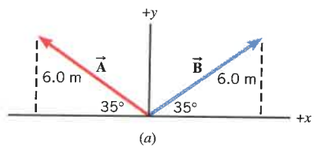
Section 1.8 Addition of Vectors by Means of Components

17. Drawing *a* shows two vectors $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$, and drawing *b* shows their components. The scalar components of these vectors are as follows:

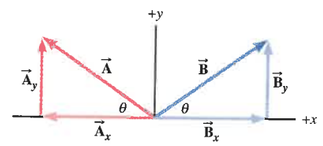
$$A_x = -4.9 \text{ m} \qquad A_y = +3.4 \text{ m}$$

$$B_x = +4.9 \text{ m} \qquad B_y = +3.4 \text{ m}$$

When the vectors $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$ are added, the resultant vector is $\vec{\mathbf{R}}$, so that $\vec{\mathbf{R}} = \vec{\mathbf{A}} + \vec{\mathbf{B}}$. What are the values of R_x and R_y, the *x* and *y* components of $\vec{\mathbf{R}}$?

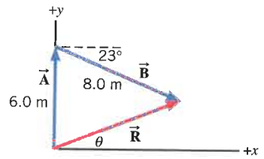


(*a*)



(*b*)

18. The displacement vectors $\vec{\mathbf{A}}$ and $\vec{\mathbf{B}}$, when added together, give the resultant vector $\vec{\mathbf{R}}$, so that $\vec{\mathbf{R}} = \vec{\mathbf{A}} + \vec{\mathbf{B}}$. Use the data in the drawing to find the magnitude *R* of the resultant vector and the angle θ that it makes with the $+x$ axis.



Continued

Problems

Problems that are not marked with a star are considered the easiest to solve. Problems that are marked with a single star (*) are more difficult, while those marked with a double star (**) are the most difficult.

Note to Instructors: *Most of the homework problems in this chapter are available for assignment via an online homework management program such as* WileyPLUS *or WebAssign, and those marked with the icons* GO *and* ▶II *are presented in* WileyPLUS *using a guided tutorial format that provides enhanced interactivity. See the Preface for additional details.*

ssm Solution is in the Student Solutions Manual.

mmh Problem-solving help is available online at www.wiley.com/college/cutnell.

This icon represents a biomedical application.

Section 1.2 Units,
Section 1.3 The Role of Units in Problem Solving

1. GO A student sees a newspaper ad for an apartment that has 1330 square feet (ft^2) of floor space. How many square meters of area are there?

2. Bicyclists in the Tour de France reach speeds of 34.0 miles per hour (mi/h) on flat sections of the road. What is this speed in **(a)** kilometers per hour (km/h) and **(b)** meters per second (m/s)?

3. **ssm** Vesna Vulovic survived the longest fall on record without a parachute when her plane exploded and she fell 6 miles, 551 yards. What is this distance in meters?

4. Suppose a man's scalp hair grows at a rate of 0.35 mm per day. What is this growth rate in feet per century?

5. Given the quantities $a = 9.7$ m, $b = 4.2$ s, $c = 69$ m/s, what is the value of the quantity $d = a^3/(cb^2)$?

6. Consider the equation $v = \frac{1}{3}zxt^2$. The dimensions of the variables *v*, *x*, and *t* are [L]/[T], [L], and [T], respectively. The numerical factor 3 is dimensionless. What must be the dimensions of the variable *z*, such that both sides of the equation have the same dimensions? Show how you determined your answer.

7. **ssm** A bottle of wine known as a magnum contains a volume of 1.5 liters. A bottle known as a jeroboam contains 0.792 U.S. gallons. How many magnums are there in one jeroboam?

8. The CGS unit for measuring the viscosity of a liquid is the poise (P): $1\ \text{P} = 1\ \text{g/(s} \cdot \text{cm)}$. The SI unit for viscosity is the kg/(s · m). The viscosity of water at 0 °C is 1.78×10^{-3} kg/(s · m). Express this viscosity in poise.

9. Azelastine hydrochloride is an antihistamine nasal spray. A standard-size container holds one fluid ounce (oz) of the liquid. You are searching for this medication in a European drugstore and are asked how many milliliters (mL) there are in one fluid ounce. Using the following conversion factors, determine the number of milliliters in a volume of one fluid ounce: 1 gallon (gal) = 128 oz, 3.785×10^{-3} cubic meters (m^3) = 1 gal, and 1 mL = 10^{-6} m^3.

