

3.1 Position and Displacement

- Two vectors, each of magnitude 4.0 cm, are inclined at a small angle a below the horizontal as shown. Let $\vec{D} = \vec{A} - \vec{B}$. Sketch the direction of \vec{D} and estimate its magnitude.
- Vector \vec{A} is directed along the positive y -axis and has magnitude $\sqrt{3.0}$ units. Vector \vec{B} is directed along the negative x -axis and has magnitude 1.0 unit. (a) What are the magnitude and direction of $\vec{A} - \vec{B}$? (b) What are the x - and y -components of $\vec{B} - \vec{A}$?
- Vector \vec{B} has magnitude 7.1 and direction 14° below the $+x$ -axis. Vector \vec{C} has x -component $C_x = -1.8$ and y -component $C_y = -6.7$. Compute: (a) the x - and y -components of \vec{B} ; (b) the magnitude and direction of \vec{C} ; (c) the magnitude and direction of $\vec{C} - \vec{B}$; (d) the x - and y -components of $\vec{C} - \vec{B}$.
- Margaret walks to the store using the following path: 0.500 miles west, 0.200 miles north, 0.300 miles east. What is her total displacement? That is, what is the length and direction of the vector that points from her house directly to the store?
- Jerry bicycles from his dorm to the local fitness center: 3.00 miles east and 2.00 miles north. Cindy's apartment is located 1.50 miles west of Jerry's dorm. If Cindy is able to meet Jerry at the fitness center by bicycling in a straight line, what is the length and direction she must travel?
- Michaela is planning a trip in Ireland from Killarney to Cork to visit Blarney Castle. She also wants to visit Mallow which is located 39 km due east of Killarney and 22 km due north of Cork. Draw the displacement vectors for the trip when she travels from Killarney to Mallow to Cork. (a) What is the magnitude of her displacement once she reaches Cork? (b) How much additional distance does Michaela travel in going to Cork by way of Mallow instead of going directly from Killarney to Cork.
- A scout troop is practicing its orienteering skills with map and compass. First they walk due east for 1.2 km. Next, they walk 45° west of north for 2.7 km. In what direction must they walk to go directly back to their starting point? How far will they have to walk? Use graph paper, ruler, and protractor to find a geometrical solution.
- Repeat Problem 7 using the component (algebraic) method.
- A sailboat sails from Marblehead Harbor directly east for 45 nautical miles, then 60° south of east for 20.0 nautical miles, returns to an easterly heading for 30.0 nautical miles, and sails 30° east of north for 10.0 nautical miles, then west for 62 nautical miles. At that time the boat becomes becalmed and the auxiliary engine fails to start. The crew decides to notify the Coast Guard of their position. Using graph paper, ruler, and protractor, find the sailboat's displacement from the harbor. Then add the displacement vectors using the component method to obtain a more accurate description of their location.
- You will be hiking to a lake with some of your friends by following the trails indicated on a map at the trailhead. The map says that you will travel 1.6 mi directly north, then 2.2 mi in a direction 35° east of north, then finally 1.1 mi in a direction 15° north of east. At the end of this hike, how far will you be from where you started, and what direction will you be from your starting point?
- The pilot of a small plane finds that the airport where he intended to land is fogged in. He flies 55 mi west to another airport to find that conditions there are too icy for him to land. He flies 25 mi at 15° east of south and is finally able to land at the third airport. (a) How far and in what direction must he fly the next day to go directly to his original destination? (b) How many extra miles beyond his original flight plan has he flown?
- We have assumed that the displacement for a trip is equal to the sum of the displacements for each leg of the trip. Prove that this is true. [*Hint*: Imagine a trip that consists of n segments. The trip starts at

position \vec{r}_1 , proceeds to \vec{r}_2 , then to \vec{r}_3 , . . . , then to \vec{r}_{n-1} , then finally to \vec{r}_n . Write an expression for each displacement as the difference of two position vectors and then add them.]

