x axis extends horizontally away from the cliff edge and a y axis extends upward. Immediately after Tarzan steps off the cliff, the tension in the vine is 760 N. Just then, what are (a) the force on him from the vine in unit-vector notation and the net force on him (b) in unit-vector notation and as (c) a magnitude and (d) an angle relative to the positive direction of the x axis? What are the (e) magnitude and (f) angle of Tarzan's acceleration just then?

••26 Figure 5-40 shows an overhead view of a 0.0250 kg lemon half and two of the three horizontal forces that act on it as it is on a frictionless table. Force $\vec{F}_1$ has a magnitude of 6.00 N and is at θ_1 = 30.0°. Force $\vec{F}_2$ has a magnitude of 7.00 N and is at θ_2 = 30.0°. In unit-vector notation, what is the third force if the lemon half (a) is stationary, (b) has constant velocity $\vec{v} = (13.0\hat{i} - 14.0\hat{j})$ m/s, and (c) has varying velocity $\vec{v} = (13.0t\hat{i} - 14.0t\hat{j})$ m/s^2, where t is time?

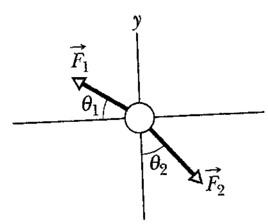

Fig. 5-40 Problem 26.

••27 A 40 kg girl and an 8.4 kg sled are on the frictionless ice of a frozen lake, 15 m apart but connected by a rope of negligible mass. The girl exerts a horizontal 5.2 N force on the rope. What are the acceleration magnitudes of (a) the sled and (b) the girl? (c) How far from the girl's initial position do they meet?

••28 A 40 kg skier skis directly down a frictionless slope angled at 10° to the horizontal. Assume the skier moves in the negative direction of an x axis along the slope. A wind force with component F_x acts on the skier. What is F_x if the magnitude of the skier's velocity is (a) constant, (b) increasing at a rate of 1.0 m/s^2, and (c) increasing at a rate of 2.0 m/s^2?

••29 A block is projected up a frictionless inclined plane with initial speed $v_0 = 3.50$ m/s. The angle of incline is $\theta = 32.0°$. (a) How far up the plane does the block go? (b) How long does it take to get there? (c) What is its speed when it gets back to the bottom? SSM WWW

••30 A dated box of dates, of mass 5.00 kg, is sent sliding up a frictionless ramp at an angle of θ to the horizontal. Figure 5-41 gives, as a function of time t, the component v_x of the box's velocity along an x axis that extends directly up the ramp. What is the magnitude of the normal force on the box from the ramp?

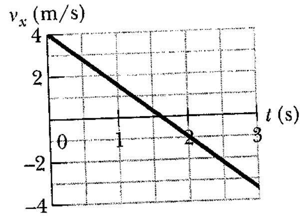

Fig. 5-41 Problem 30.

••31 A sphere of mass 3.0×10^{-4} kg is suspended from a cord. A steady horizontal breeze pushes the sphere so that the cord makes a constant angle of 37° with the vertical. Find (a) the push magnitude and (b) the tension in the cord. ILW

••32 Holding on to a towrope moving parallel to a frictionless ski slope, a 50 kg skier is pulled up the slope, which is at an angle of 8.0° with the horizontal. What is the magnitude F_{rope} of the force on the skier from the rope when (a) the magnitude v of the skier's velocity is constant at 2.0 m/s and (b) $v = 2.0$ m/s as v increases at a rate of 0.10 m/s^2?

••33 An elevator cab and its load have a combined mass of 1600 kg. Find the tension in the supporting cable when the cab, originally moving downward at 12 m/s, is brought to rest with constant acceleration in a distance of 42 m.

••34 A lamp hangs vertically from a cord in a descending elevator that decelerates at 2.4 m/s^2. (a) If the tension in the cord is 89 N, what is the lamp's mass? (b) What is the cord's tension when the elevator ascends with an upward acceleration of 2.4 m/s^2?

••35 An elevator cab that weighs 27.8 kN moves upward. What is the tension in the cable if the cab's speed is (a) increasing at a rate of 1.22 m/s^2 and (b) decreasing at a rate of 1.22 m/s^2?

••36 An elevator cab is pulled upward by a cable. The cab and its single occupant have a combined mass of 2000 kg. When that occupant drops a coin, its acceleration relative to the cab is 8.00 m/s^2 downward. What is the tension in the cable?

••37 Using a rope that will snap if the tension in it exceeds 387 N, you need to lower a bundle of old roofing material weighing 449 N from a point 6.1 m above the ground. (a) What magnitude of the bundle's acceleration will put the rope on the verge of snapping? (b) At that acceleration, with what speed would the bundle hit the ground?

••38 In Fig. 5-42, elevator cabs A and B are connected by a short cable and can be pulled upward or lowered by the cable above cab A. Cab A has mass 1700 kg; cab B has mass 1300 kg. A 12.0 kg box of catnip lies on the floor of cab A. The tension in the cable connecting the cabs is 1.91×10^4 N. What is the magnitude of the normal force on the box from the floor?

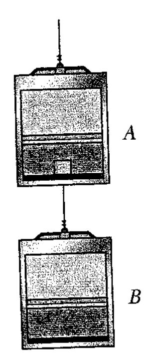

Fig. 5-42 Problem 38.

••39 In Fig. 5-43, a chain consisting of five links, each of mass 0.100 kg, is lifted vertically with constant acceleration of magnitude $a = 2.50$ m/s^2. Find the magnitudes of (a) the force on link 1 from link 2, (b) the force on link 2 from link 3, (c) the force on link 3 from link 4, and (d) the force on link 4 from link 5. Then find the magnitudes of (e) the force $\vec{F}$ on the top link from the person lifting the chain and (f) the *net* force accelerating each link. SSM

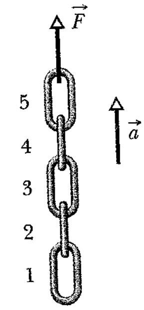

Fig. 5-43 Problem 39.

••40 In earlier days, horses pulled barges down canals in the manner shown in Fig. 5-44. Suppose the horse pulls on the rope with a force of 7900 N at an angle of $\theta = 18°$ to the direction of motion of the barge, which is headed straight along the positive direction of an x axis. The mass of the barge is 9500 kg, and the magnitude of its acceleration is 0.12 m/s^2. What are the (a) magnitude and (b) direction (relative to positive x) of the force on the barge from the water?

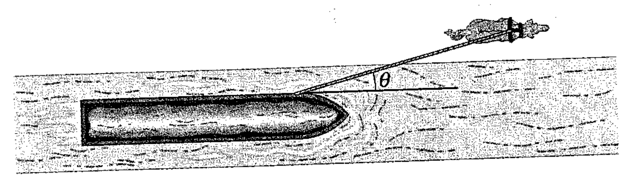

Fig. 5-44 Problem 40.

