chapter 1

INTRODUCTION AND MATHMATICAL CONCEPTS

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

☐ 1. Which one of the following is an SI base unit?
(a) gram (c) newton (e) kilogram
(b) slug (d) centimeter

◘ 2. Complete the following statement: Today, the standard meter is defined in terms of
(a) the distance from the earth's equator to the north pole.
(b) the wavelength of light emitted from a krypton atom.
(c) the wavelength of light emitted from a sodium atom.
(d) a platinum-iridium bar kept in Sèvres, France.
(e) the speed of light.

◘ 3. Complete the following statement: Today, the standard unit of mass is defined in terms of
(a) a specified volume of water at 4 °C. (d) a standard platinum bar.
(b) a standard platinum-iridium cylinder. (e) the speed of light.
(c) a specified number of cesium atoms.

◘ 4. Complete the following statement: Today, the standard unit of time is defined in terms of
(a) the electromagnetic waves emitted by cesium atoms.
(b) the motion of the moon around the earth.
(c) the motion of a precision pendulum.
(d) the average solar day.
(e) the speed of light.

◘ 5. A particle has a mass of one milligram. Which one of the following statements indicates the correct mass of the particle in grams?
(a) The particle has a mass of 1×10^{6} grams.
(b) The particle has a mass of 1×10^{3} grams.
(c) The particle has a mass of 1×10^{-1} grams.
(d) The particle has a mass of 1×10^{-3} grams.
(e) The particle has a mass of 1×10^{-6} grams.

◘ 6. Which one of the following is the longest length?
(a) 10^{0} meters (c) 10^{4} millimeters (e) 10^{7} nanometers
(b) 10^{2} centimeters (d) 10^{5} micrometers

◘ 7. In the sport of platform diving, a platform is set at a height of 7.3 m above the surface of the water. What is the height, expressed in feet, of the platform?
(a) 13 feet (c) 24 feet (e) 97 feet
(b) 18 feet (d) 33 feet

■ 8. A candy shop sells a pound of chocolate for $ 7.99. What is the price of 2.25 kg of chocolate at the shop?
(a) $ 8.17 (c) $ 17.98 (e) $ 39.64
(b) $ 12.51 (d) $ 29.66

◘ 9. The ratio $\frac{1 \text{ kilogram}}{1 \text{ milligram}}$ is

(a) 10^2. (c) 10^6. (e) 10^{-6}.
(b) 10^3. (d) 10^{-3}.

■ 10. Which one of the following choices is equivalent to 2.0 m^2?

(a) 2.0×10^{-4} cm^2 (c) 2.0×10^{-2} cm^2 (e) 2.0×10^3 cm^2
(b) 2.0×10^4 cm^2 (d) 2.0×10^2 cm^2

□ 11. Which one of the following pairs of units may *not* be added together, even after the appropriate unit conversions have been made?

(a) grams and milligrams (c) miles and kilometers (e) kilograms and kilometers
(b) slugs and kilograms (d) centimeters and yards

□ 12. Which one of the following choices is equivalent to 24.8 m?

(a) 2.48×10^1 m (c) 24.8×10^{-1} m (e) 2.48×10^0 m
(b) 2.48×10^2 m (d) 24.8×10^{-2} m

◘ 13. In the sport of horseshoe pitching, two stakes are 40.0 feet apart. What is the distance in meters between the two stakes?

(a) 24.4 m (c) 18.3 m (e) 15.7 m
(b) 4.80 m (d) 12.2 m

◘ 14. The Boston Marathon is the oldest annual foot race in which those that finish complete a distance of 26 miles, 385 yards. Express this distance in kilometers.

(a) 16.295 km (c) 42.186 km (e) 56.496 km
(b) 16.398 km (d) 42.453 km

■ 15. The surface of a lake has an area of 15.5 km^2. What is the area of the lake in m^2?

(a) 1.55×10^4 m^2 (c) 1.55×10^6 m^2 (e) 1.55×10^8 m^2
(b) 1.55×10^5 m^2 (d) 1.55×10^7 m^2

◘ 16. The mathematical relationship between three physical quantities is given by $a = \frac{b^2}{c}$. If the dimension of b is $\frac{[L]}{[T]}$; and the dimension of c is [L]. Which one of the following choices is the dimension of a?