3.2 Velocity

13. A ball thrown by a pitcher on a women's softball team is timed at 65.0 mph. The distance from the pitching rubber to home plate is 43.0 ft. In major league baseball the corresponding distance is 60.5 ft. If the batter in the softball game and the batter in the baseball game are to have equal times to react to the pitch, with what speed must the baseball be thrown? [*Hint*: There is no need to convert units; set up a ratio.]
14. See Problem 6. During Michaela's travel from Killarney to Cork via Mallow, her actual travel time in the car is 48 min. (a) What is her average speed in m/s? (b) What is the magnitude of her average velocity in m/s?
15. Two cars, a Porsche Boxster convertible and a Toyota Scion xB, are traveling in the same direction, although the Boxster is 186 m behind the Scion. The speed of the Boxster is 24.4 m/s and the speed of the Scion is 18.6 m/s. How much time does it take for the Boxster to catch the Scion? [*Hint*: What must be true about the displacement of the two cars when they meet?]
16. Jason drives due west with a speed of 35.0 mi/h for 30.0 min, then continues in the same direction with a speed of 60.0 mi/h for 2.00 h, then drives farther west at 25.0 mi/h for 10.0 min. What is Jason's average velocity?
17. Peggy drives from Cornwall to Atkins Glen in 45 min. Cornwall is 73.6 km from Illium in a direction 25° west of south. Atkins Glen is 27.2 km from Illium in a direction 15° south of west. Using Illium as your origin, (a) draw the initial and final position vectors, (b) find the displacement during the trip, and (c) find Peggy's average velocity for the trip.
18. To get to a concert in time, a harpsichordist has to drive 122 mi in 2.00 h. (a) If he drove at an average speed of 55.0 mi/h in a due west direction for the first 1.20 h, what must be his average speed if he is heading 30.0° south of west for the remaining 48.0 min? (b) What is his average velocity for the entire trip?
19. A graph is plotted of the vertical velocity component of an elevator versus time. (a) How high is the elevator above the starting point ($t = 0$) after 20 s have elapsed? (b) When is the elevator at its highest location above the starting point?
20. Speedometer readings are obtained and graphed as a car comes to a stop along a straight-line path. How far does the car move between $t = 0$ and $t = 16$ s?
21. The graph shows speedometer readings, in meters per second (on the vertical axis), obtained as a skateboard travels along a straight-line path. How far does the board move between $t = 3.00$ s and $t = 8.00$ s?
22. The graph shows values of $x(t)$ in meters, on the vertical axis, for a skater traveling in a straight line. (a) What is $v_{av,x}$ for the interval from $t = 0$ to $t = 4.0$ s? (b) from $t = 0$ to $t = 5.0$ s?
23. The graph shows values of $x(t)$ in meters for a skater traveling in a straight line. What is v_x at $t = 2.0$ s?
24. The graph shows values of $x(t)$ in meters for an object traveling in a straight line. Plot v_x as a function of time for this object from $t = 0$ to $t = 8$ s.
25. A motor scooter travels east at a speed of 12 m/s. The driver then reverses direction and heads west at 15 m/s. What is the change in velocity of the scooter? Give magnitude and direction.
26. A car travels east at 96 km/h for 1.0 h. It then travels 30.0° east of north at 128 km/h for 1.0 h. (a) What is the average speed for the trip? (b) What is the average velocity for the trip?

27. A bicycle travels 3.2 km due east in 0.10 h, then 4.8 km at 15.0° east of north in 0.15 h, and finally another 3.2 km due east in 0.10 h to reach its destination. The time lost in turning is negligible. What is the average velocity for the entire trip?
28. To pass a physical fitness test, Massimo must run 1000 m at an average rate of 4.0 m/s. He runs the first 900 m in 250 s. How fast must he run the last 100 m to pass the test?
29. A speedboat heads west at 108 km/h for 20.0 min. It then travels at 60.0° south of west at 90.0 km/h for 10.0 min. (a) What is the average speed for the trip? (b) What is the average velocity for the trip?
30. A relay race is run along a straight-line track of length 300.0 m running south to north. The first runner starts at the south end of the track and passes the baton to a teammate at the north end of the track. The second runner races back to the start line and passes the baton to a third runner who races 100.0 m northward to the finish line. The magnitudes of the average velocities of the first, second, and third runners during their parts of the race are 7.30 m/s, 7.20 m/s, and 7.80 m/s, respectively. What is the average velocity of the baton for the entire race? [*Hint*: You will need to find the time spent by each runner in completing her portion of the race.]