••41 In Fig. 5-45, a block of mass $m = 5.00$ kg is pulled along a horizontal frictionless floor by a cord that exerts a force of magnitude $F = 12.0$ N at an angle $\theta = 25.0°$. (a) What is the magnitude of the block's acceleration? (b) The force magnitude F is slowly increased. What is its value just before the block is lifted (completely) off the floor? (c) What is the magnitude of the block's acceleration just before it is lifted (completely) off the floor?

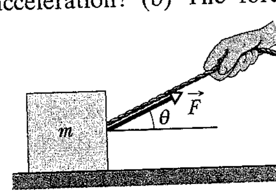

Fig. 5-45 Problem 41.

••42 Figure 5-46 shows four penguins that are being playfully pulled along very slippery (frictionless) ice by a curator. The masses of three penguins and the tension in two of the cords are $m_1 = 12$ kg, $m_3 = 15$ kg, $m_4 = 20$ kg, $T_2 = 111$ N, and $T_4 = 222$ N. Find the penguin mass m_2 that is not given.

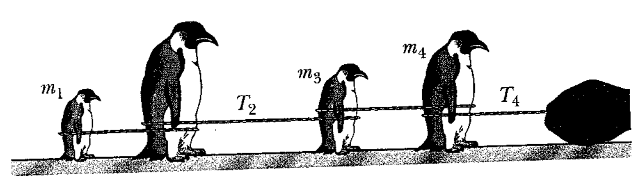

Fig. 5-46 Problem 42.

••**43** Two blocks are in contact on a frictionless table. A horizontal force is applied to the larger block, as shown in Fig. 5-47. (a) If $m_1 = 2.3$ kg, $m_2 = 1.2$ kg, and $F = 3.2$ N, find the magnitude of the force between the two blocks. (b) Show that if a force of the same magnitude F is applied to the smaller block but in the opposite direction, the magnitude of the force between the blocks is 2.1 N, which is not the same value calculated in (a). (c) Explain the difference. SSM ILW WWW

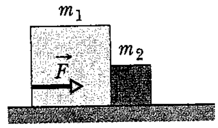

Fig. 5-47 Problem 43.

••**44** In Fig. 5-48*a*, a constant horizontal force $\vec{F}_a$ is applied to block A, which pushes against block B with a 20.0 N force directed horizontally to the right. In Fig. 5-48*b*, the same force $\vec{F}_a$ is applied to block B; now block A pushes on block B with a 10.0 N force directed horizontally to the left. The blocks have a combined mass of 12.0 kg. What are the magnitudes of (a) their acceleration in Fig. 5-48*a* and (b) force $\vec{F}_a$?

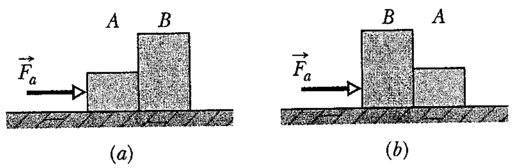

Fig. 5-48 Problem 44.

••**45** In Fig. 5-49, three connected blocks are pulled to the right on a horizontal frictionless table by a force of magnitude $T_3 = 65.0$ N. If $m_1 = 12.0$ kg, $m_2 = 24.0$ kg, and $m_3 = 31.0$ kg, calculate (a) the magnitude of the system's acceleration, (b) the tension T_1, and (c) the tension T_2.

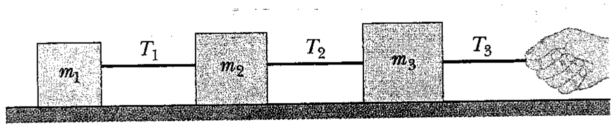

Fig. 5-49 Problem 45.

••**46** In Fig. 5-50, three ballot boxes are connected by cords, one of which wraps over a pulley having negligible friction on its axle and negligible mass. The masses are $m_A = 30.0$ kg, $m_B = 40.0$ kg, and $m_C = 10.0$ kg. When the assembly is released from rest, (a) what is the tension in the cord connecting B and C, and (b) how far does A move in the first 0.250 s (assuming it does not reach the pulley)?

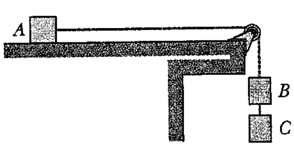

Fig. 5-50 Problem 46.

••**47** Figure 5-51 shows two blocks connected by a cord (of negligible mass) that passes over a frictionless pulley (also of negligible mass). The arrangement is known as *Atwood's machine*. One block has mass $m_1 = 1.3$ kg; the other has mass $m_2 = 2.8$ kg. What are (a) the magnitude of the blocks' acceleration and (b) the tension in the cord?

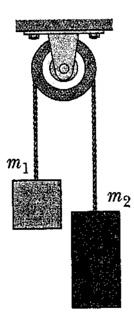

Fig. 5-51 Problem 47.

••**48** An 85 kg man lowers himself to the ground from a height of 10.0 m by holding onto a rope that runs over a frictionless pulley to a 65 kg sandbag. With what speed does the man hit the ground if he started from rest?

••**49** A 10 kg monkey climbs up a massless rope that runs over a frictionless tree limb and back down to a 15 kg package on the ground (Fig. 5-52). (a) What is the magnitude of the least acceleration the monkey must have if it is to lift the package off the ground? If, after the package has been lifted, the monkey stops its climb and holds onto the rope, what are the (b) magnitude and (c) direction of the monkey's acceleration and (d) the tension in the rope? SSM

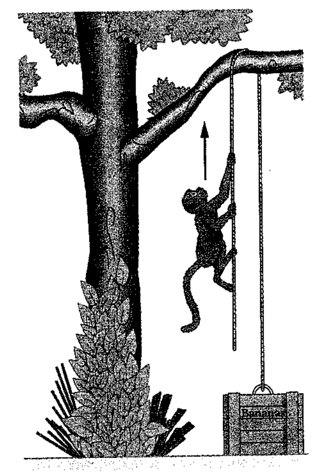
Fig. 5-52 Problem 49.

••**50** Figure 5-53 shows a man sitting in a bosun's chair that dangles from a massless rope, which runs over a massless, frictionless pulley and back down to the man's hand. The combined mass of man and chair is 95.0 kg. With what force magnitude must the man pull on the rope if he is to rise (a) with a constant velocity and (b) with an upward acceleration of 1.30 m/s^2? (*Hint:* A free-body diagram can really help.)

If the rope on the right extends to the ground and is pulled by a co-worker, with what force magnitude must the co-worker pull for the man to rise (c) with a constant velocity and (d) with an upward acceleration of 1.30 m/s^2? What is the magnitude of the force on the ceiling from the pulley system in (e) part a (f) part b, (g) part c, and (h) part d?

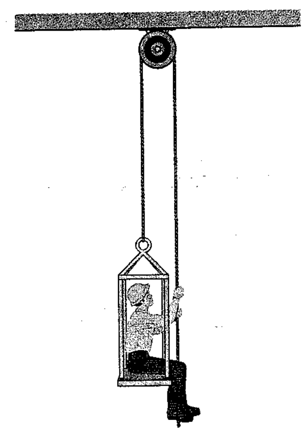
Fig. 5-53 Problem 50.