(a) [L] (c) $\frac{[L]}{[T]}$ (e) $\frac{[L]^2}{[T]^2}$
(b) [T] (d) $\frac{[L]}{[T]^2}$

◘ 17. The distance d that a certain particle moves may be calculated from the expression $d = at + bt^2$ where a and b are constants; and t is the elapsed time. The dimensions of the quantities a and b are, respectively,

(a) $\frac{[L]}{[T]}, \frac{[L]}{[T]^2}$ (c) $\frac{[L]}{[T]^2}, \frac{[L]}{[T]^3}$ (e) $\frac{1}{[T]}, \frac{1}{[T]^2}$
(b) [L], $[L]^2$ (d) $\frac{[L]}{[T]}, \frac{[L]^2}{[T]^2}$

■ 18. Using the dimensions given for the variables in the table, determine which one of the following expressions is correct.

variable	dimension
f	$\frac{1}{[\mathrm{T}]}$
l	$[\mathrm{L}]$
g	$\frac{[\mathrm{L}]}{[\mathrm{T}]^2}$

(a) $f = \frac{g}{2\pi l}$ (d) $2\pi f = \sqrt{\frac{l}{g}}$

(b) $f = 2\pi lg$ (e) $f = 2\pi\sqrt{gl}$

(c) $2\pi f = \sqrt{\frac{g}{l}}$

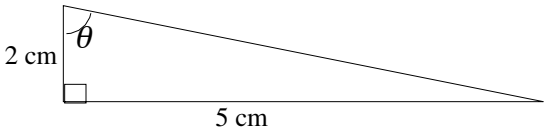
◘ 19. A certain physical quantity, R, is calculated using the formula: $R = 4a^2(b - c)$ where a, b, and c are distances. What is the SI unit for R?

(a) cm (c) m (e) m^3

(b) cm^2 (d) m^2

Section 1.4 Trigonometry

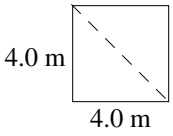
□ 20. Which one of the following expressions may be used to correctly find the angle θ in the drawing?



(a) $\theta = \cos^{-1}\left(\frac{5}{2}\right)$ (c) $\theta = \sin^{-1}\left(\frac{2}{5}\right)$ (e) $\theta = \sin^{-1}\left(\frac{5}{2}\right)$

(b) $\theta = \tan^{-1}\left(\frac{5}{2}\right)$ (d) $\theta = \tan^{-1}\left(\frac{2}{5}\right)$

◘ 21. The length of each side of a square is 4.0 m. What is the length of the diagonal of the square (shown as a dashed line in the figure)?



(a) 2.8 m (d) 8.0 m

(b) 3.5 m (e) 16 m

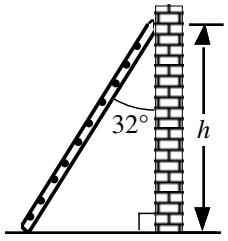
(c) 5.7 m

◘ 22. Three sticks are arranged to form a right triangle. If the lengths of the three sticks are 0.47 m, 0.62 m and 0.78 m, what are the three angles of the triangle?

(a) 90°, 45°, and 45° (c) 90°, 59°, and 31° (e) 90°, 53°, and 37°

(b) 90°, 62°, and 28° (d) 90°, 48°, and 42°

◘ 23. A 2.5-m ladder leans against a wall and makes an angle with the wall of 32° as shown in the figure. What is the height h above the floor where the ladder makes contact with the wall?



(a) 2.1 m

(b) 1.3 m

(c) 2.4 m

(d) 1.6 m

(e) 1.9 m

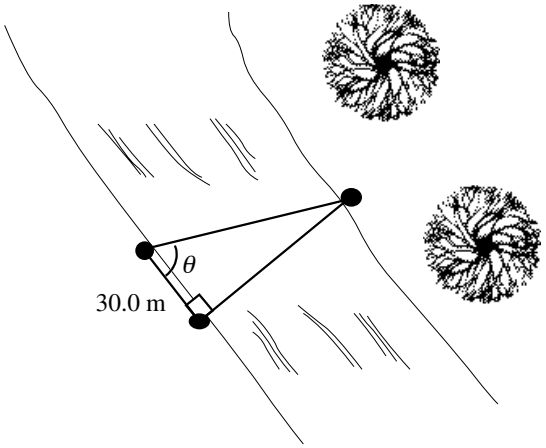
■ 24. A pole is held vertically by attaching wires at a height of 13.4 m above the ground. The other end of each wire is anchored in the ground at a distance of 9.54 m from the base of the pole. The pole makes a right angle with the ground. What is the length of each wire?