3.3 Newton's Second Law of Motion

31. If a car traveling at 28 m/s is brought to a full stop in 4.0 s after the brakes are applied, find the average acceleration during braking.
32. If a pronghorn antelope accelerates from rest in a straight line with a constant acceleration of 1.7 m/s^2 , how long does it take for the antelope to reach a speed of 22 m/s?
33. The graph shows v_x versus t for a body moving along a straight line. (a) What is a_x at $t = 11 \text{ s}$? (b) What is a_x at $t = 3 \text{ s}$? (c) How far does the body travel from $t = 12$ to $t = 14 \text{ s}$?
34. The figure shows a plot of $v_x(t)$ for a car traveling in a straight line. (a) What is $a_{\text{av},x}$ between $t = 6 \text{ s}$ and $t = 11 \text{ s}$? (b) What is $v_{\text{av},x}$ for the same time interval? (c) What is $v_{\text{av},x}$ for the interval $t = 0$ to $t = 20 \text{ s}$? (d) What is the increase in the car's speed between 10 and 15 s? (e) How far does the car travel from time $t = 10 \text{ s}$ to time $t = 15 \text{ s}$?
35. The graph with Problem 20 shows speedometer readings as a car comes to a stop. What is the magnitude of the acceleration at $t = 7.0 \text{ s}$?
36. An 1100-kg airplane starts from rest and accelerates forward for 8.0 s until it reaches its takeoff speed of 35 m/s. What is the average forward force on the airplane during this time?
37. A car travels three-quarters of the way around a circle of radius 20.0 m in a time of 3.0 s at a constant speed. The initial velocity is west and the final velocity is south. (a) Find its average velocity for this trip. (b) What is the car's average acceleration during these 3.0 s? (c) Explain how a car moving at constant speed has a nonzero average acceleration.
38. At $t = 0$, an automobile traveling north begins to make a turn. It follows one-quarter of the arc of a circle of radius 10.0 m until, at $t = 1.60 \text{ s}$, it is traveling east. The car does not alter its speed during the turn. Find (a) the car's speed, (b) the change in its velocity during the turn, and (c) its average acceleration during the turn.
39. At the beginning of a 3.0-h plane trip, you are traveling due north at 192 km/h. At the end, you are traveling 240 km/h in the northwest direction (45° west of north). (a) Draw your initial and final velocity vectors. (b) Find the change in your velocity. (c) What is your average acceleration during the trip?
40. John drives 16 km directly west from Orion to Chester at a speed of 90 km/h, then directly south for 8.0 km to Seiling at a speed of 80 km/h, then finally 34 km southeast to Oakwood at a speed of 100

km/h. (a) What was the change in velocity during this trip? (b) What was the average acceleration during this trip?

41. A particle experiences a constant acceleration that is south at 2.50 m/s^2 . At $t = 0$, its velocity is 40.0 m/s east. What is its velocity at $t = 8.00 \text{ s}$?
42. A particle experiences a constant acceleration that is north at 100 m/s^2 . At $t = 0$, its velocity vector is 60 m/s east. At what time will the magnitude of the velocity be 100 m/s ?
43. A rubber ball is attached to a paddle by a rubber band. The ball is initially moving away from the paddle with a speed of 4.0 m/s . After 0.25 s , the ball is moving toward the paddle with a speed of 3.0 m/s . What is the average acceleration of the ball during that 0.25 s ? Give magnitude and direction.
44. A 1200-kg airplane starts from rest and accelerates forward at an average rate of 5.0 m/s^2 for 10 s along a runway that is 250 m long. What is the average forward force on the airplane during this time?
45. An accelerometer—a device to measure acceleration—can be as simple as a small pendulum hanging in the cockpit. Suppose you are flying a small plane in a straight, horizontal line and your accelerometer hangs 12° behind the vertical shown in the figure. What is your acceleration at that time?