••**51** A block of mass $m_1 = 3.70$ kg on a frictionless plane inclined at angle $\theta = 30.0°$ is connected by a cord over a massless, frictionless pulley to a second block of mass $m_2 = 2.30$ kg hanging vertically (Fig. 5-54). What are (a) the magnitude of the acceleration of each block, (b) the direction of the acceleration of the hanging block, and (c) the tension in the cord? ILW

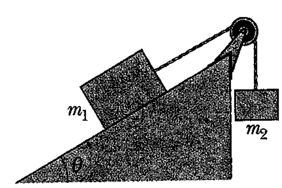

Fig. 5-54 Problem 51.

••**52** Figure 5-55 shows three blocks attached by cords that loop over frictionless pulleys. Block B lies on a frictionless table; the masses are $m_A = 6.00$ kg, $m_B = 8.00$ kg, and

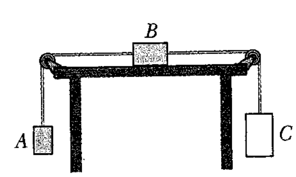

Fig. 5-55 Problem 52.

m_C = 10.0 kg. When the blocks are released, what is the tension in the cord at the right?

•••53 A hot-air balloon of mass M is descending vertically with downward acceleration of magnitude a. How much mass (ballast) must be thrown out to give the balloon an upward acceleration of magnitude a? Assume that the upward force from the air (the lift) does not change because of the decrease in mass. **SSM ILW**

•••54 Figure 5-56 shows a box of mass m_2 = 1.0 kg on a frictionless plane inclined at angle θ = 30°. It is connected by a cord of negligible mass to a box of mass m_1 = 3.0 kg on a horizontal frictionless surface. The pulley is frictionless and massless. (a) If the magnitude of horizontal force $\vec{F}$ is 2.3 N, what is the tension in the connecting cord? (b) What is the largest value the magnitude of $\vec{F}$ may have without the cord becoming slack?

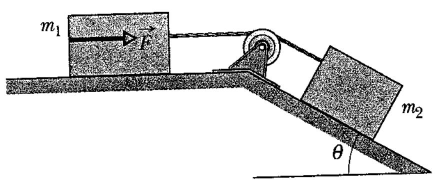

Fig. 5-56 Problem 54.

•••55 Figure 5-57 gives, as a function of time t, the force component F_x that acts on a 3.00 kg ice block that can move only along the x axis. At t = 0, the block is moving in the positive direction of the axis, with a speed of 3.0 m/s. What are its (a) speed and (b) direction of travel at t = 11 s?

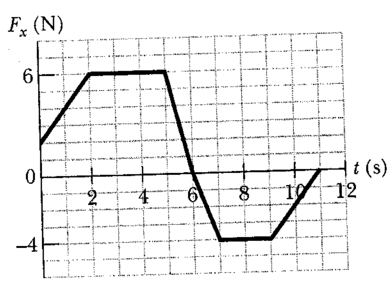

Fig. 5-57 Problem 55.

•••56 Figure 5-58 shows a section of a cable-car system. The maximum permissible mass of each car with occupants is 2800 kg. The cars, riding on a support cable, are pulled by a second cable attached to the support tower on each car. Assume that the cables are taut and inclined at angle θ = 35°. What is the difference in tension between adjacent sections of pull cable if the cars are at the maximum permissible mass and are being accelerated up the incline at 0.81 m/s²?

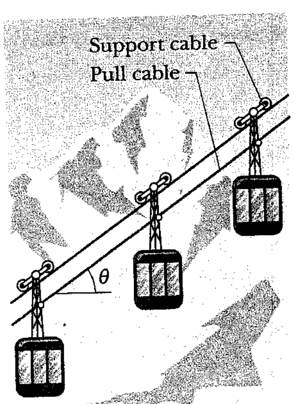

Fig. 5-58 Problem 56.

Additional Problems

57 *Blowing off units.* Throughout your physics course, your instructor will expect you to be careful with units in your calculations. Yet some students tend to neglect them and just trust that they always work out properly. Maybe this real-world example will keep you from such a sloppy habit.

On July 23, 1983, Air Canada Flight 143 was being readied for its long trip from Montreal to Edmonton when the flight crew asked the ground crew to determine how much fuel was already on board. The flight crew knew they needed to begin the trip with 22 300 kg of fuel. They knew that amount in kilograms because Canada had recently switched to the metric system; previously fuel had been measured in pounds. The ground crew could measure the onboard fuel only in liters, which they reported as 7682 L. Thus, to determine how much fuel was on board and how much additional fuel was needed, the flight crew asked the ground crew for the conversion factor from liters to kilograms of fuel. The response was 1.77, which the flight crew used (1.77 kg corresponds to 1 L). (a) How many kilograms of fuel did the flight crew think they had? (In this problem, take all given data as being exact.) (b) How many liters did they ask to be added?

Unfortunately, the response from the ground crew was based on pre-metric habits—1.77 was the conversion factor not from liters to kilograms but rather from liters to *pounds* of fuel (1.77 lb corresponds to 1 L). (c) How many kilograms of fuel were actually on board? (Except for the given 1.77, use four significant figures for other conversion factors.) (d) How many liters of additional fuel were actually needed? (e) When the airplane left Montreal, what percentage of the required fuel did it have?

On route to Edmonton, at an altitude of 7.9 km, the airplane ran out of fuel and began to fall. Although the airplane had no power, the pilot managed to put it into a downward glide. Because the nearest working airport was too far to reach by gliding only, the pilot angled the glide toward an old, nonworking airport.

Unfortunately, the runway at that airport had been converted to a track for race cars, and a steel barrier had been constructed across it. Fortunately, as the airplane hit the runway, the front landing gear collapsed, dropping the nose of the airplane onto the runway. The skidding slowed the airplane so that it stopped just short of the steel barrier, with stunned race drivers and fans looking on. All on board the airplane emerged safely. The point here is this: Take care of the units.

58 The only two forces acting on a body have magnitudes of 20 N and 35 N and directions that differ by 80°. The resulting acceleration has a magnitude of 20 m/s². What is the mass of the body?

59 A 2.0 kg particle moves along an x axis, being propelled by a variable force directed along that axis. Its position is given by $x = 3.0\text{ m} + (4.0\text{ m/s})t + ct^2 - (2.0\text{ m/s}^3)t^3$, with x in meters and t in seconds. The factor c is a constant. At t = 3.0 s, the force on the particle has a magnitude of 36 N and is in the negative direction of the axis. What is c?

60 A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m, as shown in Fig. 5-59. A horizontal force $\vec{F}$ acts on one end of the rope. (a) Show that the rope *must* sag, even if only by an imperceptible amount. Then,

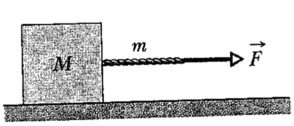

Fig. 5-59 Problem 60.

assuming that the sag is negligible, find (b) the acceleration of rope and block, (c) the force on the block from the rope, and (d) the tension in the rope at its midpoint.