(a) 14.1 m (c) 11.5 m (e) 22.8 m

(b) 19.7 m (d) 16.4 m

■ 25. A certain mountain road is inclined 3.1° with respect to the horizon. What is the change in altitude of the car as a result of its traveling 2.90 km along the road?
(a) 157 m (c) 116 m (e) 289 m
(b) 181 m (d) 203 m

◘ 26. A surveyor wants to find the distance across a river. A stake is placed on each bank of the river as shown in the figure. She measures a distance of 30.0 m from one stake to another on the same side of the river, thus finding the third vertex on a right triangle. She then measures the angle θ and finds it equal to 75.9°. What is the distance across the river?



(a) 89.2 m
(b) 119 m
(c) 268 m
(d) 15.3 m
(e) 29.0 m

Section 1.5 Scalars and Vectors
Section 1.6 Vector Addition and Subtraction

□ 27. Which one of the following choices is a vector quantity?
(a) mass (c) time (e) volume
(b) temperature (d) displacement

◘ 28. Which one of the following quantities is a vector quantity?
(a) the age of the earth
(b) the mass of a football
(c) the earth's pull on your body
(d) the temperature of an iron bar
(e) the number of people attending a baseball game

◘ 29. Which one of the following statements is true concerning scalar quantities?
(a) Scalar quantities must be represented by base units.
(b) Scalar quantities have both magnitude and direction.
(c) Scalar quantities can be added to vector quantities using rules of trigonometry.
(d) Scalar quantities can be added to other scalar quantities using rules of trigonometry.
(e) Scalar quantities can be added to other scalar quantities using rules of ordinary addition.

■ 30. Two vectors **A** and **B** are added together to form a vector **C**. The relationship between the magnitudes of the vectors is given by $A + B = C$. Which one of the following statements concerning these vectors is true?
(a) **A** and **B** must be displacements.
(b) **A** and **B** must have equal lengths.
(c) **A** and **B** must point in opposite directions.
(d) **A** and **B** must point in the same direction.
(e) **A** and **B** must be at right angles to each other.

◘ 31. Two vectors **A** and **B** are added together to form a vector **C**. The relationship between the magnitudes of the vectors is given by: $A^2 + B^2 = C^2$. Which statement concerning these vectors is true?
(a) **A** and **B** must be at right angles to each other.
(b) **A** and **B** could have any orientation relative to each other.
(c) **A** and **B** must have equal lengths.
(d) **A** and **B** must be parallel.
(e) **A** and **B** could be antiparallel.

■ 32. Three vectors **A**, **B**, and **C** add together to yield zero: **A** + **B** + **C** = **0**. The vectors **A** and **C** point in *opposite* directions and their magnitudes are related by the expression: $A = 2C$. Which one of the following conclusions is correct?
(a) **A** and **B** have equal magnitudes and point in opposite directions.
(b) **B** and **C** have equal magnitudes and point in the same direction.
(c) **B** and **C** have equal magnitudes and point in opposite directions.
(d) **A** and **B** point in the same direction, but **A** has twice the magnitude of **B**.
(e) **B** and **C** point in the same direction, but **C** has twice the magnitude of **B**.

□ 33. What is the angle between the vectors **A** and –**A** when they are drawn from a common origin?
(a) 0° (c) 180° (e) 360°
(b) 90° (d) 270°

◘ 34. What is the minimum number of vectors with *unequal* magnitudes whose vector sum can be zero?
(a) two (c) four (e) six
(b) three (d) five

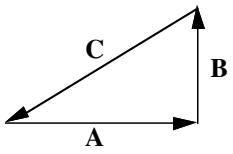
◘ 35. What is the minimum number of vectors with *equal* magnitudes whose vector sum can be zero?
(a) two (c) four (e) six
(b) three (d) five

◘ 36. A physics student adds two displacement vectors with magnitudes of 8.0 km and 6.0 km. Which one of the following statements is true concerning the magnitude of the resultant displacement?
(a) It must be 10.0 km.
(b) It must be 14.0 km.
(c) It could be equal to zero kilometers, depending on how the vectors are oriented.
(d) No conclusion can be reached without knowing the directions of the vectors.
(e) It could have any value between 2.0 km and 14.0 km depending on how the vectors are oriented.