3.4 Applying Newton's Second Law

46. A 2.0-kg toy locomotive is pulling a 1.0-kg caboose. The frictional force of the track on the caboose is 0.50 N backward along the track. If the train's acceleration forward is 3.0 m/s^2 , what is the magnitude of the force exerted by the locomotive on the caboose?
47. A 2010-kg elevator moves with an upward acceleration of 1.50 m/s^2 . What is the tension in the cable that supports the elevator?
48. A 2010-kg elevator moves with a downward acceleration of 1.50 m/s^2 . What is the tension in the cable that supports the elevator?
49. While an elevator of mass 2530 kg moves upward, the tension in the cable is 33.6 kN . (a) What is the acceleration of the elevator? (b) If at some point in the motion the velocity of the elevator is 1.20 m/s upward, what is the elevator's velocity 4.00 s later?
50. An engine pulls a train of 20 freight cars, each having a mass of $5.0 \times 10^4 \text{ kg}$ with a constant force. The cars move from rest to a speed of 4.0 m/s in 20.0 s on a straight track. Neglecting friction, what is the force with which the 10th car pulls the 11th one (at the middle of the train)?
51. In Fig. 3.35, two blocks are connected by a lightweight, flexible cord that passes over a frictionless pulley. (a) If $m_1 = 3.0 \text{ kg}$ and $m_2 = 5.0 \text{ kg}$, what are the accelerations of each block? (b) What is the tension in the cord?
52. A helicopter is lifting two crates simultaneously. One crate with a mass of 200 kg is attached to the helicopter by a cable. The second crate with a mass of 100 kg is hanging below the first crate and attached to the first crate by a cable. As the helicopter accelerates upward at a rate of 1.0 m/s^2 , what is the tension in each of the two cables?
53. A rope is attached from a truck to a 1400-kg car. The rope will break if the tension is greater than 2500 N . Neglecting friction, what is the maximum possible acceleration of the truck if the rope does not break? Should the driver of the truck be concerned that the rope might break?
54. A model sailboat is slowly sailing west across a pond at 0.33 m/s . A gust of wind blowing at 28° south of west gives the sailboat a constant acceleration of magnitude 0.30 m/s^2 during a time interval of 2.0 s . (a) If the net force on the sailboat during the 2.0-s interval has magnitude 0.375 N , what is the sailboat's mass? (b) What is the new velocity of the boat after the 2.0-s gust of wind?

55. The vertical component of the acceleration of a sailplane is zero when the air pushes up against its wings with a force of 3.0 kN. (a) Assuming that the only forces on the sailplane are that due to gravity and that due to the air pushing against its wings, what is the gravitational force on the Earth due to the sailplane? (b) If the wing stalls and the upward force decreases to 2.0 kN, what is the acceleration of the sailplane?
56. A man lifts a 2.0-kg stone vertically with his hand at a constant upward velocity of 1.5 m/s. What is the magnitude of the total force of the stone on the man's hand?
57. A man lifts a 2.0-kg stone vertically with his hand at a constant upward *acceleration* of 1.5 m/s². What is the magnitude of the total force of the stone on the man's hand?

3.5 Velocity Is Relative; Reference Frames

58. Two cars are driving toward each other on a straight, flat Kansas road. The Jeep Wrangler is traveling at 82 km/h north and the Ford Taurus is traveling at 48 km/h south, both measured relative to the road. What is the velocity of the Jeep relative to an observer in the Ford?
59. Two cars are driving toward each other on a straight and level road in Alaska. The BMW is traveling at 100.0 km/h north and the VW is traveling at 42 km/h south, both velocities measured relative to the road. At a certain instant, the distance between the cars is 10.0 km. Approximately how long will it take from that instant for the two cars to meet? [*Hint*: Consider a reference frame in which one of the cars is at rest.]
60. A car is driving directly north on the freeway at a speed of 110 km/h and a truck is leaving the freeway driving 85 km/h in a direction that is 35° west of north. What is the velocity of the truck relative to the car?
61. A Nile cruise ship takes 20.8 h to go upstream from Luxor to Aswan, a distance of 208 km, and 19.2 h to make the return trip downstream. Assuming the ship's speed relative to the water is the same in both cases, calculate the speed of the current in the Nile.
62. An airplane has a velocity relative to the ground of 210 m/s toward the east. The pilot measures his airspeed (the speed of the plane relative to the air) to be 160 m/s. What is the minimum wind velocity possible?
63. A small plane is flying directly west with an airspeed of 30.0 m/s. The plane flies into a region where the wind is blowing at 10.0 m/s at an angle of 30° to the south of west. (a) If the pilot does not change the heading of the plane, what will be the ground speed of the airplane? (b) What will be the new directional heading, relative to the ground, of the airplane?
64. A small plane is flying directly west with an airspeed of 30.0 m/s. The plane flies into a region where the wind is blowing at 10.0 m/s at an angle of 30° to the south of west. In that region, the pilot changes the directional heading to maintain her due west heading. (a) What is the change she makes in the directional heading to compensate for the wind? (b) After the heading change, what is the ground speed of the airplane?
65. A boat that can travel at 4.0 km/h in still water crosses a river with a current of 1.8 km/h. At what angle must the boat be pointed upstream to travel straight across the river? In other words, in what direction is the velocity of the boat relative to the water?
66. A boy is attempting to swim directly across a river; he is able to swim at a speed of 0.500 m/s relative to the water. The river is 25.0 m wide and the boy ends up at 50.0 m downstream from his starting point. (a) How fast is the current flowing in the river? (b) What is the speed of the boy relative to a friend standing on the riverbank?