61 Figure 5-60 is an overhead view of a 12 kg tire that is to be pulled by three horizontal ropes. One rope's force (F_1 = 50 N) is indicated. The forces from the other ropes are to be oriented such that the tire's acceleration magnitude a is least. What is that least a if (a) F_2 = 30 N, F_3 = 20 N; (b) F_2 = 30 N, F_3 = 10 N; and (c) $F_2 = F_3$ = 30 N?

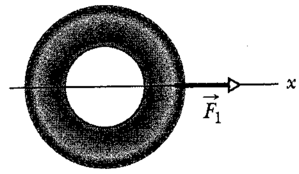

Fig. 5-60 Problem 61.

62 Three forces act on a particle that moves with unchanging velocity $\vec{v} = (2\text{ m/s})\hat{\text{i}} - (7\text{ m/s})\hat{\text{j}}$. Two of the forces are $\vec{F}_1 = (2\text{ N})\hat{\text{i}} + (3\text{ N})\hat{\text{j}} + (-2\text{ N})\hat{\text{k}}$ and $\vec{F}_2 = (-5\text{ N})\hat{\text{i}} + (8\text{ N})\hat{\text{j}} + (-2\text{ N})\hat{\text{k}}$. What is the third force?

63 A worker drags a crate across a factory floor by pulling on a rope tied to the crate (Fig. 5-61). The worker exerts a force of magnitude F = 450 N on the rope, which is inclined at angle θ = 38° to the horizontal, and the floor exerts a horizontal force of magnitude f = 125 N that opposes the motion. Calculate the magnitude of the acceleration of the crate if (a) its mass is 310 kg and (b) its weight is 310 N.

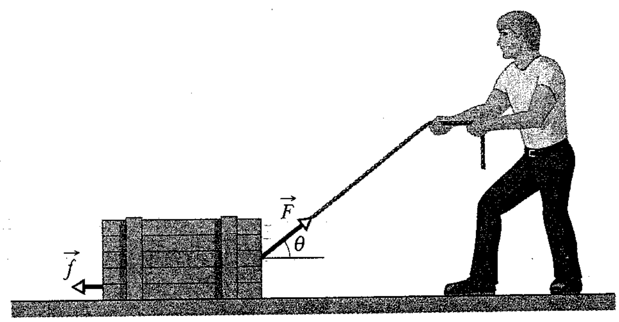

Fig. 5-61 Problem 63.

64 A nucleus that captures a stray neutron must bring the neutron to a stop within the diameter of the nucleus by means of the *strong force*. That force, which "glues" the nucleus together, is approximately zero outside the nucleus. Suppose that a stray neutron with an initial speed of 1.4×10^7 m/s is just barely captured by a nucleus with diameter $d = 1.0 \times 10^{-14}$ m. Assuming the strong force on the neutron is constant, find the magnitude of that force. The neutron's mass is 1.67×10^{-27} kg.

65 A 0.20 kg hockey puck has a velocity of 2.0 m/s toward the east as it slides over the frictionless surface of an ice hockey rink. What are the (a) magnitude and (b) direction of the constant net force that must act on the puck during a 0.40 s time interval to change the puck's velocity to 5.0 m/s toward the west? What are the (c) magnitude and (d) direction if, instead, the velocity is changed to 5.0 m/s toward the south?

66 In Fig. 5-62, 4.0 kg block A and 6.0 kg block B are connected by a string of negligible mass. Force $\vec{F}_A = (12\text{ N})\hat{\text{i}}$ acts on block A; force $\vec{F}_B = (24\text{ N})\hat{\text{i}}$ acts on block B. What is the tension in the string?

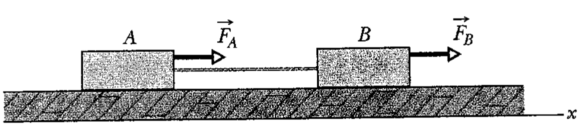

Fig. 5-62 Problem 66.

67 Figure 5-63 shows a box of dirty money (mass m_1 = 3.0 kg) on a frictionless plane inclined at angle θ_1 = 30°. The box is connected via a cord of negligible mass to a box of laundered money (mass m_2 = 2.0 kg) on a frictionless plane inclined at angle θ_2 = 60°. The pulley is frictionless and has negligible mass. What is the tension in the cord?

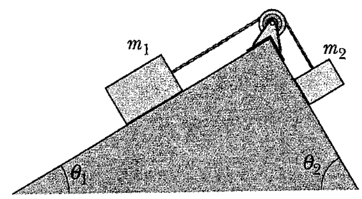

Fig. 5-63 Problem 67.

68 A 15 000 kg helicopter lifts a 4500 kg truck with an upward acceleration of 1.4 m/s². Calculate (a) the net upward force on the helicopter blades from the air and (b) the tension in the cable between helicopter and truck.

69 A 52 kg circus performer is to slide down a rope that will break if the tension exceeds 425 N. (a) What happens if the performer hangs stationary on the rope? (b) At what magnitude of acceleration does the performer just avoid breaking the rope?

70 In the overhead view of Fig. 5-64, five forces pull on a box of mass m = 4.0 kg. The force magnitudes are F_1 = 11 N, F_2 = 17 N, F_3 = 3.0 N, F_4 = 14 N, and F_5 = 5.0 N, and angle θ_4 is 30°. Find the box's acceleration (a) in unit-vector notation and as (b) a magnitude and (c) an angle relative to the positive direction of the x axis.

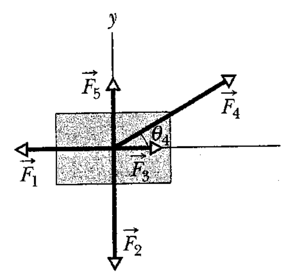

Fig. 5-64 Problem 70.

71 Only two forces act on a 3.0 kg object that moves with an acceleration of 3.0 m/s² in the positive direction of a y axis. If one of the forces acts in the positive direction of an x axis and has a magnitude of 8.0 N, what is the magnitude of the other force?

72 Imagine a landing craft approaching the surface of Callisto, one of Jupiter's moons. If the engine provides an upward force (thrust) of 3260 N, the craft descends at constant speed; if the engine provides only 2200 N, the craft accelerates downward at 0.39 m/s². (a) What is the weight of the landing craft in the vicinity of Callisto's surface? (b) What is the mass of the craft? (c) What is the magnitude of the free-fall acceleration near the surface of Callisto?

73 A certain force gives an object of mass m_1 an acceleration of 12.0 m/s² and an object of mass m_2 an acceleration of 3.30 m/s². What acceleration would the force give to an object of mass (a) $m_2 - m_1$ and (b) $m_2 + m_1$?

74 Figure 5-65 shows a kimchi container of mass m_1 = 3.0 kg connected to a block of mass m_2 by a cord looped around a frictionless pulley. The cord and pulley have negligible mass.

When the container is released from rest, it accelerates at 1.0 m/s^2 across the horizontal frictionless surface. What are (a) the tension in the cord and (b) mass m_2?