10. GO A partly full paint can has 0.67 U.S. gallons of paint left in it. **(a)** What is the volume of the paint in cubic meters? **(b)** If all the remaining paint is used to coat a wall evenly (wall area = 13 m^2), how thick is the layer of wet paint? Give your answer in meters.

11. **ssm** A spring is hanging down from the ceiling, and an object of mass *m* is attached to the free end. The object is pulled down, thereby stretching the spring, and then released. The object oscillates up and down, and the time *T* required for one complete up-and-down oscillation is given by the equation $T = 2\pi\sqrt{m/k}$, where *k* is known as the spring constant. What must be the dimension of *k* for this equation to be dimensionally correct?

Section 1.4 Trigonometry

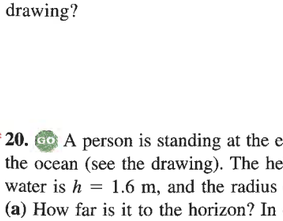
12. You are driving into St. Louis, Missouri, and in the distance you see the famous Gateway-to-the-West arch. This monument rises to a height of 192 m. You estimate your line of sight with the top of the arch to be 2.0° above the horizontal. Approximately how far (in kilometers) are you from the base of the arch?

13. **ssm** A highway is to be built between two towns, one of which lies 35.0 km south and 72.0 km west of the other. What is the shortest length of highway that can be built between the two towns, and at what angle would this highway be directed with respect to due west?

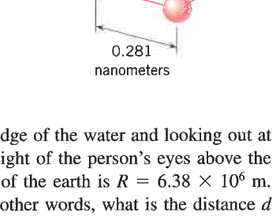
14. A hill that has a 12.0% grade is one that rises 12.0 m vertically for every 100.0 m of distance in the horizontal direction. At what angle is such a hill inclined above the horizontal?

15. GO The corners of a square lie on a circle of diameter $D = 0.35$ m. Each side of the square has a length *L*. Find *L*.

16. GO The drawing shows a person looking at a building on top of which an antenna is mounted. The horizontal distance between the person's eyes and the building is 85.0 m. In part *a* the person is looking at the base of the antenna, and his line of sight makes an angle of 35.0° with the horizontal. In part *b* the person is looking at the top of the antenna, and his line of sight makes an angle of 38.0° with the horizontal. How tall is the antenna?



(*a*)

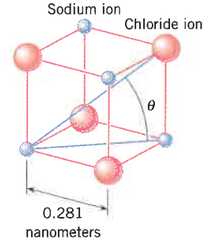


(*b*)

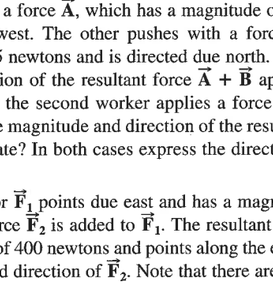
17. The two hot-air balloons in the drawing are 48.2 and 61.0 m above the ground. A person in the left balloon observes that the right balloon is 13.3° above the horizontal. What is the horizontal distance *x* between the two balloons?

18. What is the value of each of the angles of a triangle whose sides are 95, 150, and 190 cm in length? *(Hint: Consider using the law of cosines given in Appendix E.)*

19. **mmh** The drawing shows sodium and chloride ions positioned at the corners of a cube that is part of the crystal structure of sodium chloride (common table salt). The edges of the cube are each 0.281 nm (1 nm = 1 nanometer = 10^{-9} m) in length. What is the value of the angle θ in the drawing?



20. GO A person is standing at the edge of the water and looking out at the ocean (see the drawing). The height of the person's eyes above the water is $h = 1.6$ m, and the radius of the earth is $R = 6.38 \times 10^6$ m. **(a)** How far is it to the horizon? In other words, what is the distance *d* from the person's eyes to the horizon? *(Note: At the horizon the angle between the line of sight and the radius of the earth is 90°.)* **(b)** Express this distance in miles.