67. An aircraft has to fly between two cities, one of which is 600.0 km north of the other. The pilot starts from the southern city and encounters a steady 100.0 km/h wind that blows from the northeast. The plane has a cruising speed of 300.0 km/h in still air. (a) In what direction (relative to east) must the pilot head her plane? (b) How long does the flight take?
68. At an antique car rally, a Stanley Steamer automobile travels north at 40 km/h and a Pierce Arrow automobile travels east at 50 km/h. Relative to an observer riding in the Stanley Steamer, what are the x - and y -components of the velocity of the Pierce Arrow car? The x -axis is to the east and the y -axis is to the north.
69. Sheena can row a boat at 3.00 mi/h in still water. She needs to cross a river that is 1.20 mi wide with a current flowing at 1.60 mi/h. Not having her calculator ready, she guesses that to go straight across, she should head 60.0° upstream. (a) What is her speed with respect to the bank? (b) How long does it take her to cross the river? (c) How far upstream or downstream from her starting point will she reach the opposite bank? (d) In order to go straight across, what angle upstream should she have headed?
70. A dolphin wants to swim directly back to its home bay, which is 0.80 km due west. It can swim at a speed of 4.00 m/s relative to the water, but a uniform water current flows with speed 2.83 m/s in the southeast direction. (a) What direction should the dolphin head? (b) How long does it take the dolphin to swim the 0.80-km distance home?
71. Demonstrate with a vector diagram that a displacement is the same when measured in two different reference frames that are at rest with respect to each other.
72. In a plate glass factory, sheets of glass move along a conveyor belt at a speed of 15.0 cm/s. An automatic cutting tool descends at preset intervals to cut the glass to size. Since the assembly belt must keep moving at constant speed, the cutter is set to cut at an angle to compensate for the motion of the glass. If the glass is 72.0 cm wide and the cutter moves across the width at a speed of 24.0 cm/s, at what angle should the cutter be set?

Comprehensive Problems

73. A jetliner flies east for 600.0 km, then turns 30.0° toward the south and flies another 300.0 km. (a) How far is the plane from its starting point? (b) In what direction could the jetliner have flown directly to the same destination (in a straight-line path)? (c) If the jetliner flew at a constant speed of 400.0 km/h, how long did the trip take? (d) Moving at the same speed, how long would the direct flight have taken?
74. A pilot wants to fly from Dallas to Oklahoma City, a distance of 330 km at an angle of 10.0° west of north. The pilot heads directly toward Oklahoma City with an air speed of 200 km/h. After flying for 1.0 h, the pilot finds that he is 15 km off course to the west of where he expected to be after one hour assuming there was no wind. (a) What is the velocity and direction of the wind? (b) In what direction should the pilot have headed his plane to fly directly to Oklahoma City without being blown off course?
75. In a playground, two slides have different angles of incline θ_1 and θ_2 ($\theta_2 > \theta_1$). A child slides down the first at constant speed; on the second, his acceleration down the slide is a . Assume the coefficient of kinetic friction is the same for both slides. (a) Find a in terms of θ_1 , θ_2 , and g . (b) Find the numerical value of a for $\theta_1 = 45^\circ$ and $\theta_2 = 61^\circ$.
76. At 3:00 P.M., a bank robber is spotted driving north on I-15 at milepost 126. His speed is 112.0 mi/h. At 3:37 P.M., he is spotted at milepost 185 doing 105.0 mi/h. During this time interval, what are the bank robber's displacement, average velocity, and average acceleration? (Assume a straight highway.)