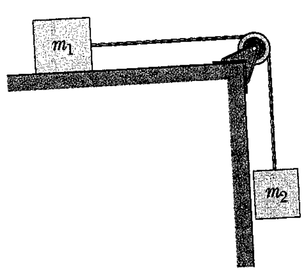

Fig. 5-65 Problem 74.

75 In Fig. 5-66, a force $\vec{F}$ of magnitude 12 N is applied to a FedEx box of mass $m_2 = 1.0$ kg. The force is directed up a plane tilted by $\theta = 37°$. The box is connected by a cord to a UPS box of mass $m_1 = 3.0$ kg on the floor. The floor, plane, and pulley are frictionless, and the masses of the pulley and cord are negligible. What is the tension in the cord?

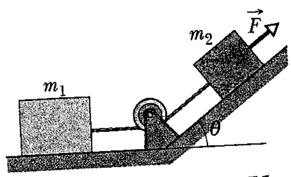

Fig. 5-66 Problem 75.

76 A 100 kg crate sits on the floor of a freight elevator that starts from rest on the ground floor of a building at time $t = 0$ and rises to the top floor during an 8.0 s interval. The speed of the elevator as a function of time is shown in Fig. 5-67. What are (a) the magnitude F_{elv} and (b) the direction (up or down) of the force on the crate from the elevator floor at $t = 1.8$ s? What are (c) F_{elv} and (d) the direction at $t = 4.4$ s? What are (e) F_{elv} and (f) the direction at $t = 6.8$ s?

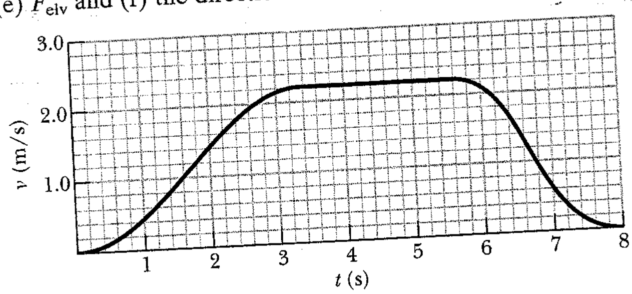

Fig. 5-67 Problem 76.

77 In Fig. 5-68, a tin of antioxidants ($m_1 = 1.0$ kg) on a frictionless inclined surface is connected to a tin of corned beef ($m_2 = 2.0$ kg). The pulley is massless and frictionless. An upward force of magnitude $F = 6.0$ N acts on the corned beef tin, which has a downward acceleration of 5.5 m/s^2. What are (a) the tension in the connecting cord and (b) angle β?

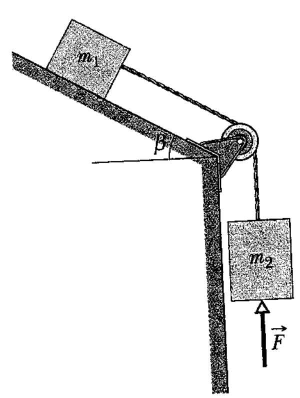

Fig. 5-68 Problem 77.

78 An object is hung from a spring balance attached to the ceiling of an elevator cab. The balance reads 65 N when the cab is standing still. What is the reading when the cab is moving upward (a) with a constant speed of 7.6 m/s and (b) with a speed of 7.6 m/s while decelerating at a rate of 2.4 m/s^2?

79 In Fig. 5-17 of Sample Problem 5-6, we could change the angle between cord 2 and the ceiling, call it θ_2, by changing the length of cord 2. (The angle between cord 1 and the ceiling is still 28°.) (a) Graph the tension T_1 in cord 1 versus angle θ_2 for θ_2 ranging from 0° to 90°, using the data in the sample problem. Approximately what are the (a) maximum and (b) minimum values of T_1? Are (c) the maximum value and (d) the minimum value physically possible?

80 Compute the weight of a 75 kg space ranger (a) on Earth, (b) on Mars, where $g = 3.8$ m/s^2, and (c) in interplanetary space, where $g = 0$. (d) What is the ranger's mass at each location?

81 A certain particle has a weight of 22 N at a point where $g = 9.8$ m/s^2. What are its (a) weight and (b) mass at a point where $g = 4.9$ m/s^2? What are its (c) weight and (d) mass if it is moved to a point in space where $g = 0$?

82 An interstellar ship has a mass of 1.20×10^6 kg and is initially at rest relative to a star system. (a) What constant acceleration is needed to bring the ship up to a speed of $0.10c$ (where c is the speed of light, 3.0×10^8 m/s) relative to the star system in 3.0 days? (b) What is that acceleration in g units? (c) What force is required for the acceleration? (d) If the engines are shut down when $0.10c$ is reached (the speed then remains constant), how long does the ship take (start to finish) to journey 5.0 light-months, the distance that light travels in 5.0 months?

83 A motorcycle and 60.0 kg rider accelerate at 3.0 m/s^2 up a ramp inclined 10° above the horizontal. What are the magnitudes of (a) the net force on the rider and (b) the force on the rider from the motorcycle?

84 When an automobile weighing 17.0 kN accelerates at 3.66 m/s^2, what is the magnitude of the net force on it?

85 An 80 kg person is parachuting and experiencing a downward acceleration of 2.5 m/s^2. The mass of the parachute is 5.0 kg. (a) What is the upward force on the open parachute from the air? (b) What is the downward force on the parachute from the person?

86 A 1400 kg jet engine is fastened to the fuselage of a passenger jet by just three bolts (this is the usual practice). Assume that each bolt supports one-third of the load. (a) Calculate the force on each bolt as the plane waits in line for clearance to take off. (b) During flight, the plane encounters turbulence, which suddenly imparts an upward vertical acceleration of 2.6 m/s^2 to the plane. Calculate the force on each bolt now.

87 For sport, a 12 kg armadillo runs onto a large pond of level, frictionless ice. The armadillo's initial velocity is 5.0 m/s along the positive direction of an x axis. Take its initial position on the ice as being the origin. It slips over the ice while being pushed by a wind with a force of 17 N in the positive direction of the y axis. In unit-vector notation, what are the animal's (a) velocity and (b) position vector when it has slid for 3.0 s?

88 A 50 kg passenger rides in an elevator cab that starts from rest on the ground floor of a building at $t = 0$ and rises to the top floor during a 10 s interval. The cab's acceleration as a function of the time is shown in Fig. 5-69, where positive values of the acceleration mean that it is directed upward. What are the (a) magnitude and (b) direction (up or down)

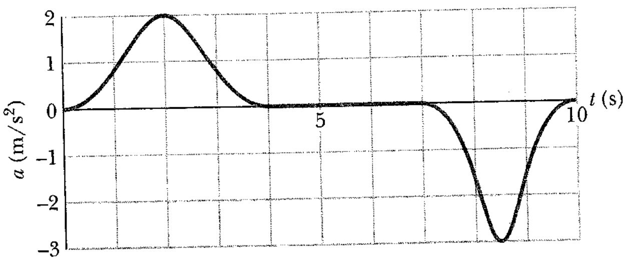

Fig. 5-69 Problem 88.

of the maximum force on the passenger from the floor, the (c) magnitude and (d) direction of the minimum force on the passenger from the floor, and the (e) magnitude and (f) direction of the maximum force on the floor from the passenger?