◘ 37. A student adds two displacement vectors with magnitudes of 3.0 m and 4.0 m, respectively. Which one of the following could *not* be a possible choice for the resultant?
(a) 1.3 m (c) 5.0 m (e) 7.8 m
(b) 3.3 m (d) 6.8 m

■ 38. Two displacement vectors of magnitudes 21 cm and 79 cm are added. Which one of the following is the *only* possible choice for the magnitude of the resultant?
(a) 0 cm (c) 37 cm (e) 114 cm
(b) 28 cm (d) 82 cm

■ 39. Which expression is *false* concerning the vectors shown in the sketch?
(a) **C** = **A** + **B**
(b) **C** + **A** = –**B**
(c) **A** + **B** + **C** = **0**
(d) $C < A + B$
(e) $A^2 + B^2 = C^2$



□ 40. City A lies 30 km directly south of city B. A bus, beginning at city A travels 50 km at 37° north of east to reach city C. How far, and in what direction must the bus go from city C to reach city B?
(a) 20 km, west (c) 80 km, west (e) 80 km, east
(b) 40 km, west (d) 40 km, east

□ 41. Town A lies 20 km north of town B. Town C lies 13 km west of town A. A small plane flies directly from town B to town C. What is the displacement of the plane?
(a) 33 km, 33° north of west (d) 31 km, 57° north of west
(b) 19 km, 33° north of west (e) 6.6 km, 40° north of west
(c) 24 km, 57° north of west

□ 42. A runaway dog walks 0.64 km due north. He then runs due west to a hot dog stand. If the magnitude of the dog's total displacement vector is 0.91 km, what is the magnitude of the dog's displacement vector in the due west direction?
(a) 0.27 km (c) 0.41 km (e) 0.65 km
(b) 0.33 km (d) 0.52 km

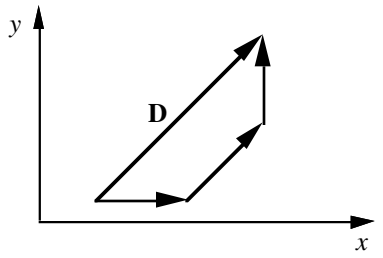
□ 43. An escaped convict runs 1.70 km due east of the prison. He then runs due north to a friend's house. If the magnitude of the convict's total displacement vector is 2.50 km, what is the direction of his total displacement vector with respect to due east?
(a) 43° south of east (c) 56° north of east (e) 34° north of east
(b) 47° north of east (d) 34° south of east

■ 44. Four members of the Main Street Bicycle Club meet at a certain intersection on Main Street. The members then start from the same location, but travel in different directions. A short time later, displacement vectors for the four members are:
$\mathbf{A}$ = 2.0 km, west; $\mathbf{B}$ = 1.6 km, north; $\mathbf{C}$ = 2.0 km, east; $\mathbf{D}$ = 2.4 km, south
What is the resultant displacement $\mathbf{R}$ of the members of the bicycle club: $\mathbf{R} = \mathbf{A} + \mathbf{B} + \mathbf{C} + \mathbf{D}$?
(a) 0.8 km, south (c) 3.6 km, 37° north of west (e) 4.0 km, south
(b) 0.4 km, 45° south of east (d) 4.0 km, east

■ 45. A force, $\mathbf{F}_1$, of magnitude 2.0 N and directed due east is exerted on an object. A second force exerted on the object is $\mathbf{F}_2$ = 2.0 N, due north. What is the magnitude and direction of a third force, $\mathbf{F}_3$, which must be exerted on the object so that the resultant force is zero?
(a) 1.4 N, 45° north of east (c) 2.8 N, 45° north of east (e) 4.0 N, 45° east of north
(b) 1.4 N, 45° south of west (d) 2.8 N, 45° south of west

■ 46. A sailboat leaves a harbor and sails 1.1 km in the direction 75° north of east, where the captain stops for lunch. A short time later, the boat sails 1.8 km in the direction 15° south of east. What is the magnitude of the resultant displacement?
(a) 2.1 km (c) 2.9 km (e) 0.59 km
(b) 1.5 km (d) 1.2 km

□ 47. Three vectors **A**, **B**, and **C** have the following x and y components:
A_x = 1 m, A_y = 0 m, B_x = 1 m, B_y = 1 m, C_x = 0 m, C_y = –1 m
According to the graph, how are **A**, **B**, and **C** combined to result in the vector **D**?
(a) $\mathbf{D} = \mathbf{A} - \mathbf{B} - \mathbf{C}$
(b) $\mathbf{D} = \mathbf{A} - \mathbf{B} + \mathbf{C}$
(c) $\mathbf{D} = \mathbf{A} + \mathbf{B} - \mathbf{C}$
(d) $\mathbf{D} = \mathbf{A} + \mathbf{B} + \mathbf{C}$
(e) $\mathbf{D} = -\mathbf{A} + \mathbf{B} + \mathbf{C}$



Section 1.7 The Components of a Vector

◘ 48. Which one of the following statements concerning vectors and scalars is *false*?
(a) In calculations, the vector components of a vector may be used in place of the vector itself.
(b) It is possible to use vector components that are not perpendicular.
(c) A scalar component may be either positive or negative.
(d) A vector that is zero may have components other than zero.
(e) Two vectors are equal only if they have the same magnitude and direction.