21. **ssm** Three deer, A, B, and C, are grazing in a field. Deer B is located 62 m from deer A at an angle of 51° north of west. Deer C is located 77° north of east relative to deer A. The distance between deer B and C is 95 m. What is the distance between deer A and C? *(Hint: Consider the law of cosines given in Appendix E.)*

22. An aerialist on a high platform holds on to a trapeze attached to a support by an 8.0-m cord. (See the drawing.) Just before he jumps off the platform, the cord makes an angle of 41° with the vertical. He jumps, swings down, then back up, releasing the trapeze at the instant it is 0.75 m below its initial height. Calculate the angle θ that the trapeze cord makes with the vertical at this instant.

Section 1.6 Vector Addition and Subtraction

23. **ssm** **(a)** Two workers are trying to move a heavy crate. One pushes on the crate with a force $\vec{\mathbf{A}}$, which has a magnitude of 445 newtons and is directed due west. The other pushes with a force $\vec{\mathbf{B}}$, which has a magnitude of 325 newtons and is directed due north. What are the magnitude and direction of the resultant force $\vec{\mathbf{A}} + \vec{\mathbf{B}}$ applied to the crate? **(b)** Suppose that the second worker applies a force $-\vec{\mathbf{B}}$ instead of $\vec{\mathbf{B}}$. What then are the magnitude and direction of the resultant force $\vec{\mathbf{A}} - \vec{\mathbf{B}}$ applied to the crate? In both cases express the direction relative to due west.

24. A force vector $\vec{\mathbf{F}}_1$ points due east and has a magnitude of 200 newtons. A second force $\vec{\mathbf{F}}_2$ is added to $\vec{\mathbf{F}}_1$. The resultant of the two vectors has a magnitude of 400 newtons and points along the east/west line. Find the magnitude and direction of $\vec{\mathbf{F}}_2$. Note that there are two answers.

25. **ssm** Consider the following four force vectors:

$$\vec{\mathbf{F}}_1 = 50.0 \text{ newtons, due east}$$

$$\vec{\mathbf{F}}_2 = 10.0 \text{ newtons, due east}$$

$$\vec{\mathbf{F}}_3 = 40.0 \text{ newtons, due west}$$

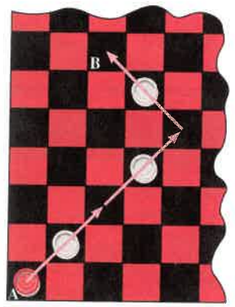
$$\vec{\mathbf{F}}_4 = 30.0 \text{ newtons, due west}$$

Which two vectors add together to give a resultant with the smallest magnitude, and which two vectors add to give a resultant with the largest magnitude? In each case specify the magnitude and direction of the resultant.

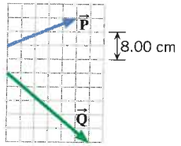
26. GO Vector $\vec{\mathbf{A}}$ has a magnitude of 63 units and points due west, while vector $\vec{\mathbf{B}}$ has the same magnitude and points due south. Find the magnitude and direction of **(a)** $\vec{\mathbf{A}} + \vec{\mathbf{B}}$ and **(b)** $\vec{\mathbf{A}} - \vec{\mathbf{B}}$. Specify the directions relative to due west.

27. Two bicyclists, starting at the same place, are riding toward the same campground by two different routes. One cyclist rides 1080 m due east and then turns due north and travels another 1430 m before reaching the campground. The second cyclist starts out by heading due north for 1950 m and then turns and heads directly toward the campground. **(a)** At the turning point, how far is the second cyclist from the campground? **(b)** In what direction (measured relative to due east) must the second cyclist head during the last part of the trip?

28. GO The drawing shows a triple jump on a checkerboard, starting at the center of square A and ending on the center of square B. Each side of a square measures 4.0 cm. What is the magnitude of the displacement of the colored checker during the triple jump?

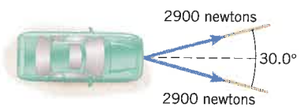


29. Given the vectors $\vec{\mathbf{P}}$ and $\vec{\mathbf{Q}}$ shown on the grid, sketch and calculate the magnitudes of the vectors **(a)** $\vec{\mathbf{M}} = \vec{\mathbf{P}} + \vec{\mathbf{Q}}$ and **(b)** $\vec{\mathbf{K}} = 2\vec{\mathbf{P}} - \vec{\mathbf{Q}}$. Use the tail-to-head method and express the magnitudes in centimeters with the aid of the grid scale shown in the drawing.