77. The coefficient of static friction between a block and a horizontal floor is 0.35, while the coefficient of kinetic friction is 0.22. The mass of the block is 4.6 kg and it is initially at rest. (a) What is the minimum horizontal applied force required to make the block start to slide? (b) Once the block is sliding, if you keep pushing on it with the same minimum starting force as in part (a), does the block move with constant velocity or does it accelerate? (c) If it moves with constant velocity, what is its velocity? If it accelerates, what is its acceleration?
78. In a movie, a stuntman places himself on the front of a truck as the truck accelerates. The coefficient of friction between the stuntman and the truck is 0.65. The stuntman is not standing on anything but can “stick” to the front of the truck as long as the truck continues to accelerate. What minimum forward acceleration will keep the stuntman on the front of the truck?
79. A crate of oranges weighing 180 N rests on a flatbed truck 2.0 m from the back of the truck. The coefficients of friction between the crate and the bed are ($\mu_s = 0.30$ and $\mu_k = 0.20$). The truck drives on a straight, level highway at a constant 8.0 m/s. (a) What is the force of friction acting on the crate? (b) If the truck speeds up with an acceleration of 1.0 m/s^2 , what is the force of the friction on the crate? (c) What is the maximum acceleration the truck can have without the crate starting to slide?
80. A bicycle is moving along a straight line. The graph in the figure shows its position from the starting point as a function of time. (a) In which section(s) of the graph does the object have the highest speed? (b) At which time(s) does the object reverse its direction of motion? (c) How far does the object move from $t = 0$ to $t = 3 \text{ s}$?
81. A crate of books is to be put on a truck by rolling it up an incline of angle θ using a dolly. The total mass of the crate and the dolly is m . Assume that rolling the dolly up the incline is the same as sliding it up a frictionless surface. (a) What is the magnitude of the *horizontal* force that must be applied just to hold the crate in place on the incline? (b) What horizontal force must be applied to roll the crate up at constant speed? (c) In order to start the dolly moving, it must be accelerated from rest. What horizontal force must be applied to give the crate an acceleration up the incline of magnitude a ?
82. A toy cart of mass m_1 moves on frictionless wheels as it is pulled by a string under tension T . A block of mass m_2 rests on top of the cart. The coefficient of static friction between the cart and the block is μ . Find the maximum tension T that will not cause the block to slide on the cart if the cart rolls on (a) a horizontal surface; (b) up a ramp of angle θ above the horizontal. In both cases, the string is parallel to the surface on which the cart rolls.
83. Imagine a trip where you drive along an east-west highway at 80.0 km/h for 45.0 min and then you turn onto a highway that runs 38.0° north of east and travel at 60.0 km/h for 30.0 min. (a) What is your average velocity for the trip? (b) What is your average velocity on the return trip when you head the opposite way and drive 38.0° south of west at 60.0 km/h for the first 30.0 min and then west at 80.0 km/h for the last 45.0 min?
84. A rocket is launched from rest. After 8.0 min, it is 160 km above the Earth’s surface and is moving at a speed of 7.6 km/s. Assuming the rocket moves up in a straight line, what are its (a) average velocity and (b) average acceleration?
85. Based on the information given in Problem 84, is it possible that the rocket moves with constant acceleration? Explain.
86. To pass a physical fitness test, Marcella must run 1000 m at an average speed of 4.00 m/s. She runs the first 500 m at an average of 4.20 m/s. What should be her average speed over the last 500 m in order to finish with an overall average speed of 4.00 m/s?
87. A locomotive pulls a train of 10 identical cars, on a track that runs east-west, with a force of $2.0 \times 10^6 \text{ N}$ directed east. What is the force with which the *last* car to the west pulls on the rest of the train?