□ 49. A displacement vector has a magnitude of 810 m and points at an angle of 18° above the positive *x* axis. What are the *x* and *y* scalar components of this vector?

	x scalar component	*y scalar component*
(a)	770 m	250 m
(b)	560 m	585 m
(c)	585 m	560 m
(d)	250 m	750 m
(e)	713 m	385 m

□ 50. A displacement vector is 23 km in length and is directed 65° south of east. What are the components of this vector?

	Eastward Component	*Southward Component*
(a)	21 km	9.7 km
(b)	23 km	23 km
(c)	23 km	0 km
(d)	9.7 km	21 km
(e)	0 km	23 km

◘ 51. The *x* and *y* components of a displacement vector are –3.00 m and +4.00 m, respectively. What angle does this vector make with the positive *x* axis?
(a) 233° (c) –53.0° (e) 37.0°
(b) 127° (d) 53.0°

◘ 52. A racecar makes one lap around a circular track of radius *R*. When the car has traveled *halfway* around the track, what is the magnitude of the car's displacement from the starting point?
(a) R (c) πR (e) zero meters
(b) $2R$ (d) $2\pi R$

◘ 53. A bug crawls 4.25 m along the base of a wall. Upon reaching a corner, the bug's direction of travel changes from south to west. The bug then crawls 3.15 m before stopping. What is the magnitude of the bug's displacement?
(a) 7.40 m (c) 3.83 m (e) 5.29 m
(b) 2.72 m (d) 4.91 m

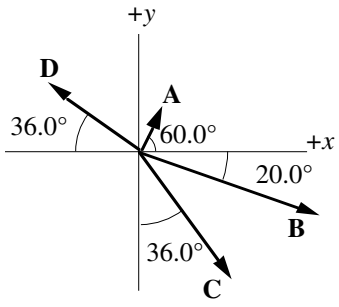
■ 54. During the execution of a play, a football player carries the ball for a distance of 33 m in the direction 76° north of east. To determine the number of meters gained on the play, find the northward component of the ball's displacement.
(a) 8.0 m (c) 24 m (e) 32 m
(b) 16 m (d) 28 m

■ 55. A bird flies 25.0 m in the direction 55° east of south to its nest. The bird then flies 75.0 m in the direction 55° west of north. What are the northward and westward components of the resultant displacement of the bird from its nest?

	northward	*westward*
(a)	29 m	41 m
(b)	41 m	29 m
(c)	35 m	35 m
(d)	81 m	57 m
(e)	57 m	81 m

Section 1.8 Addition of Vectors by Means of Components

□ 56. Use the component method of vector addition to find the components of the resultant of the four displacements shown in the figure. The magnitudes of the displacements are: $A = 2.25$ cm, $B = 6.35$ cm, $C = 5.47$ cm, and $D = 4.19$ cm.



	x component	*y* component
(a)	2.19 cm	–6.92 cm
(b)	3.71 cm	–1.09 cm
(c)	5.45 cm	–2.82 cm
(d)	1.09 cm	–3.71 cm
(e)	6.93 cm	–2.19 cm

◘ 57. A vector $\mathbf{F}_1$ has a magnitude of 40.0 units and points 35.0° above the positive x axis. A second vector $\mathbf{F}_2$ has a magnitude of 65.0 units and points in the negative y direction. Use the component method of vector addition to find the magnitude and direction, relative to the positive x axis, of the resultant $\mathbf{F} = \mathbf{F}_1 + \mathbf{F}_2$.

(a) 53.3 units, 52.1° below the +x axis
(b) 53.3 units, 52.1° above the +x axis
(c) 76.3 units, 37.9° below the +x axis
(d) 76.3 units, 52.1° above the +x axis
(e) 9.23 units, 37.9° below the +x axis

◘ 58. Use the component method of vector addition to find the resultant of the following three vectors:

A = 56 km, east
B = 11 km, 22° south of east
C = 88 km, 44° west of south

(a) 81 km, 14° west of south
(b) 97 km, 62° south of east
(c) 52 km, 66° south of east
(d) 68 km, 86° south of east
(e) 66 km, 7.1° west of south

■ 59. Two vectors **A** and **B**, are added together to form the vector **C** = **A** + **B**. The relationship between the magnitudes of these vectors is given by:

$$C_x = A \cos 30° + B$$
$$C_y = -A \sin 30°$$

Which statement best describes the orientation of these vectors?