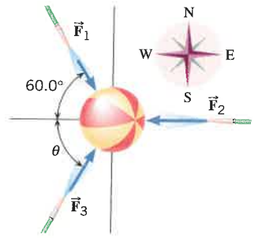
30.* mmh Vector $\vec{\mathbf{A}}$ has a magnitude of 12.3 units and points due west. Vector $\vec{\mathbf{B}}$ points due north. **(a) What is the magnitude of $\vec{\mathbf{B}}$ if $\vec{\mathbf{A}} + \vec{\mathbf{B}}$ has a magnitude of 15.0 units? **(b)** What is the direction of $\vec{\mathbf{A}} + \vec{\mathbf{B}}$ relative to due west? **(c)** What is the magnitude of $\vec{\mathbf{B}}$ if $\vec{\mathbf{A}} - \vec{\mathbf{B}}$ has a magnitude of 15.0 units? **(d)** What is the direction of $\vec{\mathbf{A}} - \vec{\mathbf{B}}$ relative to due west?

31.* ssm A car is being pulled out of the mud by two forces that are applied by the two ropes shown in the drawing. The dashed line in the drawing bisects the 30.0° angle. The magnitude of the force applied by each rope is 2900 newtons. Arrange the force vectors tail to head and use the graphical technique to answer the following questions. **(a) How much force would a single rope need to apply to accomplish the same effect as the two forces added together? **(b)** How would the single rope be directed relative to the dashed line?



32.* GO A jogger travels a route that has two parts. The first is a displacement $\vec{\mathbf{A}}$ of 2.50 km due south, and the second involves a displacement $\vec{\mathbf{B}}$ that points due east. **(a) The resultant displacement $\vec{\mathbf{A}} + \vec{\mathbf{B}}$ has a magnitude of 3.75 km. What is the magnitude of $\vec{\mathbf{B}}$, and what is the direction of $\vec{\mathbf{A}} + \vec{\mathbf{B}}$ relative to due south? **(b)** Suppose that $\vec{\mathbf{A}} - \vec{\mathbf{B}}$ had a magnitude of 3.75 km. What then would be the magnitude of $\vec{\mathbf{B}}$, and what is the direction of $\vec{\mathbf{A}} - \vec{\mathbf{B}}$ relative to due south?

33.* At a picnic, there is a contest in which hoses are used to shoot water at a beach ball from three directions. As a result, three forces act on the ball, $\vec{\mathbf{F}}_1$, $\vec{\mathbf{F}}_2$, and $\vec{\mathbf{F}}_3$ (see the drawing). The magnitudes of $\vec{\mathbf{F}}_1$ and $\vec{\mathbf{F}}_2$ are $F_1 = 50.0$ newtons and $F_2 = 90.0$ newtons. Using a scale drawing and the graphical technique, determine **(a) the magnitude of $\vec{\mathbf{F}}_3$ and **(b)** the angle θ such that the resultant force acting on the ball is zero.

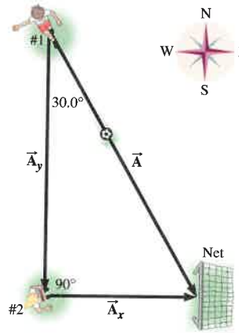


Section 1.7 The Components of a Vector

34. GO A force vector has a magnitude of 575 newtons and points at an angle of 36.0° below the positive x axis. What are **(a)** the x scalar component and **(b)** the y scalar component of the vector?

35. ssm Vector $\vec{\mathbf{A}}$ points along the $+y$ axis and has a magnitude of 100.0 units. Vector $\vec{\mathbf{B}}$ points at an angle of 60.0° above the $+x$ axis and has a magnitude of 200.0 units. Vector $\vec{\mathbf{C}}$ points along the $+x$ axis and has a magnitude of 150.0 units. Which vector has **(a)** the largest x component and **(b)** the largest y component?

36. Soccer player #1 is 8.6 m from the goal (see the drawing). If she kicks the ball directly into the net, the ball has a displacement labeled $\vec{\mathbf{A}}$. If, on the other hand, she first kicks it to player #2, who then kicks it into the net, the ball undergoes two successive displacements, $\vec{\mathbf{A}}_y$ and $\vec{\mathbf{A}}_x$. What are the magnitudes and directions of $\vec{\mathbf{A}}_x$ and $\vec{\mathbf{A}}_y$?