89 You pull a short refrigerator with a constant force $\vec{F}$ across a greased (frictionless) floor, either with $\vec{F}$ horizontal (case 1) or with $\vec{F}$ tilted upward at an angle θ (case 2). (a) What is the ratio of the refrigerator's speed in case 2 to its speed in case 1 if you pull for a certain time t? (b) What is this ratio if you pull for a certain distance d?

90 Suppose the 1 kg standard body accelerates at 4.00 m/s^2 at 160° from the positive direction of an x axis due to two forces; one is $\vec{F}_1 = (2.50 \text{ N})\hat{i} + (4.60 \text{ N})\hat{j}$. What is the other force (a) in unit-vector notation and as (b) a magnitude and (c) an angle?

91 A rocket and its payload have a total mass of 5.0×10^4 kg. How large is the force produced by the engine (the thrust) when the rocket is (a) "hovering" over the launchpad just after ignition and (b) accelerating upward at 20 m/s^2?

92 An 80 kg man drops to a concrete patio from a window 0.50 m above the patio. He neglects to bend his knees on landing, taking 2.0 cm to stop. (a) What is his average acceleration from when his feet first touch the patio to when he stops? (b) What is the magnitude of the average stopping force exerted on him by the patio?

93 A motorcycle of weight 2.0 kN accelerates from 0 to 88.5 km/h in 6.0 s. What are the magnitudes of (a) the constant acceleration and (b) the net force causing the acceleration?

94 Suppose that in Fig. 5-14, the masses of the blocks are 2.0 kg and 4.0 kg. (a) Which mass should the hanging block have if the magnitude of the acceleration is to be as large as possible? What then are (b) the magnitude of the acceleration and (c) the tension in the cord?

95 If the 1 kg standard body is accelerated by only $\vec{F}_1 = (3.0 \text{ N})\hat{i} + (4.0 \text{ N})\hat{j}$ and $\vec{F}_2 = (-2.0 \text{ N})\hat{i} + (-6.0 \text{ N})\hat{j}$, then what is $\vec{F}_{net}$ (a) in unit-vector notation and as (b) a magnitude and (c) an angle relative to the positive x direction? What are the (d) magnitude and (e) angle of $\vec{a}$?

96 A spaceship lifts off vertically from the Moon, where $g = 1.6$ m/s^2. If the ship has an upward acceleration of 1.0 m/s^2 as it lifts off, what is the magnitude of the force exerted by the ship on its pilot, who weighs 735 N on Earth?

97 In a laboratory experiment, an initially stationary electron (mass $= 9.11 \times 10^{-31}$ kg) undergoes a constant acceleration through 1.5 cm, reaching a speed of 6.0×10^6 m/s at the end of that distance. What are (a) the magnitude of the force accelerating the electron and (b) the electron's weight?

98 Compute the initial upward acceleration of a rocket of mass 1.3×10^4 kg if the initial upward force produced by its engine (the thrust) is 2.6×10^5 N. Do not neglect the gravitational force on the rocket.

99 Figure 5-70a shows a mobile hanging from a ceiling; it consists of two metal pieces ($m_1 = 3.5$ kg and $m_2 = 4.5$ kg) strung together by cords of negligible mass. What is the tension in (a) the bottom cord and (b) the top cord? Figure 5-70b shows a mobile consisting of three metal pieces. Two of the masses are $m_3 = 4.8$ kg and $m_5 = 5.5$ kg. The tension in the top cord is 199 N. What is the tension in (c) the lowest cord and (d) the middle cord?

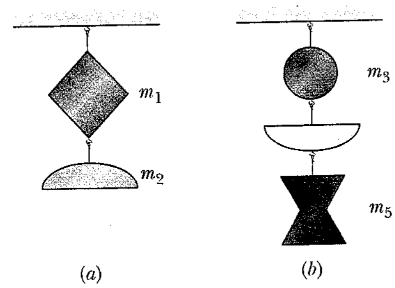

Fig. 5-70 Problem 99.

100 A 12 kg penguin with an initial velocity of 6.0 m/s toward the east runs onto a large area of level, frictionless ice. As the penguin slides across the ice, it is pushed by the wind with a force that is constant in magnitude and direction. Figure 5-71 shows the position of the penguin, at 1.0 s intervals, as it slides on the ice; the positive direction of the x axis is toward the east. The penguin first makes contact with the ice at $t = 0$. What are the (a) magnitude and (b) direction of the force of the wind on the penguin?

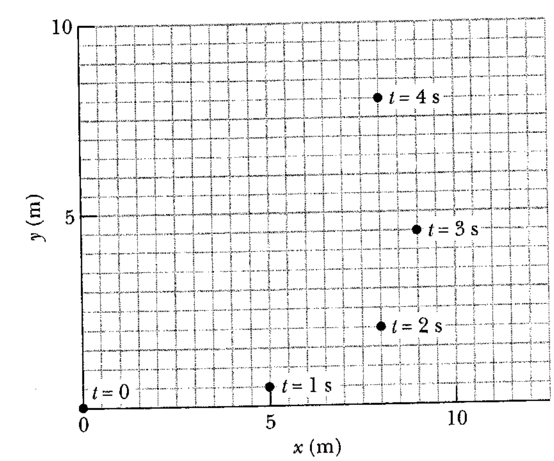

Fig. 5-71 Problem 100.

101 A 0.20 kg hockey puck has a velocity of 2.0 m/s toward the east as it slides over the frictionless surface of a frozen lake. What are the magnitude and direction of the average force that must act on the puck during a 0.50 s interval to change its velocity to (a) 5.0 m/s, west, and (b) 5.0 m/s, south?