(a) **A** points in the negative x direction while **B** points in the positive y direction.
(b) **A** points in the negative y direction while **B** points in the positive x direction.
(c) **A** points 30° below the positive x axis while **B** points in the positive x direction.
(d) **A** points 30° above the positive x axis while **B** points in the positive x direction.
(e) **A** points 30° above the negative x axis while **B** points in the positive x direction.

Additional Problems

□ 60. Which one of the following answers would give the correct number of significant figures when the following masses are added together: 3.6 kg, 113 kg, and 4.19 kg?

(a) 121 kg (c) 120.79 kg (e) 120.8×10^3 kg

(b) 120.8 kg (d) 1.20×10^2 kg

■ 61. A physics text has 532 sheets (1064 pages) and is 33.5 millimeters thick between the inside front cover and the inside back cover. What is the thickness of a sheet?

(a) 6.36×10^{-4} m (c) 6.28×10^{-3} m (e) 6.30×10^{-5} m

(b) 3.16×10^{-2} m (d) 7.24×10^{-6} m

◘ 62. Justine and her friends exit the physics classroom and walk 0.81 km to their math class. While walking, Justine's average step length is 58 cm. How many steps does she take in walking between these two classes?

(a) 310 (c) 1400 (e) 7200

(b) 720 (d) 3100

Questions 63 and 64 pertain to the situation described below:

Two vectors, **A** and **B**, are added together to form the vector **C** = **A** + **B**. The relationship between the magnitudes of these vectors is given by:

$$C_x = 0$$
$$C_y = A \sin 60° + B \sin 30°$$

A_x and A_y point in the positive x and y directions, respectively.

■ 63. Which one of the following statements best describes the orientation of vectors **A** and **B**?

(a) **A** and **B** point in opposite directions.
(b) **A** points 60° above the positive x axis while **B** points 30° above the negative x axis.
(c) **A** points 60° above the negative x axis while **B** points 30° above the positive x axis.
(d) **A** points 60° below the positive x axis while **B** points 30° above the positive y axis.
(e) **A** points 60° below the positive x axis while **B** points 30° below the positive y axis.

■ 64. How does the magnitude of **A** compare with that of **B**?

(a) $A = B$ (c) $A = 0.4B$ (e) $A = 0.7B$

(b) $A = 1.7B$ (d) $A = 0.5B$

Questions 65 through 67 pertain to the statement and table below:

The table gives the x and y components of two vectors **A** and **B**:

Vector	x component	y component
A	+15 units	+10 units
B	+15 units	–10 units

◘ 65. Which one of the following statements concerning these vectors is true?

(a) The vector **A** – **B** has no x component.
(b) The two vectors have different magnitudes.
(c) **A** makes a 56° angle with the positive x axis.
(d) **B** makes a 34° angle with the positive y axis.
(e) The vector **A** + **B** makes a 34° angle with the positive x axis.

□ 66. Determine the magnitude of the vector sum **A** + **B**.

(a) 5 units (c) 20 units (e) 50 units
(b) 15 units (d) 30 units

□ 67. Determine the magnitude of the vector difference **A** – **B**.

(a) 5 units (c) 20 units (e) 50 units
(b) 15 units (d) 30 units

Questions 68 and 69 pertain to the situation described below.

A boat radioed a distress call to a Coast Guard station. At the time of the call, a vector **A** from the station to the boat had a magnitude of 45.0 km and was directed 15.0° east of north. A vector from the station to the point where the boat was later found is **B** = 30.0 km, 15.0° north of east..

■ 68. What are the components of the vector from the point where the distress call was made to the point where the boat was found? In other words, what are the components of vector **C** = **B** – **A**?

	x component	*y* component
(a)	17.3 km, east	35.7 km, south
(b)	35.7 km, west	17.4 km, north
(c)	40.6 km, east	51.2 km, south
(d)	17.3 km, west	51.2 km, south
(e)	40.6 km, east	35.7 km, north

□ 69. How far did the boat travel from the point where the distress call was made to the point where the boat was found? In other words, what is the magnitude of vector **C**?

(a) 65.3 km (c) 26.5 km (e) 42.5 km
(b) 39.7 km (d) 54.0 km