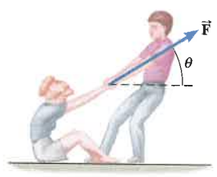
Problem 36

37. GO The components of vector $\vec{\mathbf{A}}$ are A_x and A_y (both positive), and the angle that it makes with respect to the positive x axis is θ. Find the angle θ if the components of the displacement vector $\vec{\mathbf{A}}$ are **(a)** $A_x = 12$ m and $A_y = 12$ m, **(b)** $A_x = 17$ m and $A_y = 12$ m, and **(c)** $A_x = 12$ m and $A_y = 17$ m.

38. During takeoff, an airplane climbs with a speed of 180 m/s at an angle of 34° above the horizontal. The speed and direction of the airplane constitute a vector quantity known as the velocity. The sun is shining directly overhead. How fast is the shadow of the plane moving along the ground? (That is, what is the magnitude of the horizontal component of the plane's velocity?)

39. ssm The x vector component of a displacement vector $\vec{\mathbf{r}}$ has a magnitude of 125 m and points along the negative x axis. The y vector component has a magnitude of 184 m and points along the negative y axis. Find the magnitude and direction of $\vec{\mathbf{r}}$. Specify the direction with respect to the negative x axis.

40. Your friend has slipped and fallen. To help her up, you pull with a force $\vec{\mathbf{F}}$, as the drawing shows. The vertical component of this force is 130 newtons, and the horizontal component is 150 newtons. Find **(a)** the magnitude of $\vec{\mathbf{F}}$ and **(b)** the angle θ.

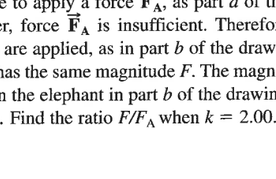


41. The displacement vector $\vec{\mathbf{A}}$ has scalar components of $A_x = 80.0$ m and $A_y = 60.0$ m. The displacement vector $\vec{\mathbf{B}}$ has a scalar component of $B_x = 60.0$ m and a magnitude of $B = 75.0$ m. The displacement vector $\vec{\mathbf{C}}$ has a magnitude of $C = 100.0$ m and is directed at an angle of 36.9° above the $+x$ axis. Two of these vectors are equal. Determine which two, and support your choice with a calculation.

42.* GO Two racing boats set out from the same dock and speed away at the same constant speed of 101 km/h for half an hour (0.500 h), the blue boat headed 25.0° south of west, and the green boat headed 37.0° south of west. During this half hour **(a) how much farther west does the blue boat travel, compared to the green boat, and **(b)** how much farther south does the green boat travel, compared to the blue boat? Express your answers in km.

43.* ssm mmh The magnitude of the force vector $\vec{\mathbf{F}}$ is 82.3 newtons. The x component of this vector is directed along the $+x$ axis and has a magnitude of 74.6 newtons. The y component points along the $+y$ axis. **(a) Find the direction of $\vec{\mathbf{F}}$ relative to the $+x$ axis. **(b)** Find the component of $\vec{\mathbf{F}}$ along the $+y$ axis.

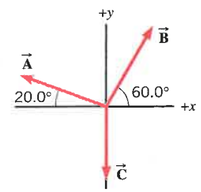
***44.* The drawing shows a force vector that has a magnitude of 475 newtons. Find the **(a)** x, **(b)** y, and **(c)** z components of the vector.



Section 1.8 Addition of Vectors by Means of Components

45. ssm Consult Multiple-Concept Example 9 in preparation for this problem. A golfer, putting on a green, requires three strokes to "hole the ball." During the first putt, the ball rolls 5.0 m due east. For the second putt, the ball travels 2.1 m at an angle of 20.0° north of east. The third putt is 0.50 m due north. What displacement (magnitude and direction relative to due east) would have been needed to "hole the ball" on the very first putt?

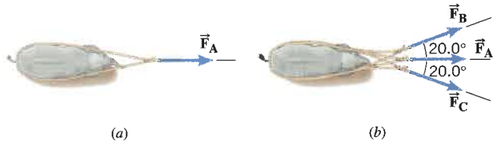
46. The three displacement vectors in the drawing have magnitudes of $A = 5.00$ m, $B = 5.00$ m, and $C = 4.00$ m. Find the resultant (magnitude and directional angle) of the three vectors by means of the component method. Express the directional angle as an angle above the positive or negative x axis.