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, $\phi = 0°$; (d) 90.0°; (e) $-5.14\hat{i} + 6.13\hat{j} + 3.00\hat{k}$; (f) 8.54, $\theta = 130°$, $\phi = 69.4°$ **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° **61.** (a) 3.0 m²; (b) 52 m³; (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) $(8\hat{i} - 6\hat{j})$ 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/s³, −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 km/h, distance increasing; (c) +80 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) $(8\text{ m/s}^2)t\hat{j} + (1\text{ m/s})\hat{k}$; (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/s²; (c) down; (d) 4.1 m/s²; (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/s² **55.** (a) 13 m/s²; (b) eastward; (c) 13 m/s²; (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) 2×10^2 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) 4.8×10^2 m/s **89.** (a) 6.7×10^6 m/s; (b) 1.4×10^{-7} s **91.** 3×10^1 m **93.** (a) 5.4×10^{-13} 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/s²; (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 m, 54 m) **113.** (a) 0, 0; 2.0 m, 1.4 m; 4.0 m, 2.0 m; 6.0 m, 1.4 m; 8.0 m, 0; (b) 2.0 m/s, 1.1 m/s; 2.0 m/s, 0; 2.0 m/s, −1.1 m/s; (c) 0, −0.87 m/s²; 0, −1.2 m/s²; 0, −0.87 m/s² **115.** (a) 19 m/s; (b) 35 rev/min; (c) 1.7 s **117.** (a) 76 m; (b) 4.2 s **119.** (a) $(10\hat{i} + 10\hat{j})$ m/s; (b) 8.0 m/s²; (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/s² **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/s² **15.** (a) 11.7 N; (b) −59.0° **17.** 1.2×10^5 N **19.** (a) 0.022 m/s²; (b) 8.3×10^4 km; (c) 1.9×10^3 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/s²; (f) −22.0° **27.** (a) 0.62 m/s²; (b) 0.13 m/s²; (c) 2.6 m **29.** (a) 1.18 m; (b) 0.674 s; (c) 3.50 m/s **31.** (a) 2.2×10^{-3} N; (b) 3.7×10^{-3} N **33.** 1.8×10^4 N **35.** (a) 31.3 kN; (b) 24.3 kN **37.** (a) 1.4 m/s²; (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/s²; (b) 116 N; (c) 21.0 m/s² **43.** (a) 1.1 N **45.** (a) 0.970 m/s²; (b) 11.6 N; (c) 34.9 N **47.** (a) 3.6 m/s²; (b) 17 N **49.** (a) 4.9 m/s²; (b) 2.0 m/s²; (c) up; (d) 120 N **51.** (a) 0.735 m/s²; (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/s² **61.** (a) 0;

(b) 0.83 m/s²; (c) 0 **63.** (a) 0.74 m/s²; (b) 7.3 m/s² **65.** (a) 3.5 N; (b) west; (c) 2.7 N; (d) 22° west of due south **67.** 16 N **69.** (a) rope breaks; (b) 1.6 m/s² **71.** 12 N **73.** (a) 4.6 m/s²; (b) 2.6 m/s² **75.** 4.6 N **77.** (a) 2.6 N; (b) 17° **79.** (b) 313 N; (c) 0 N; (d) no; (e) yes **81.** (a) 11 N; (b) 2.2 kg; (c) 0; (d) 2.2 kg **83.** (a) 1.8×10^2 N; (b) 6.4×10^2 N **85.** (a) 620 N; (b) 580 N **87.** (a) (5.0 m/s)$\hat{i}$ + (4.3 m/s)$\hat{j}$; (b) (15 m)$\hat{i}$ + (6.4 m)$\hat{j}$ **89.** (a) cos θ; (b) $(\cos\theta)^{0.5}$ **91.** (a) 4.9×10^5 N; (b) 1.5×10^6 N **93.** (a) 4.1 m/s²; (b) 836 N **95.** (a) $(1.0\hat{i} - 2.0\hat{j})$ N; (b) 2.2 N; (c) −63°; (d) 2.2 m/s²; (e) −63° **97.** (a) 1.1×10^{-15} N; (b) 8.9×10^{-30} N **99.** (a) 44 N; (b) 78 N; (c) 54 N; (d) 152 N **101.** (a) 2.8 N, due west; (b) 2.2 N, 22° west of due south

chapter 6

CP **1.** (a) zero (because there is no attempt at sliding); (b) 5 N; (c) no; (d) yes; (e) 8 N **2.** (a) same (10 N); (b) decreases; (c) decreases (because N decreases) **3.** greater (from Sample Problem 6-5, v_t depends on $\sqrt{R}$) **4.** ($\vec{a}$ is directed toward center of circular path) (a) $\vec{a}$ downward, $\vec{N}$ upward; (b) $\vec{a}$ and $\vec{N}$ upward **5.** (a) same (must still match the gravitational force on the rider); (b) increases ($N = mv^2/R$); (c) increases ($f_{s,\max} = \mu_s N$) **6.** (a) $4R_1$; (b) $4R_1$ **Q** **1.** (a) F_1, F_2, F_3; (b) all tie **3.** (a) upward; (b) horizontal, toward you; (c) no change; (d) increases; (e) increases **5.** (a) decrease; (b) decrease; (c) decrease; (d) decrease; (e) decrease **7.** At first, $\vec{f}_s$ is directed up the ramp and its magnitude increases from $mg \sin\theta$ until it reaches $f_{s,\max}$. Thereafter the force is kinetic friction directed up the ramp, with magnitude f_k (a constant value smaller than $f_{s,\max}$). **9.** (a) 5 m/s² to 10 m/s²; (b) 0 to 5 m/s² **11.** (a) all tie; (b) all tie; (c) 2, 3, 1 **P** **1.** 2° **3.** (a) 2.0×10^2 N; (b) 1.2×10^2 N **5.** (a) 1.9×10^2 N; (b) 0.56 m/s² **7.** (a) 11 N; (b) 0.14 m/s² **9.** 0.58 **11.** (a) 1.3×10^2 N; (b) no; (c) 1.1×10^2 N; (d) 46 N; (e) 17 N **13.** (a) 3.0×10^2 N; (b) 1.3 m/s² **15.** (a) no; (b) (−12 N)$\hat{i}$ + (5.0 N)$\hat{j}$ **17.** (a) 19°; (b) 3.3 kN **19.** (a) (17 N)$\hat{i}$; (b) (20 N)$\hat{i}$; (c) (15 N)$\hat{i}$ **21.** 1.0×10^2 N **23.** 0.37 **25.** (a) 3.5 m/s²; (b) 0.21 N **27.** (a) 0; (b) (−3.9 m/s²)$\hat{i}$; (c) (−1.0 m/s²)$\hat{i}$ **29.** 4.9×10^2 N **31.** 9.9 s **33.** 2.3 **35.** (a) 3.2×10^2 km/h; (b) 6.5×10^2 km/h; (c) no **37.** 21 m **39.** 0.60 **41.** 1.37×10^3 N **43.** (a) 10 s; (b) 4.9×10^2 N; (c) 1.1×10^3 N **45.** (a) light; (b) 778 N; (c) 223 N; (d) 1.11 kN **47.** 2.2 km **49.** 1.81 m/s **51.** (a) 8.74 N; (b) 37.9 N; (c) 6.45 m/s; (d) radially inward **53.** (a) 69 km/h; (b) 139 km/h; (c) yes **55.** (a) 222 N; (b) 334 N; (c) 311 N; (d) 311 N; (e) c, d **57.** (a) 7.5 m/s²; (b) down; (c) 9.5 m/s²; (d) down **59.** (a) $\mu_k mg/(\sin\theta - \mu_k \cos\theta)$; (b) $\theta_0 = \tan^{-1} \mu_s$ **61.** (a) 27 N; (b) 3.0 m/s² **63.** (a) 35.3 N; (b) 39.7 N; (c) 320 N **65.** (a) 3.0 N; (b) 3.0 N; (c) 1.6 N; (d) 4.4 N; (e) 1.0 N; (f) e **67.** $g(\sin\theta - 2^{0.5}\mu_k \cos\theta)$ **69.** (a) 13 N; (b) 1.6 m/s² **71.** 118 N **73.** (a) $v_0^2/(4g \sin\theta)$; (b) no **75.** 0.76 **77.** (a) 30 cm/s; (b) 180 cm/s²; (c) inward; (d) 3.6×10^{-3} N; (e) inward; (f) 0.37 **79.** 4.6 N **81.** 20° **83.** (a) 0.11 m/s²; (b) 0.23 m/s²; (c) 0.041; (d) 0.029 **85.** (a) 0.34; (b) 0.24 **87.** (a) 3.21×10^3 N; (b) 3.75×10^3 N **89.** 178 km/h **91.** 0.18 **93.** (a) 100 N; (b) 245 N; (c) 86.6 N; (d) 195 N; (e) 50.0 N; (f) 158 N; (g) at rest; (h) slides; (i) at rest **95.** 0.56 **97.** (a) 2.1 m/s²; (b) down the plane; (c) 3.9 m; (d) it stays there **99.** (a) 275 N; (b) 877 N **101.** 874 N **103.** (a) 84.2 N; (b) 52.8 N; (c) 1.87 m/s² **105.** (a) 74 N; (b) (76 N)/(cos θ + 0.42 sin θ); (c) 23°; (d) 70 N **107.** (a) bottom of circle; (b) 9.5 m/s