88. Beatrice needs to drag her suitcase again (see Example 3.8). This time she pulls with a force of 105 N at 38.0° with the horizontal. The coefficients of static and kinetic friction between the suitcase and the floor are 0.273 and 0.117, respectively. (a) Draw a free-body diagram of the suitcase. (b) What is the magnitude of the normal force acting on the suitcase due to the floor? (c) Does the suitcase slide, or does she need to increase her force? (d) If the suitcase slides, what is its acceleration? If it does not slide, to what magnitude should she increase her force?
89. A woman of mass 51 kg is standing in an elevator. (a) If the elevator floor pushes up on her feet with a force of 408 N, what is the acceleration of the elevator? (b) If the elevator is moving at 1.5 m/s as it passes the fourth floor on its way down, what is its speed 4.0 s later?
90. Two blocks lie side by side on a frictionless table. The block on the left is of mass m ; the one on the right is of mass $2m$. The block on the right is pushed to the left with a force of magnitude F , pushing the other block in turn. What force does the block on the left exert on the block to its right?
91. A person climbs from a Paris metro station to the street level by walking up a stalled escalator in 94 s. It takes 66 s to ride the same distance when standing on the escalator when it is operating normally. How long would it take for him to climb from the station to the street by walking up the moving escalator?
92. A pilot starting from Athens, New York, wishes to fly to Sparta, New York, which is 320 km from Athens in the direction 20.0° N of E. The pilot heads directly for Sparta and flies at an airspeed of 160 km/h. After flying for 2.0 h, the pilot expects to be at Sparta, but instead he finds himself 20 km due west of Sparta. He has forgotten to correct for the wind. (a) What is the velocity of the plane relative to the air? (b) Find the velocity (magnitude and direction) of the plane relative to the ground. (c) Find the wind speed and direction.
93. Two blocks, masses m_1 and m_2 , are connected by a massless cord. If the two blocks are pulled with a constant tension on a frictionless surface by applying a force of magnitude T_2 to a second cord connected to m_2 , what is the ratio of the tensions in the two cords T_1/T_2 in terms of the masses?
94. The coefficient of static friction between a brick and a wooden board is 0.40 and the coefficient of kinetic friction between the brick and board is 0.30. You place the brick on the board and slowly lift one end of the board off the ground until the brick starts to slide down the board. (a) What angle does the board make with the ground when the brick starts to slide? (b) What is the acceleration of the brick as it slides down the board?
95. In the human nervous system, signals are transmitted along neurons as *action potentials* that travel at speeds of up to 100 m/s. (An action potential is a traveling influx of sodium ions through the membrane of a neuron.) The signal is passed from one neuron to another by the release of neurotransmitters in the synapse. Suppose someone steps on your toe. The pain signal travels along a 1.0-m-long sensory neuron to the spinal column, across a synapse to a second 1.0-m-long neuron, and across a second synapse to the brain. Suppose that the synapses are each 100 nm wide, that it takes 0.10 ms for the signal to cross each synapse, and that the action potentials travel at 100 m/s. (a) At what average speed does the signal cross a synapse? (b) How long does it take the signal to reach the brain? (c) What is the average speed of propagation of the signal?
96. An airplane of mass 2800 kg has just lifted off the runway. It is gaining altitude at a constant 2.3 m/s while the horizontal component of its velocity is increasing at a rate of 0.86 m/s^2 . Assume $g = 9.81 \text{ m/s}^2$. (a) Find the direction of the force exerted on the airplane by the air. (b) Find the horizontal and vertical components of the plane's acceleration if the force due to the air has the same magnitude but has a direction 2.0° closer to the vertical than its direction in part (a).
97. The graph shows the position x of a switch engine in a rail yard as a function of time t . At which of the labeled times t_0 to t_7 is (a) $a_x < 0$, (b) $a_x = 0$, (c) $a_x > 0$, (d) $v_x = 0$, (e) the speed decreasing?

98. An elevator starts at rest on the ninth floor. At $t = 0$, a passenger pushes a button to go to another floor. The graph for this problem shows the acceleration a_y of the elevator as a function of time. Let the y -axis point upward. (a) Has the passenger gone to a higher or lower floor? (b) Sketch a graph of the velocity v_y of the elevator versus time. (c) Sketch a graph of the position y of the elevator versus time. (d) If a 63.5-kg person stands on a scale in the elevator, what does the scale read at times t_1 , t_2 , and t_3 ?
99. A helicopter of mass M is lowering a truck of mass m onto the deck of a ship. (a) At first, the helicopter and the truck move downward together (the length of the cable doesn't change). If their downward speed is decreasing at a rate of $0.10g$, what is the tension in the cable? (b) As the truck gets close to the deck, the helicopter stops moving downward. While it hovers, it lets out the cable so that the truck is still moving downward. If the truck's downward speed is decreasing at a rate of $0.10g$, while the helicopter is at rest, what is the tension in the cable?