Problem 46

47. mmh Multiple-Concept Example 9 reviews the concepts that play a role in this problem. Two forces are applied to a tree stump to pull it out of the ground. Force $\vec{\mathbf{F}}_A$ has a magnitude of 2240 newtons and points 34.0° south of east, while force $\vec{\mathbf{F}}_B$ has a magnitude of 3160 newtons and points due south. Using the component method, find the magnitude and direction of the resultant force $\vec{\mathbf{F}}_A + \vec{\mathbf{F}}_B$ that is applied to the stump. Specify the direction with respect to due east.

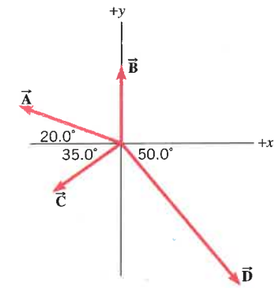
48. GO A baby elephant is stuck in a mud hole. To help pull it out, game keepers use a rope to apply a force $\vec{\mathbf{F}}_A$, as part a of the drawing shows. By itself, however, force $\vec{\mathbf{F}}_A$ is insufficient. Therefore, two additional forces $\vec{\mathbf{F}}_B$ and $\vec{\mathbf{F}}_C$ are applied, as in part b of the drawing. Each of these additional forces has the same magnitude F. The magnitude of the resultant force acting on the elephant in part b of the drawing is k times larger than that in part a. Find the ratio F/F_A when $k = 2.00$.



Problem 48

49. Displacement vector $\vec{\mathbf{A}}$ points due east and has a magnitude of 2.00 km. Displacement vector $\vec{\mathbf{B}}$ points due north and has a magnitude of 3.75 km. Displacement vector $\vec{\mathbf{C}}$ points due west and has a magnitude of 2.50 km. Displacement vector $\vec{\mathbf{D}}$ points due south and has a magnitude of 3.00 km. Find the magnitude and direction (relative to due west) of the resultant vector $\vec{\mathbf{A}} + \vec{\mathbf{B}} + \vec{\mathbf{C}} + \vec{\mathbf{D}}$.

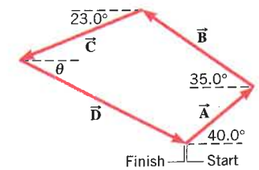
50. Multiple-Concept Example 9 provides background pertinent to this problem. The magnitudes of the four displacement vectors shown in the drawing are $A = 16.0$ m, $B = 11.0$ m, $C = 12.0$ m, and $D = 26.0$ m. Determine the magnitude and directional angle for the resultant that occurs when these vectors are added together.



51. mmh On a safari, a team of naturalists sets out toward a research station located 4.8 km away in a direction 42° north of east. After traveling in a straight line for 2.4 km, they stop and discover that they have been traveling 22° north of east, because their guide misread his compass. What are **(a)** the magnitude and **(b)** the direction (relative to due east) of the displacement vector now required to bring the team to the research station?

52.* GO Two geological field teams are working in a remote area. A global positioning system (GPS) tracker at their base camp shows the location of the first team as 38 km away, 19° north of west, and the second team as 29 km away, 35° east of north. When the first team uses its GPS to check the position of the second team, what does the GPS give for the second team's **(a) distance from them and **(b)** direction, measured from due east?

**53.* ssm A sailboat race course consists of four legs, defined by the displacement vectors $\vec{\mathbf{A}}$, $\vec{\mathbf{B}}$, $\vec{\mathbf{C}}$, and $\vec{\mathbf{D}}$, as the drawing indicates. The magnitudes of the first three vectors are $A = 3.20$ km, $B = 5.10$ km, and $C = 4.80$ km. The finish line of the course coincides with the starting line. Using the data in the drawing, find the distance of the fourth leg and the angle θ.



**54.* Multiple-Concept Example 9 deals with the concepts that are important in this problem. A grasshopper makes four jumps. The displacement vectors are (1) 27.0 cm, due west; (2) 23.0 cm, 35.0° south of west; (3) 28.0 cm, 55.0° south of east; and (4) 35.0 cm, 63.0° north of east. Find the magnitude and direction of the resultant displacement. Express the direction with respect to due west.