chapter 7

CP **1.** (a) decrease; (b) same; (c) negative, zero **2.** d, c, b, a **3.** (a) same; (b) smaller **4.** (a) positive; (b) negative; (c) zero **5.** zero **Q** **1.** all tie **3.** c, b, a **5.** all tie **7.** (a) A, $\vec{F}_2$; B, $\vec{F}_1$; C, $\vec{F}_3$; D, $\vec{F}_4$; (b) E, A, and D; F, B, and C; G and H meaningless because K cannot have negative values **9.** e through h **P** **1.** 1.8×10^{13} J **3.** (a) 2.9×10^7 m/s; (b) 2.1×10^{-13} J **5.** (a) 2.4 m/s; (b) 4.8 m/s **7.** 6.8 J **9.** 0.96 J **11.** (a) 1.7×10^2 N; (b) 3.4×10^2 m; (c) -5.8×10^4 J; (d) 3.4×10^2 N; (e) 1.7×10^2 m; (f) -5.8×10^4 J **13.** (a) 1.50 J; (b) increases **15.** (a) 62.3°; (b) 118° **17.** (a) 12 kJ; (b) −11 kJ; (c) 1.1 kJ; (d) 5.4 m/s **19.** (a) $-3Mgd/4$; (b) Mgd; (c) $Mgd/4$; (d) $(gd/2)^{0.5}$ **21.** 25 J **23.** (a) 25.9 kJ; (b) 2.45 N **25.** (a) $x = -4.9$ cm and $x = +4.9$ cm **27.** (a) 16 J; (b) 16 J; (c) 0; (d) −14 J **29.** (a) 6.6 m/s; (b) 4.7 m **31.** 8.0×10^2 J **33.** (a) 0; (b) 0 **35.** 5.3×10^2 J **37.** (a) 42 J; (b) 30 J; (c) 12 J; (d) 6.5 m/s, $+x$ axis; (e) 5.5 m/s, $+x$ axis; (f) 3.5 m/s, $+x$ axis **39.** +41.7 J **41.** 4.9×10^2 W **43.** (a) 0.83 J; (b) 2.5 J; (c) 4.2 J; (d) 5.0 W **45.** 7.4×10^2 W **47.** (a) 1.0×10^2 J; (b) 8.4 W **49.** (a) 12 J; (b) 4.0 m; (c) 18 J **51.** (a) 2.7×10^2 N; (b) -4.0×10^2 J; (c) 4.0×10^2 J; (d) 0; (e) 0 **53.** (a) 11 J; (b) −21 J **55.** (a) 0.6 J; (b) 0; (c) −0.6 J **57.** (a) 1.20 J; (b) 1.10 m/s **59.** (a) 314 J; (b) −155 J; (c) 0; (d) 158 J **61.** (a) 8.0 N; (b) 8.0 N/m **63.** (a) 98 N; (b) 4.0 cm; (c) 3.9 J; (d) −3.9 J **65.** −6 J **67.** (a) 1.7 W; (b) 0; (c) −1.7 W **69.** (a) 2.1×10^2 J; (b) 2.1×10^2 J **71.** (a) 23 mm; (b) 45 N **73.** 235 kW **75.** (b) $x = 3.00$ m; (c) 13.5 J; (d) $x = 4.50$ m; (e) $x = 4.50$ m **77.** (a) 1.8×10^5 ft · lb; (b) 0.55 hp **79.** (a) 1×10^5 megatons TNT; (b) 1×10^7 bombs

chapter 8

CP **1.** no (consider round trip on the small loop) **2.** 3, 1, 2 (see Eq. 8-6) **3.** (a) all tie; (b) all tie **4.** (a) CD, AB, BC (0) (check slope magnitudes); (b) positive direction of x **5.** all tie **Q** **1.** (a) 12 J; (b) −2 J **3.** (a) 4; (b) returns to its starting point and repeats the trip; (c) 1; (d) 1 **5.** (a) AB, CD, then BC and DE tie (zero force); (b) 5 J; (c) 5 J; (d) 6 J; (e) FG; (f) DE **7.** +30 J **9.** (a) increasing; (b) decreasing; (c) decreasing; (d) constant in AB and BC, decreasing in CD **P** **1.** 89 N/cm **3.** (a) 4.31 mJ; (b) −4.31 mJ; (c) 4.31 mJ; (d) −4.31 mJ; (e) all increase **5.** (a) 0; (b) 170 kJ; (c) 340 kJ; (d) 170 kJ; (e) 340 kJ; (f) increase **7.** (a) 0.15 J; (b) 0.11 J; (c) 0.19 J; (d) 38 mJ; (e) 75 mJ; (f) all the same **9.** (a) 2.08 m/s; (b) 2.08 m/s; (c) increase **11.** (a) 17.0 m/s; (b) 26.5 m/s; (c) 33.4 m/s; (d) 56.7 m; (e) all the same **13.** (a) 2.6×10^2 m; (b) same; (c) decrease **15.** (a) 3.0 m; (b) 0.81 m; (c) 11 m/s; (d) 6.3 m/s; (f) 0.51 m **17.** (a) 0.98 J; (b) −0.98 J; (c) 3.1 N/cm **19.** (a) $U = 27 + 12x - 3x^2$; (b) 39 J; (c) −1.6 m; (d) 5.6 m **21.** (a) 2.5 N; (b) 0.31 N; (c) 30 cm **23.** (a) 4.85 m/s; (b) 2.42 m/s **25.** (a) 4.4 m; (b) same **27.** (a) 5.0 m/s; (b) 79°; (c) 64 J **29.** (a) 35 cm; (b) 1.7 m/s **31.** (a) 39.2 J; (b) 39.2 J; (c) 4.00 m **33.** (a) 2.8 m/s; (b) 2.7 m/s **35.** −18 mJ **37.** (a) 2.1 m/s; (b) 10 N; (c) $+x$ direction; (d) 5.7 m; (e) 30 N; (f) $-x$ direction **39.** (a) −3.7 J;