* **55.** mmh Vector $\vec{A}$ has a magnitude of 145 units and points 35.0° north of west. Vector $\vec{B}$ points 65.0° east of north. Vector $\vec{C}$ points 15.0° west of south. These three vectors add to give a resultant vector that is zero. Using components, find the magnitudes of **(a)** vector $\vec{B}$ and **(b)** vector $\vec{C}$.

* **56.** The route followed by a hiker consists of three displacement vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$. Vector $\vec{A}$ is along a measured trail and is 1550 m in a direction 25.0° north of east. Vector $\vec{B}$ is not along a measured trail, but the hiker uses a compass and knows that the direction is 41.0° east of south. Similarly, the direction of vector $\vec{C}$ is 35.0° north of west. The hiker ends up back where she started. Therefore, it follows that the resultant displacement is zero, or $\vec{A} + \vec{B} + \vec{C} = \vec{0}$. Find the magnitudes of **(a)** vector $\vec{B}$ and **(b)** vector $\vec{C}$.

Additional Problems

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57. A chimpanzee sitting against his favorite tree gets up and walks 51 m due east and 39 m due south to reach a termite mound, where he eats lunch. **(a)** What is the shortest distance between the tree and the termite mound? **(b)** What angle does the shortest distance make with respect to due east?

58. A monkey is chained to a stake in the ground. The stake is 3.00 m from a vertical pole, and the chain is 3.40 m long. How high can the monkey climb up the pole?

59. ssm The speed of an object and the direction in which it moves constitute a vector quantity known as the velocity. An ostrich is running at a speed of 17.0 m/s in a direction of 68.0° north of west. What is the magnitude of the ostrich's velocity component that is directed **(a)** due north and **(b)** due west?

60. The volume of liquid flowing per second is called the volume flow rate Q and has the dimensions of $[L]^3/[T]$. The flow rate of a liquid through a hypodermic needle during an injection can be estimated with the following equation:

$$Q = \frac{\pi R^n (P_2 - P_1)}{8\eta L}$$

The length and radius of the needle are L and R, respectively, both of which have the dimension [L]. The pressures at opposite ends of the needle are P_2 and P_1, both of which have the dimensions of $[M]/\{[L][T]^2\}$. The symbol η represents the viscosity of the liquid and has the dimensions of $[M]/\{[L][T]\}$. The symbol π stands for pi and, like the number 8 and the exponent n, has no dimensions. Using dimensional analysis, determine the value of n in the expression for Q.

61. An ocean liner leaves New York City and travels 18.0° north of east for 155 km. How far east and how far north has it gone? In other words, what are the magnitudes of the components of the ship's displacement vector in the directions **(a)** due east and **(b)** due north?

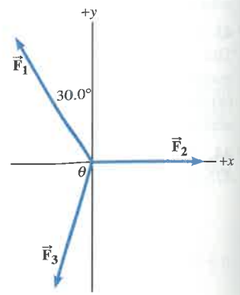
62. GO A pilot flies her route in two straight-line segments. The displacement vector $\vec{A}$ for the first segment has a magnitude of 244 km and a direction 30.0° north of east. The displacement vector $\vec{B}$ for the second segment has a magnitude of 175 km and a direction due west. The resultant displacement vector is $\vec{R} = \vec{A} + \vec{B}$ and makes an angle θ with the direction due east. Using the component method, find the magnitude of $\vec{R}$ and the directional angle θ.

63. ssm A circus performer begins his act by walking out along a nearly horizontal high wire. He slips and falls to the safety net, 25.0 ft below. The magnitude of his displacement from the beginning of the walk to the net is 26.7 ft. **(a)** How far out along the high wire did he walk? **(b)** Find the angle that his displacement vector makes below the horizontal.

* **64.** A force vector points at an angle of 52° above the $+x$ axis. It has a y component of +290 newtons. Find **(a)** the magnitude and **(b)** the x component of the force vector.

* **65.** ssm Vector $\vec{A}$ has a magnitude of 6.00 units and points due east. Vector $\vec{B}$ points due north. **(a)** What is the magnitude of $\vec{B}$, if the vector $\vec{A} + \vec{B}$ points 60.0° north of east? **(b)** Find the magnitude of $\vec{A} + \vec{B}$.

* **66.** Three forces act on an object, as indicated in the drawing. Force $\vec{F}_1$ has a magnitude of 21.0 newtons (21.0 N) and is directed 30.0° to the left of the $+y$ axis. Force $\vec{F}_2$ has a magnitude of 15.0 N and points along the $+x$ axis. What must be the magnitude and direction (specified by the angle θ in the drawing) of the third force $\vec{F}_3$ such that the vector sum of the three forces is 0 N?



* **67.** Before starting this problem, review Conceptual Example 7. The force vector $\vec{F}_A$ has a magnitude of 90.0 newtons and points due east. The force vector $\vec{F}_B$ has a magnitude of 135 newtons and points 75° north of east. Use the graphical method and find the magnitude and direction of **(a)** $\vec{F}_A - \vec{F}_B$ (give the direction with respect to due east) and **(b)** $\vec{F}_B - \vec{F}_A$ (give the direction with respect to due west).

* **68.** You live in the building on the left in the drawing, and a friend lives in the other building. The two of you are having a discussion about the heights of the buildings, and your friend claims that the height of his building is more than 1.50 times the height of yours. To resolve the issue you climb to the roof of your building and estimate that your line of sight to the top edge of the other building makes an angle of 21° above the horizontal, whereas your line of sight to the base of the other building makes an angle of 52° below the horizontal. Determine the ratio of the height of the taller building to the height of the shorter building. State whether your friend is right or wrong.

** **69.** What are the x and y components of the vector that must be added to the following three vectors, so that the sum of the four vectors is zero? Due east is the $+x$ direction, and due north is the $+y$ direction.

$\vec{A}$ = 113 units, 60.0° south of west
$\vec{B}$ = 222 units, 35.0° south of east
$\vec{C}$ = 177 units, 23.0° north of east

CHAPTER 2

These surfers maneuver to keep from falling and colliding with each other. They do so by controlling the displacement, velocity, and acceleration of their surf boards. These three concepts and the relationships among them are the focus of this chapter. (© Purestock/Getty Images, Inc.)

Kinematics in One Dimension

2.1 Displacement

There are two aspects to any motion. In a purely descriptive sense, there is the movement itself. Is it rapid or slow, for instance? Then, there is the issue of what causes the motion or what changes it, which requires that forces be considered. ***Kinematics*** deals with the concepts that are needed to describe motion, without any reference to forces. The present chapter discusses these concepts as they apply to motion in one dimension, and the next chapter treats two-dimensional motion. ***Dynamics*** deals with the effect that forces have on motion, a topic that is considered in Chapter 4. Together, kinematics and dynamics form the branch of physics known as ***mechanics.*** We turn now to the first of the kinematics concepts to be discussed, which is displacement.

To describe the motion of an object, we must be able to specify the location of the object at all times, and Figure 2.1 shows how to do this for one-dimensional motion. In this drawing, the initial position of a car is indicated by the vector labeled $\vec{x}_0$. The length of $\vec{x}_0$ is the distance of the car from an arbitrarily chosen origin. At a later time the car has moved to a new position, which is indicated by the vector $\vec{x}$. The ***displacement*** of the car $\Delta\vec{x}$ (read as "delta x" or "the change in x") is a vector drawn from the initial position to the final position. Displacement is a vector quantity in the sense discussed in Section 1.5, for it conveys both a magnitude (the distance between the initial and final positions) and a direction. The displacement can be related to $\vec{x}_0$ and $\vec{x}$ by noting from the drawing that

$$\vec{x}_0 + \Delta\vec{x} = \vec{x} \quad \text{or} \quad \Delta\vec{x} = \vec{x} - \vec{x}_0$$

Thus, the displacement $\Delta\vec{x}$ is the difference between $\vec{x}$ and $\vec{x}_0$, and the Greek letter delta (Δ) is used to signify this difference. It is important to note that the change in any variable is always the final value minus the initial value.

Definition of Displacement

The displacement is a vector that points from an object's initial position to its final position and has a magnitude that equals the shortest distance between the two positions.

SI Unit of Displacement: meter (m)

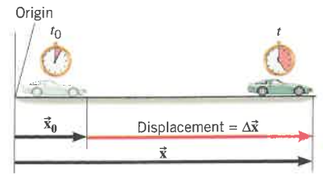


Figure 2.1 The displacement $\Delta\vec{x}$ is a vector that points from the initial position $\vec{x}_0$ to the final position $\vec{x}$.